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INTRODUCTION

This paper discusses the role of academic makerspaces in creating social impact, in light of the work done at Makeistan; D-Lab courses taught at Massachusetts Institute of Technology (MIT) and Information Technology University (ITU); and the program of Information and Communication Technology for Development (ICTD) at Atlas Institute, University of Colorado Boulder.

A. MAKEISTAN AT ITU

Makeistan is a makerspace based at Information Technology University (ITU) of the Punjab in Lahore, Pakistan. ITU offers undergraduate and graduate degrees in computer science and electrical engineering. Although Makeistan is formally a part of the Department of Electrical Engineering at ITU, it is a publicly accessible space (during designated hours, open workshops and residency programs), and focuses on socially responsible capacity building for Pakistan's nascent maker community.

B. D-LAB AT MIT & ITU

D-Lab at MIT has a workshop where the enrolled students test ideas, build prototypes, and refine technologies intended to improve the lives of people living in poverty. Inspired by MIT's D-Lab, ITU also offers D-Lab courses to undergraduate and graduate students of Computer Science and Electrical Engineering. D-Lab students at ITU use Makeistan extensively to build and test their prototypes. This collaboration will be discussed in detail in this paper.

C. BTU LAB AT CU, BOULDER

Master's degree in Information and Communication Technology for Development (ICTD) is being offered at ATLAS institute. The ATLAS Institute has a lab called Blow Things Up Lab which is also accessible to people outside of the institute.

METHODS

There are many ways in which the university and workshop managers enable users of their space to work on global development related projects. Although the underlying goal of such activities is social impact creation, but like any other makerspace, ease of access, and supportive as well as inclusive work environments are critical to engaging more users. Following are the different avenues through which users are engaged at these spaces.

A. COURSES AND ACADEMIC CREDITS

DLAB AT MIT

D-Lab at MIT offers many courses designed around the problems faced by the people in the developing world. These courses are cross-listed with academic departments and provide credit toward minor and major courses of study. D-Lab is offering 18 different courses this year (MIT Courses, 2017) [1]. These courses explore many different aspects of the global development issues including designing, testing, manufacturing, deploying and selling the technologies aimed at solving the developing world's problems. D-Lab also offers partial funding opportunities to students wanting to travel, and have out-of-country field work related to their courses. The workshop is used for testing ideas, building prototypes, and refining technologies.

DLAB AT ITU

Inspired by the D-Lab at MIT, Information Technology University of the Punjab (ITU) in Lahore, Pakistan offers a course named D-Lab to undergraduate and graduate students of Computer Science and Electrical Engineering. ITU is funded by the provincial government of the Punjab and it works closely with the technology policy makers for the province. For this reason, ITU has a research focus on cross-disciplinary research that is grounded in real-world problem (About ITU, n.d.) [2]. The D-Lab course at ITU is based on similar principles, but molded for ITU's students and resources. The course spans 16 lectures and 16 lab periods at undergraduate level. The course aims to equip them with the tools to solve such problems through co-design and creative capacity building. Lectures and workshops are conducted on topics like problem identification, ideation techniques, qualitative research methods, participatory design, and rapid prototyping and testing. Once students have been introduced to these topics as well as case studies from MIT's D-Lab and design firms such as Grid Impact and IDEO, they are expected to spend six weeks applying these methodologies to prototype a solution to a real-world problem.

The prototyping stage of these projects is facilitated by the various labs at ITU, but is centered around Makeistan. Apart from using Makeistan's tools, space, expertise and network, feedback sessions are also held at Makeistan, since the electrical engineering D-Lab course is taught by Ali Murtaza, one of the co-authors of this paper, and Makeistan's Program Manager.

MS-TMS (ICTD) AT ATLAS, CU BOULDER

Alliance for Technology, Learning and Society (ATLAS) institute at the University of Colorado Boulder is an interdisciplinary institute that offers various degrees. Their Master's degree in Information and Communication Technology for Development (ICTD) is aimed at helping their students devise or adapt technological solutions to fulfill basic human needs (MS-TMS ICTD, n.d.) [3]. There are different labs and centers for the students at the ATLAS institute where they can learn the use of technology and prototype solutions, but the Blow Things Up (BTU Lab) stands out as it calls itself a hackerspace and has the most flexible membership policy, and is not restricted to ATLAS institute.

B. NON ACADEMIC AFFILIATIONS AND PROJECTS

In addition to the academic side of global development and design for social impact, a framework for real-world applications and research needs to be established.

