Developing new approaches to equitable education for a growing diversity of students at the university

ABSTRACT

Promoting equitable education among diversity groups of university students is the main goal of a program designed by Fab Lab Madrid CEU, the digital fabrication laboratory based at CEU University, through new learning approaches and open access to digital fabrication facilities. The present paper describes a case study in which architectural students that come to the university classroom with a different background and cultural context, at risk of poverty and social exclusion, engage in on-site and remote access to digital fabrication technologies through a platform designed for the Horizon 2020 European Union Project NEWTON (Networked Labs for Training Science and Technologies). The platform is an innovative tool that provides technology-enhanced learning to increase learner quality experiences for all.

KEYWORDS

Fab Lab, Diversity, Inclusion, Digital Fabrication, Architecture

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INTRODUCTION

Spain is the second country of the European Union (EU) in Early School Leaving (AEP), with a rate of 19% of young people between 18 and 24 years old, who have left the education system prematurely, having completed at the very least the first cycle of Secondary Education (ESO) and not having received any type of training in the last month. However, Spain has managed to reduce the school dropout rate in the last decade from 30% in 2006 to 19% in 2016, although it is still far from reaching the national goal of reducing it by 15% in 2020, five points less than the goal for the whole EU. On the other hand, the rate of people between 30 and 34 years old who have completed their higher education was 39% in the EU, only one tenth below the target set for 2020 of 40%. Spain registers better results in this indicator, with a rate of 40%, close to 44% agreed and well above the 39% of the community average. [1] This percentage is explained by issues such as economic difficulties, but mainly by "the differences in the cultural capital of the students and the absence of family and institutional support networks". [2] While educational exclusion is one of the main problems of social exclusion, education seems to be a promising solution to avoid it.

Developing new approaches for equitable education for the growing diversity of students at the university level has become an imperative at Fab Lab Madrid CEU, the digital fabrication laboratory based at CEU University. We aim to create a more inclusive and successful learning community for our students by increasing our focus on equality and diversity. Our mayor goal is promoting diversity and increasing equity through initiatives that allow instruction and open access to digital fabrication facilities for young people of vulnerable social environments in disadvantage. To that end, a program has been designed based in new learning approaches and using educational materials that enhance the capacities of university students to design and fabricate, acquiring training in new technologies required in the job market, through on-site and remote activities that facilitates the inclusion of at-risk groups. Thanks to it, students have the opportunity to learn new content and develop skills that boost their labor insertion and get access to university courses that motivate and inspire their future goals from an inclusion perspective.

RELATED WORK

Fab Labs have been proved as attractive models of education, particularly as places to provide training in a wide range of areas from design thinking to product development [3], to teach courses at the university facilities, looking for motivating high-school students on their future careers [4], or to use next generation technologies on active learning activities [5], to mention just a few examples. Yet, less research exists on how Fab Labs can affect student's interaction and communication to promote diversity, social inclusion and equity at the university level. Voigt,

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Unterfrauner and Stelzer [6] suggested that ethnic, gender and socio-economic diversity is not yet at the forefront of digital fabrication laboratories agendas for change, based on a combination of qualitative and quantitative data collected from Fab Labs. Eversmann [7] highlighted that the realization of large-scale prototypes in architecture using digital fabrication technologies made university students keener to self-learning and that the social interaction and learning with and from multiple team members can be a very efficient way of studying. Vecchioni [8] reported that Makerspaces and Fab Labs are often used by individuals from high socioeconomic backgrounds, and users are predominantly male, bringing up some practices to open both spaces for all. Finally, van Gammeren [9] demonstrated how educational technologies and curriculum design can successfully integrated a diverse student demographic into a vibrant learning community through a Higher Education distance-learning course.

