Barcino, Creation of a Cross-Disciplinary City

Nancy Otero
Stanford University
Center for Educational Research
520 Galvez Mall
notero@alumni.stanford.edu

Paulo Blikstein
Stanford University
Center for Educational Research
520 Galvez Mall
paulo@stanford.edu

Abstract

More and more schools are implementing "maker" spaces and using digital technology to support students' interest and learning in STEM fields. Little is known about schools' interactions with those type spaces and their impact in formal assessment. We describe the implementation of a FabLab@School (FL@S) and the interaction of teachers' and school administration with it in Rubi, Spain. Additionally, we do a preliminary analysis on teachers' interviews and on the grade effect the FL@S might have had on students. FL@S was implemented at the beginning of the second trimester of the school year, we found a positive significant effect on grade change from the first trimester to the third trimester and a change on teachers' expectations on students' performance.

Author Keywords

project-based learning, digital-fabrication, fablab@school, maker spaces, multidisciplinary content, laser cutter.

ACM Classification Keywords

Education/Learning, Fabrication

Introduction

Seymour Papert, building on Piaget's idea of constructivism, developed constructionism, a learning theory and strategy for education. Constructionism proposes that knowledge is not simply transmitted from teacher to student, but actively constructed by the mind of the learner. Today Papert's ideas form a theory of learning as well as a set of pedagogical practices, strategies, and tools for creating an environment to allow Papert's two layers of making to happen, making understanding and making objects [8].

Having its roots on Papert's ideas FabLab@School (FL@S) was conceived by Paulo Blikstein in 2008 as a space that will support students' exploration of real word problems, invention and collaborative problem solving. FL@S is a network of educational digital fabrication labs with technology for design and construction – such as 3D printers, laser cutters and robotics. In the hands of teachers, such resources can be tailored to students in very culturally diverse classrooms, and used in engaging ways that increase learning motivation.

The use of digital fabrication and a constructionist approach to the learning process has been shown to improved learning outcomes, promote creativity, inquiry, critical thinking, and collaboration [2]. Project-based learning has been found to double the learning gains of the traditional lecture method [12] and interconnectedness of knowledge fields leads to higher motivation to "explore individual subjects in deeper ways" [9]. The characteristics of inventing and making of the Maker Movement which are consistent with its constructionist roots offer children powerful tools for autonomously exploring the world and learning by making [6].

Engaging in project-based learning can help unmotivated students to overcome the moments of struggle that are essential to exploration, experimentation and learning. This process of becoming stuck and then 'unstuck' is an opportunity for teachers and peers to offer suggestions in terms of student's ideas and goals with the focus of expressing project complexity in students' own terms. The activities describe in this paper were designed to create a safe-space where students have an object to point to — "an artifact that may be rickety or lopsided, but yet has resolved the problem that so puzzled the learner" [9].

Setting

The Colegio Liceu Politecnic is located in Rubi, a small town (75,038 habitants) close to Barcelona with 13% immigrant population. Rubi has an unemployment rate of 20%, 40% of which are youth, 45% of the population have not finished elementary education or have problems reading and writing, and the number of businesses has decreased from 2,500 in 2006 to 1,900 in 2011 [1]. Colegio Liceu Politecnic saw in the "makers movement" a way to deeply engage their students into real world problem and connect different domains of learning. After going to several conferences the co-founder of the school decided to create a FL@S. The implementation was planned in the summer of 2014 and began in January 2015 during the second trimester of school. During summer 2014 teachers from Technology, Math, History, English, Art and Music meet several times to co-design an activity that will allow to integrate the different domains and help students understand their present experience.

School's administration provided space, time, technology guidance and facilitation for the process.

Activity Design

Barcino was designed with the goal of widening the definitions of learning, science, art, design and intelligence. It supports imagination, creativity and play in a learning environment that promotes collaboration and links the program to a social context. It involves a range of different disciplines and teachers, and purposefully integrate diverse tools, materials, methodologies and media with the goal of promoting reexamination of students' conception of the same phenomenon [8, 9]. These principles have been considered to promote equity in teaching and learning [12].

Barcino, is a multidisciplinary project that integrates Math, History, English, Art, Music, and Technology subject areas into a cohesive thematic project that tells the story of Barcelona during the Roman era. Barcino's designs heavily relies on the use of the laser cutter, teachers decided to selected that technology of the FabLab@School to start building their own and students skills for designing, prototyping and engineering. As a final collective project the class needed to build a maquette of the city, where each team had the responsibility to build a Roman temple. The class as a whole designs the arrangement of the buildings based on historical facts. From each domain teachers' design activities that complement each other and build skills that where used for the design of the city and the final presentation of it.

