Makers in Residence Mexico: Creating the Conditions for Invention

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Abstract
We describe our experience customizing and implementing the program Makers in Residence, created by the Transformative Learning Technology Lab (TLTL) at Stanford University. 33 randomly selected high school students participated in an 80-hour after school program where they learned how to used cutting edge technology such as 3D printers, laser cutter, and robotics. We discuss the pros and cons of the program implementation. Based on preliminary video analysis of the participants' experience and pre and post surveys we analyze the possible short-term effect of the program along three dimensions: participants' technology awareness, self-efficacy regarding invention, and career choices. We also point to implications for designing similar programs and understanding their effects.

Author Keywords
FabLab@School, Education, Constructivism, Invention, Hand-On Learning, Project-Based Learning, Robotics, 3D Printing, Laser Cutter

Introduction
The role of the teacher is to create the conditions for invention rather than provide ready-made knowledge.
-Seymour Papert

From the Next Generation Science Standards (NGSS) to every day news there are calls everywhere for educational approaches that teach engineering and design while fostering creativity and inventiveness [1,3] The grow of digital fabrication and 'making' in learning environments such as schools and museums represents

a major chapter in this process of bringing not just programming but a wide range of big ideas, literacies, and expressive tools to children [2].

Makers in Residence is a 200-hour program where 10 to 12 students from different high schools go twice per year to the FabLab@School at Stanford University for 5 hours every day for 4 weeks. The time at FabLab@School is instead of, rather than in addition to their time at their normal high school. The program includes learning how to use 3D printers, microcontrollers such as GoGoBoards and Arduinos, laser cutters, Scratch, and other fabrication tools with the help of Stanford graduate students. At the end of the program the participants engage in an invention project where they build something from scratch for several days and present it to their peers and community. We wanted to implement the same workshop with a public high school in Mexico City and explore the possibilities of making it a sustainable project and research its long-term effects. With this goal in mind we engaged in conversations with the University Tecnológico de Monterrey Campus Santa Fe. This university has the unique combination of a space with 3D printers and a laser cutter, students with skills related to design and engineering, and was interested in running the pilot project. The Colegio de Bachilleres Plantel 8 was the public high school that was interested in participating in the program as an after-school activity. We could not find a high school that will let their students substitute the FabLab@School program for their time at school. The first implementation of Makers in Residence in Mexico was in September 2013 and with 21 students participants of which 18 completed the program. The second program was implemented in March 2014 due to the success of the first, 17 students participated and 15 completed the program.

In this paper, we provide a description of our experience implementing the program and creating the conditions for invention in a temporary setup. Towards our goal of making FabLab@School accessible and interesting to vulnerable populations we describe the pros and cons of this implementation for the participants and institutions. Based on the analysis of video recordings, interviews and pre and post surveys of the participants we present some patterns found in their experience.

This implementation has demonstrated to have at least a short-term positive effect in participants self-efficacy regarding invention, technology awareness, and career choices. Additionally, it has been a powerful display of the possibilities that FabLab@School can offer in a permanent setup for the institutions that collaborate in the project. One of the main problems with this implementation is the lack of continuity of the creative process, the lack of space for the participants to forward develop their inventions, and the program separation from formal education.

Implementation

We faced the same restrictions that most schools do when implementing FabLab@School: lack of space, no funding for equipment, materials and qualified personnel to assist the participants, and no time in the formal education schedule. Because of these reasons we partnered with a University that has the necessary equipment and students who can help facilitated the program.

The main modifications we had to do to the TLTL Makers in Residence program was that this program was after-school rather than linked to the school activities. A consequence of this was that participants had no obligation or reward for completing the workshop and that it will require additional effort in addition to their normal school work. To compensate for this we shorten the duration to four hours per day instead of five and we did just one program per year for the same participants instead of two. Special attention was given to create a gender-neutral environment where participants would feel very confortable, and to prepare activities that will build-up their inventiveness skills.

Another important modification was a 2-day training for the facilitators, covering with particular focus on the pedagogical principles that the program stands for and some design thinking knowledge. The facilitators were undergraduates with majors in engineering, design, telecommunications or mechatronics. We had a ratio of at least one facilitator per three participants. A senior mechanical and electrical engineer was also assisting the workshop, we found his presence very useful not just because of his practical knowledge but students seemed to responded very positively to his life advice and stories.

The last significant modification was that participants were randomly selected. The first group was selected from a population of 300 students, and the second group from a 120 student population. Pre and post surveys were administered to both populations. For the first program we selected 40 students (20 females), the invitation was made in person with a follow up phone call. Same process was repeated with the second group, but we selected 30 students (15 females).

Implementation Analysis

We found that participants were able to complete the program at a higher rate than expected, showing that under the right conditions students are willing to participate in intense fabrication programs even if that implies spending almost all their free time doing it. When asked what should be improved in the program, 30% of students replied that it should be longer.

This implementation served well as a showcase for the organizations involved. The University Tecnológico de Monterrey was interesting in trying the FabLab@School concept with their own high school after the first implementation, and the Colégio de Bachilleres Plantel 8 opened the doors to expand the collaboration. Many of the facilitators wanted to participate in the second implementation, and training was given to the University Tecnólogico de Monterrey for them to implement the program on their own.

One of the main restrictions with this implementation is that it is a one-time experience that has no continuation. Many of the students wanted to continue developing their inventions, other students wanted to explore other domain of knowledge such as architecture or biology, but after the program was over they did not have a place to do it. The fact that it was an after-school program made it very hard for students to keep up at school making it difficult to extent the program's duration.

Video Analysis

One person was hired to videotape the participants' development throughout the program and each student was video interviewed at the end of the program as well. A preliminary video analysis of the recordings

shows changes in the participant's technological awareness, self-efficacy especially regarding their inventing abilities and technological skills, and career choices. In the cluster regarding technological awareness many students express that after the program they understand "how things work" or "how things are made" that they see something and they think "this works with something I know".

We found a cluster of comments from the participants around how after the program they feel they can build new ideas and ideas they had had in the past. They expressed comments such as "I didn't think I could do it but know I think I can", other type of comments in this cluster are about how hard they thought learning the material was and how hard they think it is now. Comments like "at the beginning I didn't like it, until I started practicing and now I realize I'm becoming good at it" were also common. Further analysis of the videos will be done.

In the last interview students were asked again what are their career choices. We found a domain change in many of the participants' choice, especially in the female population. Some of the changes were from studying to become a teacher to nanotechnology for one participant and a PhD in biology for another one. Also we found a shift to industrial design for another female participant and mechatronic engineer for a male participant. Further analysis will be done regarding career choices.

Conclusion

After these implementations we learnt that even intense fabrication programs such as Maker in Residence could be implemented in difficult conditions with a high response from participants. To assess the short and long-term effects of the program more analysis needs to be done, qualitative and quantitative analysis will be performed in future research to better understand learning processes and perceptual changes in the students. Makers in Residence is a viable way program to show the possible outcomes of the FabLab@School experience and can serve as an inspirational platform for organizations and institutions to find the motivations need to commit to more permanent implementation of the experience.

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Video Information

https://www.youtube.com/watch?v=kQayN86RVB0

https://www.youtube.com/watch?v=dT3MBSh6vNg

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