METHODOLOGY

The present paper describe a case study that show the practical outcomes of a course in which architectural students engage with on-site and remote access to digital fabrication technologies, showing that Fab Labs can help in acquiring technical skills, but also in encouraging social interaction to promote diversity among university students. Fab Labs are considered as small workshops [10] equipped with a set of computer-controlled tools ─3D printers, laser and vinyl cutters, milling machines and an electronics laboratory─ that endorse a new learning paradigm, favoring the use of technology as a building material to promote educational approaches that involve "learning by doing" and "enjoying while learning" to enable students to take part in all phases of the fabrication workflow [11]. Although Fab Labs have existed in pedagogy for years [12], there are still few initiatives that study the use of remote and on-site access to Fab Lab facilities at the university level and their impact on social interaction among students, looking for promoting the inclusion of diverse groups.

Our paper discusses how the initiative carried out at Fab Lab Madrid CEU improves students' skills with digital fabrication technologies to increase their curricula using a hands-on approach. It also analyze students' interaction during the activities carried out on-site and remotely, the degree of interaction among them and their feelings of belonging to the university community after the course. To that end, the course involved the design and fabrication of a summer pavilion using two specific technologies: laser and vinyl cutters machines. It was organized in three phases: the first one was focused on the design of the pavilion using an open-source 3D parametric software called Grasshopper. Students were trained on how to express design intentions with parameters and explicit functions, which requires a different way of thinking than simple 3D modeling. Learning to think parametrically is a hard-won skill, not acquired with ease, but the logical precision of it worth it. The workshop tested a new "learn and design" approach including classes, tutorials and digital fabrication techniques during two intensive weeks, which took students design skills to a high level.

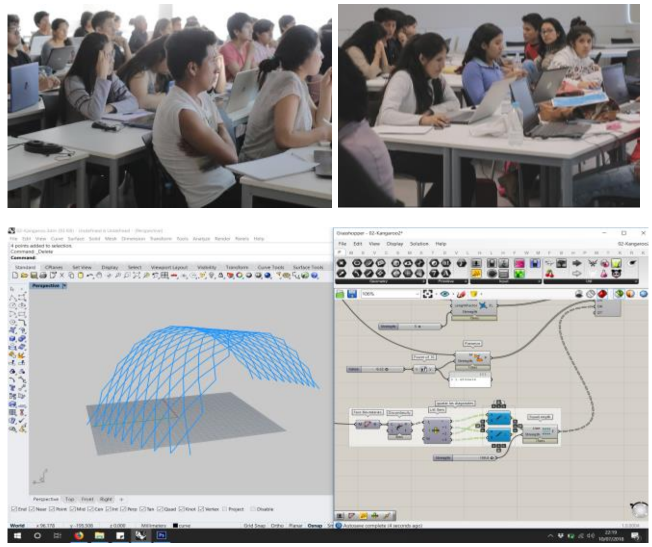

Figure 1: Architectural students attending to the classes on parametric design at Fab Lab Madrid CEU.

The second phase of the university's course taught students on how to fabricate small-scale prototypes of their design via remote access to Fab Labs' vinyl cutter machines, thanks to the Cloud Hub application created for the NEWTON project. [13] NEWTON is a large European Union project focused on the integration of new solutions for technology-enhanced learning that enables learning content use and supports the generation of new material and content exchange among students to increase learner quality of experience for all. Thanks to this platform students get a quick and easy access to Fab Lab machines without having any knowledge on how to use the software associated to each machine. Files were sent to a Raspberry Pi connected to the vinyl cutter machine. Using the Cloud Hub app, students selected the Fab Lab machine to be used and the material to be cut. The platform is designed to assign all parameters needed to cut the pieces on paper or cardboard. A small-scale model is required to each of the students in order to test their designs and improve the quality of the real size prototypes.