<u>Math</u>.- i) Investigate the Fibonacci series and use it to calculate the dimensions and proportions of a roman temple. The final project of that activity was to build a scale model of the roman temple using the laser cutter. ii) Using the regular polygon theorem and use it to construct the floor of the temple by filling a 12'' x 24'' area with regular polygons using the laser cutter. <u>History</u>.- *i)* Construction of a banner per team with roman tribal justifications using the laser cutter. ii) Decorated the entrance of their buildings based on Roman gods. iii) Justified the shape of the city they built as a whole class paying special

attention to importance of the sacred. Art.- i) Activities focus on the characteristics of roman art, its greek influence and propagandistic use. ii) Learning to use Corel Draw which in turned was used in the other domain activities for designing what needed to be cut in the laser cutter. Music.- i) The activity consist in build a lira, a roman empire musical instrument using the laser cutter using a resonance box. ii) Tuning the lira. Technology.- i) Use of the laser cutter. ii) SAP programing to do basic calculus of areas and dimensions of columns to support the temple. iii) Reflection on interaction between different domains of knowledge. English.- i) Learning the vocabulary for the material used and processes. ii) Final interviews in English across teams about their experience, lessons learned and links between different domain subjects.21 first year middle-school students (11-12 years old) participated in weekly project-based activities inside the FL@S for 7 hours on average per week during the last two trimesters of the school year. Students worked in teams of 4 for all the activities, and they stayed within the same team throughout the school year.

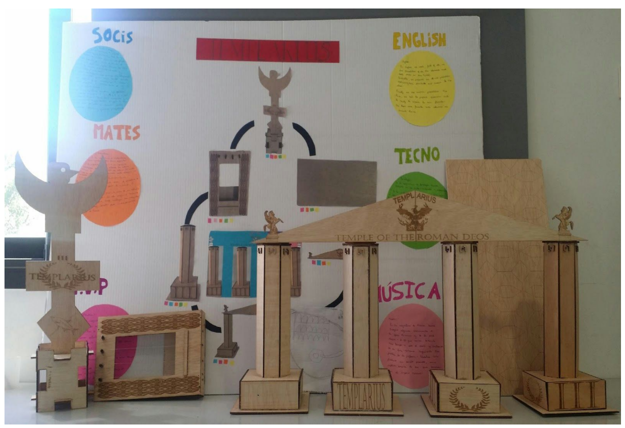

Figure 1. Example of one team projects for the different domains. From left to right: team banner, lira, Roman temple following the Fibonacci series, on the back right, floor temple tessellation. On the back of all explanation of how different domains were use in the projects

Figure 2: Final project in progress

Figure 3: *Barcino's* final project

Teacher Interaction

We present the preliminary analyses of teachers' interviews. All the teachers from the first year of middle school were interviewed during the beginning of the third trimester of the school year. The interview circulated around their interaction with the FL@S, and the direct or indirect changes they felt related to it.

Because teachers gave the grades to the students, we were interested in understanding their rational for grade-change and what were the changes they notice with their students. We understand that teachers in

terview presents a conflict of interest as an explanation of why the grade changes. Teachers' interviews are not the only path to understand the broad impact FL@S has at the school, we also interview students that participate and did not participate in activities inside the FL@S and applied the Exploration and Fabrication Technologies (EFT) index pre and post activities in the FL@S, we are in the process of analyze them but those results will not be presented here.

All participant teachers mention that at the beginning they were skeptical of the use of technology in their classes and the possible collaboration between each other. Themention that the support from the school administration was very important.

Participant teachers mention that the interaction with their students was different when the class was done inside the lab than in the traditional classroom. Some students were more interested in class when the class was held in the lab. Most participant teachers talk about how students will mention what they learn in the other domains related to the current class and the *Barcino* activity. Most teachers were also interested in expanding their use of technology in their classroom, tools as 3D printers and robotics were mention.

All the teachers that participated in *Barcino* mentioned the surprise they got when three students that were mostly distracted and uninterested in the traditional classroom became team leaders inside the lab. Teachers also mention that other students start asking these three students for help, something that never happened before. Some teachers mention that few students who normally are the best in the traditional classroom had some difficulties adapting to the FL@S dynamics. Teachers that did not participated in *Barcino* (Catalan, Castellano, and Science teachers) commented on how surprised they were when participating teachers talked about how much some students changed when in the lab, specially because they saw no change in their classroom. Participant teachers invited not participant teachers to watch some of the students' presentation so they can also witness the big change that some of the students were showing in the lab. Non-participant teachers mention how after seeing the presentation and project in the lab their expectations for those students that were distracted and uninterested in the classroom started shifting.

