Think Out of the Class, the Makerspace is Open

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ABSTRACT
Plan Ceibal carries out part of large-scale public policies regarding innovation, technology and education. One of our greatest challenges is to frame new strategies in the national ecosystem that allow us to rethink education practises, where new tools, new materials, new technologies and new skills are permanent invitations to the game proposed by the makers, inveterate enthusiasts who play with technology to learn from it. This paper shows our experience in Uruguay of implementing 20 makerspaces (or ceilabs as we call them) in different schools and contexts and the impact of this new educational space in daily activities by introducing maker culture aspects in everyday teaching practises. Thinking about learning by doing has resulted in a good strategy to promote exploration as a vehicle for discovery learning, as well as to allow the development of some of the cognitive, intrapersonal and interpersonal competencies, thus fostering the social construction of knowledge driven for creativity and the generation of innovative solutions facing the growing social and environmental challenges. In particular, we want to highlight the case of the School 339, where the proposal has flourished with very positive results in terms of meaningful learning for all partakers, either students, teachers, experts or policy makers.

Keywords
Maker Education; Makerspaces; Problem Based Learning; Computational Thinking

1. DESCRIPTION

1.1 Plan Ceibal: an Inclusive and Innovative Public Policy
In 2007, the Uruguayan Government creates Plan Ceibal, an equity and social inclusion plan with the aim of supporting educational policies with technology. From its creation to date, this public policy that connects inclusion and innovation, ensures that students and teachers of all socioeconomic origins, regardless of their geographical location, have access to digital devices, high quality content and connectivity nationwide, achieving the symmetrical and gradual incorporation of the population in the digital society.

Since its genesis, this multi-stakeholder public policy has worked closely with the National Administration of Public Education (ANEP) in the implementation of different proposals that can be used by teachers in their classes with the aim of providing resources and platforms that improve the experiences of meaningful learning in the classroom. The latter does not necessarily imply that the national curriculum has been changed but promotes higher levels of autonomy among educators, ensuring that technology is at the service of education (not the other way around). Without a doubt, it has been a collaborative construction path, where the technological infrastructure has played a key role in fulfilling the objective of providing a solid technological-educational solution that responds with solvency to current educational demands.

In more than 10 years of existence, Plan Ceibal offers a national ecosystem of pedagogical innovations that transcend the distribution of technology and connectivity, projecting in multiple landscapes where the New Pedagogies of Deep Learning as well as the conceptual development of Computational Thinking have promoted the implementation of different educational programs based on new ways of learning, teaching and assessment.

In this sense, in 2017, the possibility of developing the concept of "makerspace" as a program to be implemented in the public education system arises, within the framework of a constructivist-constructionist didactic proposal based on learning by doing, where the student is the center of the pedagogical strategy that challenges the promotion of learning by building knowledge while developing critical thinking by solving problems in a flexible, playful, vibrant physical space, equipped with tools, materials and technologies to do almost everything imaginable, where teachers and students explore the invention and fabrication mediated by design processes that allow them to face the challenge of solving complex problems.

1.2 The Classroom as a Lab
Proof de Concept
The starting point to develop the concept of "makerspace" within the educational system required, in the first instance, the design of a proof of concept where the definition of the general objective was to intervene physical spaces in the public education buildings, in both levels, primary and secondary, to implement a new space provided with equipment, technologies and qualified facilitating teachers, necessary to promote the development of imaginative, innovative and autonomous students, technologically literate, motivated by their curiosity in the

creative approach to solving problems, promoting exploration as a vehicle for learn by discovery, enhancing the interest in the STEAM disciplines as well as the strengthening of cognitive abilities and the development of critical thinking.

The proof of concept, which lasted three months, progressed from September to November 2017. Before the beginning, two public schools were selected, one from primary and the other from secondary where proactive teachers were convened and worked together with the experts team in the co-design of the class sessions to be implemented. The target public at the primary education level were 5th and 6th grade students (10-12 years old) while at the secondary educational level they were asked to do it with 1st grade students (12-13 years old).

Pilot Phase

From the encouraging results of the proof of concept carried out in 2017, we move on to the pilot phase in progress in 2018 that integrates 20 makerspaces distributed in five primary schools and fifteen secondary schools. At the start, the target audience remains on the proof of concept proposal but other age groups are added. In almost all cases, the proposal is curricular, addressed to all students belonging to the selected groups.

The biggest challenge that the pilot phase raised was teacher training to work in accordance with this methodology that requires detailed planning of the sessions in which the practices that will be carried out in the makerspace must make sense when designing learning processes that allow facing the real problems addressed in educational centers. It must be remembered that these proposals are open and available for those teachers who wish to integrate them but who are not part of the official curriculum. Another aspect, no less important, was the lack of physical spaces in the educational centers to adapt to such purposes.