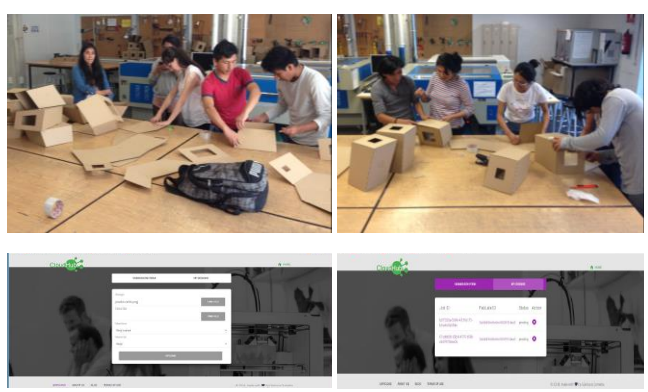

Figure 2: Architectural students using Fab Lab machines on-site and remotely through the Cloud Hub Application.

The third phase of the course focused on the use of laser cutter machines located at the Fab Lab facilities to build a real size pavilion using cardboard. Students were required to work collaboratively during one week preparing their design files and working in groups of five. They were taught in the use of laser cutter machines, so that they could work autonomously, although under the supervision of Fab Lab instructors, before assembly all pieces to build the summer pavilion. Students learned how to prepare the files to be laser cut, focus the laser, setting mode, speed and power using the appropriated values for each specific material and finally, use the control panel of the laser cutter to test the laser head and cut the pieces.

Figure 3: Summer pavilion built by architectural students at Fab Lab Madrid CEU.

1 Participants

Fab Lab course's participants include architectural students that come to the university classroom with different backgrounds and cultural contexts, some of them at risk of poverty and social exclusion. A number of 32 students between the age of 19 and 24 enrolled on the course, among which 60% identified as female and 40% as male. According to the data collected, 12% of students came from a big city, 16% from a small town and most of them; a percentage of 72% came from the countryside. 10% of participants reported that they have never used a smartphone; 50% stated that they used it very rarely to communicate with classmates and family; 25% affirmed that they use it a few times a week and finally, only 15% said that they use it every day to search on internet, communicate with friends and family and look for information required in course assignments. The course included workshops on-site and assignments carried out outside the university's facilities, which were possible thanks to the Cloud Hub application. During the workshops held at the Fab Lab, two professors and one Fab Lab instructor were in charge of classes.

2 Data Collection

Students, professors and the Fab Lab instructor were invited to participate in interviews and questionnaires along with classroom observation. The core of the evaluation procedure employed was developed by the NEWTON project's Pedagogical Assessment Committee (PAC) [14] that provided templates and guidelines for various assessments including various questionnaires. Firstly, a Learner Demographic questionnaire, used to collect information about learners, such as gender, age, feeling about studies and the use of technology. Secondly, a Learner Motivation and Affective State questionnaire (pre and post activities) used to assess learners perception toward university's courses and their motivation while learning before and after the course. Finally, a Learner Usability questionnaire to assess learners feeling about the usability of Fab Lab on-site and remotely through the NEWTON platform, and also their impact on their social interaction during the course. Besides, professors carried out learner observational assessment and interviews after the course ended.

2 Results

After collecting all data, the following results were found. When filling the Learner Demographic questionnaire, students were asked to rate their motivation in relation to architectural courses at the university. All the answers ranged between "Very interested" (45% of students) and "Extremely interested" (55%). When asked about their interest in graphic classes (Architectural Drawing, Descriptive Geometry, Form Analysis and Architectural Design), 50% of students seemed very interested, while 45% were "Extremely interested" and only a 5% answered "Somewhat interested". Related to Fab Lab activities on-site, answers ranged between "Extremely interested" (70%) and "Very interested" (30%), while in remote access to digital fabrication facilities 50% stated to be "Extremely interested" and 50% "Very interested".

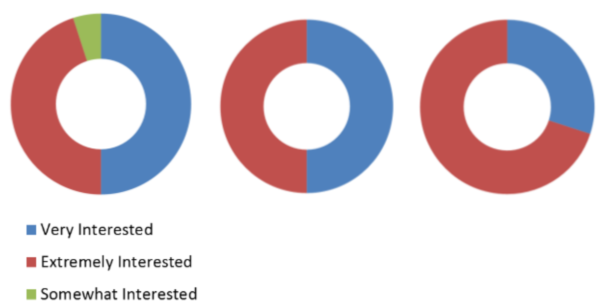

Figure 4: Motivation of students in architectural courses (left), remote (center) and on-site (right) access to Fab Lab facilities.