Participant teachers mention that some times they did not know how to assess how much students were learning in the activities and what they were learning.

	FL@S	Mean	Std. Deviation	N
T1 AVG	No	5.516667	1.3838163	12
	Yes	5.365714	1.1369245	20
	Total	5.422321	1.2154207	32
T3 AVG	No	5.458333	1.4579633	12
	Yes	5.863571	1.0639031	20
	Total	5.711607	1.2197272	32

Table 1: The first column is the trimester number, T1 is the first trimester, T3 the last trimester. The second column (FL@S) indicate No if students did not participate in FL@S and Yes if students participated in it.

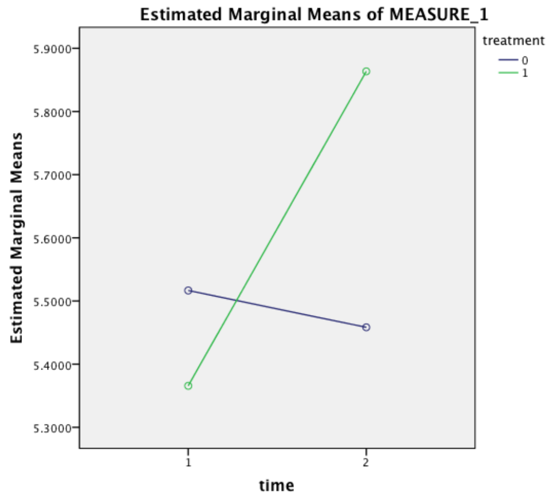

Figure 4. Shows in green the change in grades of the group that participated in the FL@S and in purple the change in grades of the group that did not participated

Method

We were interested to see the effect throughout time of the FL@S in the overall performance of the students represented by their grades. Students are graded by trimester, there are three trimesters (T1, T2 and T3). We are interested in the change in grades from T1 to T3. For all the group that participate in FL@S we calculate the mean of all the average grades from all the students (N=20, female=8) of T1 and T3. We did the same with the last school year cohort (N=12, female=8) (see table 1). We wanted to compare the change in grade between those two group because the 2013-2014 group did not participate in any FL@S activity.

In a preliminary analysis we compared the participant group change on average grades from the first trimester (T1) to average grades from the third trimester (T3) with the change on average grades from T1 to average grades from T3 from the previous year students from the same school. Teachers were the same for both groups except for the Math teacher.

Discussion

The interaction of teachers and students in the FL@S and the design of *Barcino* seemed to have had a positive effect on students' average grades. An Effect Size of .45 can be seen according to Cohen [4,5] as a medium effect, in education the suggestion is to interpret the effectiveness of a particular intervention in relation to other interventions. Reducing class size from 23 to 15 had an ES = .32 [4] and inquiry-based vs traditional science curriculum had an ES = .30 [11]. It is also interesting to notice a decrement in the standard deviation in T3 for the group that participated in the FL@S, this can be interpreted as a closing gap in the performance of students.

More research is needed to understand what is producing this positive impact in students and what are the design choices related with the space, technology, activity and administration support that relate to it. Also it is important to understand if the effect is a long term effect and will last in the next school year.

One interesting interaction is the change in students' performance expectations that teachers experience after seeing students present in the lab, even if the teacher did not have an activity in that space. It is possible that after students are recognized as good learners inside the lab by teachers and peer they can transfer that identity into more traditional learning settings. It is important to consider this interaction when designing this type of learning activities and when designing it implementation.

Additional research should also be done to the interaction that traditionally "good" students have when changing settings into non-traditional environments such as the FL@S.

Conclusion

According to research in order to transformed the school capacity and integrate into the school's culture non-traditional ways of teaching the leadership of the school needs to provide support in space, time, content flexibility, and promote teachers' collaboration [3]. The Colegio Liceu Politecnic was able to provide this support to its teachers and students, which allow teachers to actively participate in the creation of activities and collaborate between them. The *Barcino* activity seemed to had been especially beneficial for vulnerable students, but still the data from the grades showed that as a group most students benefit from it. Because Rubi's population has restricted access to technology and education, implementation of activities like this that spark the motivation for learning can show us how a well design activity around a laser cutter can transformed the perspective of teachers towards the use of technology in the classroom and bring more technology to the hands of students though meaningful activities. But further research is needed to understand what is mediating this change, it might help us understand how to design for the kind of interactions that promote motivation to learn, classroom engagement and leads to a change that even teachers that do not participate in the activity can perceive.

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