D-Lab at MIT has a scale-up fellowship program that offers one year of support to social entrepreneurs bringing hardware-based, poverty-alleviating products and services to market at scale. Scale-Ups Fellows receive a \$20,000 grant, tailored mentorship, skills-building, and networking opportunities (D-Lab Scale-ups, n.d.) [4]. D-Lab also helps conduct International Development Design Summits (IDDS) in different parts of the world. IDDS brings together a diverse set of innovators from around the globe to work for a duration of two to four weeks during which they identify development related problems and prototype their solutions (International Development Design Summits, n.d.) [5]. Some of the projects continue after the summits are over. Alumni of the International Development Design Summit are eligible to apply for the scale-up grants. D-Lab alumni, fellows, visiting inventors, and other D-Lab associates are allowed to use the shop to pursue international development-related projects.

Numerous projects have come out of ATLAS institute's ICTD track, aimed at solving problems in the real world (ICTD Projects, 2017) [6]. Additionally, there also are projects where ICTD alumni from ATLAS are contributing their skills in development related projects where technology is being used to fulfill societal needs.

Inspired by the impact Makeistan has had on ITU's D-Lab students, a six-week long Designers-in-Residence (DIR) program has recently started at Makeistan which aims to bring together college students and recent graduates from across Pakistan to follow the D-Lab methodology to help solve real-world problems. Among the twelve residents are industrial designers, architects, visual artists, electrical engineers, computer scientists and software engineers. In teams of two, the residents will be working to identify problems in their community, before using our facilities to co-create prototypes with the people who are meant to use them. These prototypes will then be tested by the users, and successful projects will be given the opportunity to seek funding from the Punjab government.

Outside the D-Lab class at ITU and the DIR program, students, tinkerers and professionals unlike se Makeistan for

hobby and non-academic projects. Although the scope of such projects is not limited to any specific domain, we encourage students, volunteers and users of the space to take up projects which are aimed at creating social impact. One of the ongoing project which we got funded through one of our donors was an ag-tech project. It is an electro-mechanical safety add-on for a chaff cutting machine.

Another ongoing project is the road surface quality meter. It is a low cost system developed for measuring and analyzing the road surface quality. This has a hardware component that uses data science to solve a classification problem, and has applications in the field of civic tech. It started out as a result of the collaboration with one of the International Center for Journalism's (ICFJ) fellows.

Apart from specific projects, Makeistan also has ongoing partnerships to support organizations that are creating long-lasting social change. One such partnership is with SOS Children's Villages Pakistan - one of the country's largest organizations dedicated to helping feed, house and educate orphans. Makeistan has conducted over a dozen workshops with children from SOS, focusing on teaching them skills that may improve their employability in the future.

RESULTS AND DISCUSSION

In context of social impact creation, makerspaces are generally divided into four categories: spaces that; act as social spaces; support wellbeing; serve the needs of the communities they are located in; and reach out to excluded groups. [7]. That is if a makerspace is located in the community they aim to serve.

Apart from giving maximum access to the ITU students, Makeistan reaches out to the excluded groups of the community and support the wellbeing of those groups directly and indirectly. One such example is our collaboration with SOS village orphanage, where we conducted series of workshops on prototyping for their high school students. The wellbeing aspect is not always related to solving problems, but also about the simple joy of making. Makeistan was used by 45 D-Lab students, 12 designers in residence and 15 high school students for prototyping of development related hardware projects this past year.

In MIT D-Lab's case, their shop is open to alumni, fellows and visiting inventors but the communities that it aims to serve are different from the users of the space. Workshop at D-Lab MIT is used by 150 users for prototyping and testing of development related projects every year.

All three makerspaces (Makeistan, D-Lab workshop, BTU Lab) support students and inventors in solving problems faced by the developing world, and value creation is quantified in terms of the number of students/users trained, and skills that are taught and practiced at the space, but tracking the positive outcomes after the users graduate, and highlighting stories of alumni success is a challenge for most of the spaces working in this domain [7]. MIT's D-Lab's success in this regard is helped by having a clear agenda of social impact creation. Although social impact is a constituent of Makeistan's identity too, but its journey to social impact creation is longer due to

being having an education focused approach than being a project focused space. BTU Lab at CU Boulder neither exclusively caters to social innovators nor is social impact a part of their philosophy (About BTU Lab, n.d.) [8], but the ICTD track graduate students use the space for prototyping their development related projects and learn the skills that they utilize in the global development setting after graduating.

The three types of makerspaces discussed here differ with respect to goals, philosophies, regional and institutional contexts, yet their contribution in global development space, and challenges faced by their space managers are similar. In all three cases, it was observed that not only do the development courses (D-Lab, ICTD) steer the direction of the respective makerspaces, space managers also help the course instructors in identifying the skills that are the most crucial for prospective social innovators.

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