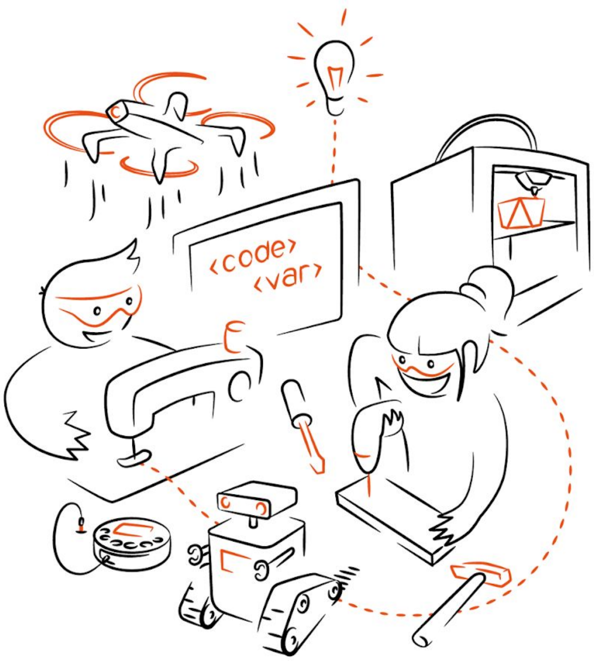

Figure 1 - We imagine

Figure 2 - We live

Study Case: School 339

The School 339, in Montevideo, belongs to the Uruguayan public primary education system. It is a medium urban school, located in a neighborhood of working families. It is composed of 378 students from 6 to 12 years old, distributed in 14 classes from 1st to 6th grade. The teachers team, formed by the director, the secretary, 14 classroom teachers and two special teachers (English and Gym), manifests a strong sense of belonging to the institution and a great knowledge of the socio-cultural and educational characteristics of the students since several of them live in the area or in close neighborhoods and have a long career as teachers. The school had as technological equipment some robotics and STEM kits delivered over the years by Plan Ceibal as well as each teacher and student had a laptop or tablet. It should be noted that to encourage the use of these resources, the ANEP incorporates a Facilitator, a teacher who favors the integration of technologies with pedagogical sense.

In this school the proof of concept begins in September 2017 in which 108 students participate in two classes of 5th and two classes of 6th, with an average of 27 students per class. Although teachers and students present different levels of appropriation in the use of technologies, they had not had previous experiences with the maker education, reason why, prior to the beginning of the activities, different instances are carried out among the teachers in charge of the groups, the facilitator teacher and the team of experts to understand the work methodology and co-design the sessions that involve the projects to be developed. Topics are defined by classroom teachers in accordance with the interests of students and curriculum content are shown in Table 1.

Table 1- Proof of Concepts Projects by Grade

Grade	Problem and possible solution
5th A	Identifies difficulties to plant the lettuce seeds in a unitary way in the vegetable garden so they need to fabricate a device to separate them.
5th B	Is interested in learning about electric circuits through the creation of musical instruments.
6th A and 6th B	Address the issue of thermal energy through the construction of solar ovens.

The projects addressed require the arrival of new technological resources: laptops, tablets, Makey Makey boards and a variety of concrete material (cardboard, foam plast, disposable cups, cutters, paper tape, aluminum, cardboard, straws, among others). The educational center did not have a physical space to set the "makerspace", therefore in each session, the classrooms were converted for one hour into a crazy lab of ideas and experimentation.

The projects follow a similar logic: a real problem is identified and previous ideas are exchanged, later design and prototyping activities are carried out with concrete material, socializing the primary results of the fabrication prototypes, which enables the reformulation of the initial constructions to integrate the new ideas. The same problem is solved through a variety of solutions that are being built from one session to the next. The passage from the 2D to 3D representation, from the plane to the volume, from the drawing on paper to the construction in cardboard usually leads the students to make multiple modifications in their prototypes, which is lived naturally, seeking to discover the best way to concrete your ideas. The technologies are integrated at different times, according to the needs of each project. In some cases in the first sessions, to encourage experimentation, while in others it makes sense to use it only halfway through the process, when they need to automate mechanisms. Programming in Scratch, robotics with Fischer kits, use of physical-chemical sensors to measure temperature, creations with Makey Makey boards, are part of the digital resources that alternate or coexist with the use of concrete material.

Collaborative work is fundamental in the development of projects. The students organize in teams of up to six members, which are maintained from session to session. However, this does not prevent children from one group from collaborating with another group if necessary. Adults also work in a collaborative way: the facilitator teacher guides the proposal, accompanied by an expert who works with her, and the classroom teacher learns from both, thus appropriating gradually the methodology and technological knowledge. Each time the proposal requires it, the teacher integrates her pedagogical and disciplinary knowledge to enrich the approach of the curriculum contents. Thus, a true synergy is generated among all the participants.