Regarding questions about methodology used in university courses, students where asked if they found graphic courses difficult and if they though there were something they would change about them to be more easy to approach and active, using more technology in the classroom. When asking students about the first question, 5% of students stated that they found university courses "Extremely difficult", while 10% of them answered "Very difficult", 50% stated that courses were "Difficult" and 35% selected the answer "Slightly difficult". In relation to Fab Lab courses, all students ranged between "Difficult" (70%) and "Slightly difficult" (30% of students).

When asked about their grades on graphic courses students answers ranged among low (35%), average (35%), good (20%) and very good marks (only 10% of students). A comparison between the marks of the graphic courses and the grades obtained during the Fab Lab courses are promising, as they revealed statistically significant improvements. The percentages of low grades decreased to a 15% of students, while the amount of students with average grades increased to a 50%. Good results were obtained by 30% of participants and the percentage of very good marks remained at 10% of architectural students.

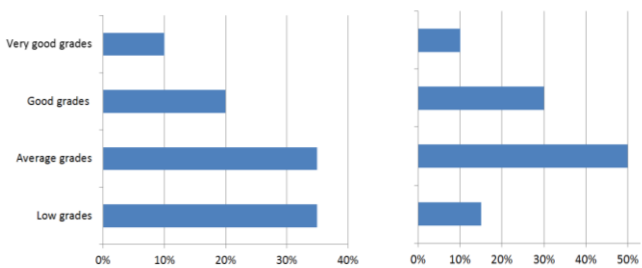

Figure 5: Marks of students in architectural courses (left) and Fab Lab courses using digital fabrication technologies (right).

Regarding the impact of the courses' methodologies on students social inclusion, 10% of students stated they didn't feel integrated at all in university classes, 40% answered they felt slightly integrated and 50% seemed completely integrated on classes. In relation to Fab Lab courses, the percentage of students that felt integrated during the workshop increase considerably to reach a percentage of 70%, while 10% of students felt slightly integrated. Surprisingly, 20% of students adopted the role of leaders of their own groups taking initiatives and encouraging other students to engage on class activities and discussions.

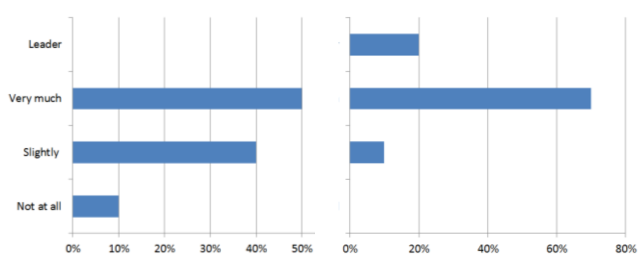

Figure 6: Social inclusion of students in architectural courses (left) and Fab Lab courses (right).

Interviews revealed that students felt more integrated in Fab Lab activities than in conventional classes. According to one student, the fact of working hand in hand with professors, receiving advice from the instructor to solve problems that arose during the workshop help him to feel more engaged. He stated, "Thanks to the personal attention received when needed, I kept pace with my classmates". When asked about their feeling of belonging to the university community, one of the students stated, "Working collaboratively allowed me to feel more integrated with my classmates as part of a team". Another student stated, "When working in group, you feel more confident to intervene in class on behalf of a supporting team".

CONCLUSIONS

Results reveal that Fab Labs courses not only help students in acquiring technical skills, but also in allowing social interaction among students, promoting diversity and equity in the classroom. Findings also indicate that learners are more motivated when engaging in more personalization, collaboration and pedagogical approaches that run between on-site and remote learning helped by professors who are confident in creating a richer environment available for all. Work is ongoing and although this experience does not provide validation of the program, it achieves its goals providing better educational practices for all.

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