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CSF Dream Academy: Using Fiction, Cardboard and Simple Electrical Circuits as Educational Tools to Lift Disadvantaged Children Out of the Poverty Trap

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Abstract. In this paper we propose a strategy for educational inclusion aimed at supporting marginalized children, using a model proposed by the Creative Science Foundation, based on the development of a science fiction micro stories and low cost physical paper/cardboard prototypes. This strategy has been successfully tested with Mexican children aged between 8 and 15, motivating them to develop their STEAM (Science, Technology, Engineering, Arts, Mathematics) skills. Additionally, it allows the development of social skills, such as teamwork, tolerance, respect, etc. This paper describes the model used and reports on its first deployment in a community centre in the outskirts of Leon Guanajuato México, demonstrating it has the power to attract and motivate such children to engage with STEAM studies which is an essential step on their road to a brighter future for them and their families. In support of the work the paper includes numerous examples of the children's work.

Keywords: Education, inclusion, motivation, aspiration, poverty, disadvantaged children, innovation, creativity, science fiction, prototyping.

1 Introduction

Innovation, creativity and entrepreneurship have become extremely important topics in recent years, driving the success of companies and individuals alike. Thus, it's not surprising to find there is increasing demand for learning such skills. Various tools exist in the market focused on helping children develop their creative skills. However, for children in poverty, the cost of these tools is often beyond their reach, causing them to fall behind their richer contemporaries, thereby making it difficult for them to escape the poverty trap. Thus supporting the educational needs of such children is a critical element of improving their live prospects

Universities already play an important role in addressing inclusion issues relating to disadvantaged communities, such as providing access to digital technology and networks. Moreover, major efforts have been made where a University adopts a community, offering various supports, such as psycho-pedagogical support for children, delivery of education, and promotion of family and social values [1].

Despite all these efforts, the results are still not acceptable. In the case of Mexico, 55% of 15-year-old Mexican students fail to reach basic proficiency levels in math; 41% of 15-year-old Mexican students fail to reach basic proficiency levels in reading. Only 1% of 15-year-old Mexican students achieve the highest levels of proficiency in mathematics; only 0.5% of 15-year-old Mexican students achieve the highest proficiency levels in reading [2][3][4].

Science, Technology, Engineering and Mathematics (STEM) are a set of disciplines that are especially important to national economies and a child's future job prospects [5][6]. Innovation and creative thinking are key factors in enabling individuals and organisation to positively differentiate themselves from their competitors leading to a desire to include Arts (a discipline frequently associated with creativity) within this educational package, transforming STEM into STEAM (Science, Technology, Engineering, Arts and Mathematics [7].

There have been several initiatives that seek to supplement the efforts of educators and government in countering the drift away from sciences which has been observed in upper secondary education [8]. These initiatives have sought to encourage the use of technology within classrooms as well as introducing computational theory through enabling the use of simplified programming languages such as Scratch, Alice, Greenfoot (based on Java). These initiatives have achieved good results, opening up cutting edge technologies, such as robotics, to a young audience [9].

Although some packages such as Lego Mindstorms (a robotic themed kit) may be relatively expensive, they have been used to good effect with elementary school children using simple languages (eg Scratch) developed especially for children and people unfamiliar with technology [10]. These approaches have even been successfully deployed with children with dyslexia [11] or with autism [12].

Beyond the underlying science, certain applications, such as Robotics, have played an important role in motivating and attracting children and young people to science and technology. However in many cases such applications require a strong investment or sponsorship from those with a philanthropic mindset [13]. Academies and organizations that aim to support young people and children in disadvantaged conditions play a fundamental role in helping create a fairer educational landscape based on equality of opportunity plus contributing to the supply of the next generation of scientists in the world [14]. Technology facilitates the transfer of knowledge, even independently of the tutor; once the children's interest is captured by harnessing their creativity and imagination, children can achieve meaningful learning [15].

Innovation and creativity has had a significant impact on both academic and business success. The latter is of great importance since it can help persuade businesses that it is in their interest to support these initiatives. In Mexico, this has had an impact on the Entrepreneurial culture, as well as the creation and certification of many educational entrepreneurship models. In addition, several local governments, private or federal initiatives have been born and have been reinforced during the last years, including *Punto México Conectado* [16], networks of *Technology Parks* [17], and business incubators [18][19][20][16]. In Mexico, a number of programs have been developed to attract young scientific talent at undergraduate and postgraduate level [21] [22] [23] [24] [25] [26], in addition to some focused on business [27]. However, few initiatives have focused on creating an aspirational model for children, and even less, those in conditions of marginalization. This article makes a proposal based on the Science Fiction Prototyping innovation model, originally developed by INTEL, that allows children from marginalized or disadvantaged communities to aspire to develop innovative technology and processes that improve their social mobility.