In 2018, the pilot phase begins, with an annual duration. Again the 5th and 6th grades participate, in 5th grade a new generation is introduced for the first time into the work methodology while 6th grade students go through their second year working in the classroom as a "makerspace". The triad: expert - facilitator - classroom teacher becomes a pedagogical pair. The experts maintain their support, reducing the instances in which they attend the school in order to promote greater autonomy in the teaching team. New projects linked to sustainable development objectives emerge, as shown in Table 2.

Table 2 - Pilot Phase Projects by Grade

Grade	Problem and possible solution
5th A and 5th B	Explore the operation of the school's drain system and identify the need to fabricate devices to collect, filter and store rainwater to water the vegetable garden.
6th A and 6th B	Study the possibility of using biomass as a source of renewable energy. They create automated containers to accumulate organic waste and biodigesters to process.

The identified problems require the integration of new resources; drones and GoGo boards are added and the concrete material is renewed. Once again, problem solving is promoted from the collaborative development of innovative solutions. Through the different sessions, the work teams explore the environment, design and build prototypes integrating waste materials and technology, exchange ideas and make modifications.

2. CONCLUSION

2.1 Results

Both in the study case we described above and in the other schools that formed part of the proof of concept and the pilot phase, tools and materials for daily use were combined with digital resources, favoring the creative appropriation of technologies. In the process, different access points to knowledge were proposed. Sometimes from art, sometimes from maths, sometimes from science, sometimes from technology; each student was discovering their strengths and, from there, they positioned themselves in an active role, according to their rhythm and learning style, which positively impacted their motivation to get involved in solving different problems. The fabrication of concrete prototypes, personally significant, allowed the students to visualize themselves as makers and not merely as consumers of existing products.

Those students who participated in the proof of concept in 2017, evidenced in the pilot phase in 2018:

- Managing new vocabulary as well as improvement of their oral fluency and evaluate arguments.
- Tendency to work collaboratively spontaneously, supporting each other to solve challenges.
- Natural integration of the design and prototyping instances generating creative products.
- Perseverance to specify their ideas and make the necessary changes, without frustration.
- Great interest in generating positive actions in social and environmental sustainability.

Communication, collaboration, creativity, character, critical thinking and citizenship were key competences developed during the experience in accordance with the Uruguayan educational policies[1]. As educators, we must return to the roots of learning, which are usually present in the first years of schooling, but then become blurred as the educational areas are formalized, such as the regeneration of instances that involve the exploration and manipulation of different materials, fostering the students curiosity and their creativity through various projects and mainly, without forgetting the importance of enjoying the processes, of having fun while they learn.

2.2 Broader Value

In these new learning scenarios we need to think outside the traditional formats of education, it is necessary to remake the paths learned to teach. Gary Stager (2013) advises us "Less Us, More Them!"[2], that does not exempt teachers from the teaching process nor does it minimize their expertise in these learning environments. which is based on a model centered on the student, active protagonist and responsible for new meaningful learning.

This method of exploration through the interaction of ideas with concrete materials of daily use in a spontaneous and unexpected way promotes the construction of concrete prototypes. There are no expected results, there are no instructions to follow, which is why production is highly diverse. The action of doing is closely linked to the action of failing, of making mistakes. This is a space where error is the protagonist, everything that is designed and constructed is tested and if it does not work it is improved by allowing the prototype to iterate until it solves the initial hypothesis of work. This leads to losing the fear of being wrong, to see it as a natural result in front of an action and find improvement. Students accept the challenge and offer very creative solutions when they are asked to think through complex problems in a cyclical way. The objective here would be for them to be able to develop all the skills involved in these operations. The spaces for reflection included in the work sessions become indispensable when it comes to analyzing and socializing the different solutions reached in relation to the same problem.

The planning of the work sessions to guide these creative processes is the core because it allows the facilitator teacher to dose the teaching-learning instances in such a way that the students are the true makers within the makerspace. If the process is based on these premises and the times are adequate to allow cognitive developments we will be facing autonomous students, with high self-esteem, able to respond to the new challenges of improvement that complex problems manifest.

In the present perspective it is essential to work from these spaces to transform the educational scenarios where students build the knowledge that will allow them to successfully insert themselves in the society of the future, where the emerging knowledge involved in their current formation will become powerful tools in the face of new cognitive challenges.

3. BIOS

Karina Pintos is an architect completely passionate about design, art, inventions and technologies. She has been working for Plan Ceibal for 10 years, first in the 3D Modeling and Printing Department and currently as Project Coordinator of the **ceilab Program**. Pintos shares her passion with the teams of teachers she trains based on the premise that learning by doing and making mistakes through the process are endless sources of meaningful learning.

Elisa Cristi is a kindergarten and elementary school teacher, with a postgraduate degree in Learning Disabilities. She has been working in ANEP public schools for 14 years. Since the beginning of her career, she has researched how to integrate technology into her classroom practices with pedagogical sense. Since 2017, Cristi has been developing the ceilab Program at school 339, teaching other teachers and elementary students to work at a makerspace and explore how to use technology in creative ways.

4. REFERENCES

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