The federal government of Mexico has also been pushing initiatives aimed at the democratization of science technology and innovation. For example, the Punto México Conectado program [16] is a network of 32 digital education and training centres, which facilitate training courses, creativity development and support to undertake innovation projects and generation of new companies. Some regions have launched initiatives aimed at promoting scientific and technological vocations, where children and young participants are selected to participate in visits to universities and research centres, development of collaborative projects under the guidance of a research professor.

To create a fairer system that works for the benefit of the society as a whole there needs to be more attention paid to marginalized communities but, as it stands, there are no models for resource-poor children focused on provision of innovation skills or affordable low-cost prototyping strategies.

2 Science Fiction Prototyping

Science Fiction Prototyping (SFP) was developed by Brian David Johnson, who at that time was a futurist at INTEL, working on the challenges the company faced in having to anticipate the needs of integrated circuits for a market that was some 7 to 10 years into the future (the typical design and production period for a modern computer processor integrated circuit) [28][29]. SFP's core methodology is the use of creative arts (eg creative writing, drawings, film making etc) as a means to introduce innovations into science, engineering, business and sociopolitical systems [30]. It differs to foresight activities as it doesn't aim to be predictive (forecasting the future), rather it focuses on innovation (creating new concepts, schemes, services and products). The main (but not exclusive) methodology is the use of science-fiction/fantasy stories, grounded in existing practice which are written for the explicit purpose of acting as prototypes for people to explore a wide variety of futures. These 'prototypes' (commonly called *Science Fiction Prototypes*[1]), can be created by

[1] https://en.wikipedia.org/wiki/Science_fiction_prototyping

students, scientists, engineers, business or sociopolitical professionals to stretch their work or, for example, by school children and members of the public to influence the work of professionals. In this way these stories act as a way of involving the widest section of the population to help set the research agenda and thereby empowering everyone to have a hand in shaping the future. Related methodologies include *Design Fiction* [31] (the use of narrative scenarios to explore design related issues) and *Diegetic Innovation Templating* (getting inspiration for innovations from pre-existing fiction written for the purpose of entertainment) [32]. These methodologies have been applied successfully not only in engineering, but also in English language teaching [33] and the development of new products in the industry [34].

In *Dream Mexico,* we use a variant of Science Fiction prototyping (SFP) called ***µSFP*** *(Micro-SFP)* [35][36]. This uses a genre of writing called Micro-Fiction that aims to write ultra-short stories as small as just 6 words but more commonly 140 and 160 characters (30 words) which fit into a Twitter and SMS phone message. The general structure of these stories is as follows:

[Person] in [Situation] uses [Innovation] to do [Action] resulting in [Benefit]

An example of a *µSFP* is: *Jack fall asleep in the sun. His* ***smart sun protection sensor*** *woke him up with an alarm & soft vibration. He avoids sun strokes!* [37]

The writing procedure is to 1) start by identifying an innovation (technology, service etc), 2) Identify a user (use a very short name eg Joe) and finally 3) create an event that illustrates the use and benefit of the technology, process or service (should include an inflection point). The general rule is to start big, then reduce it to the required size. It is also possible to use drawings with, or in place of, narrative. The role of a ***µSFP*** is to capture the idea (as a type of innovation shorthand) which can then be expanded into a larger narrative (eg a mini-fiction) or a more elaborate drawing, film or paper/cardboard prototype.

3 Dream México

As we have discussed above, it is necessary to incorporate additional strategies that contribute to a student's social development, particularly to children of limited resources. The main objective of the *Dream Mexico* initiative is to provide an option for children and young people in socially disadvantaged environments (economic, cultural, etc.), to empower them with STEAM skill and to capture their interest and, through use of Science Fiction Prototyping, to become motivated to engage with education (especially STEAM) and thereby improve prospects for their life.

Thus, the Dream Mexico initiative focuses on children from poor suburban or rural communities, who generally do not have access to complementary activities (art, culture, innovation, science workshops, etc.). Thus the design of the activities is predicated on the availability of ultra-low budgets, reusing materials, and utilising digital resources in an open way, wherever possible.

3.1 Methodology

The methodology is based on the creation of both narrative and physical prototypes inspired from near-term science fiction stories that capture and spoof product ideas they have for their lives, in a way that enables them to develop various skills such as innovation, teamwork, prototyping, tolerance, respect, etc.

Each session of the workshops has the following phases (see Fig. 1):

1. *Introduction*: basic elements of science and/or technology are explained briefly and simply.
2. Guided practice: Participants are guided by a facilitator to apply what was introduced in phase 1.
3. ***µSFP histories***: children imagine products and processes they would like to be available in the future for their communities, describing it be creating a short story and / or drawing (***µ***SFP is introduced as an implicit aspect of story-writing).
4. *Making*: Children build a prototype using cheap reusable material (eg cardboard), which can be customized (colours, functionality, innovation, etc.) according to their **µSFP**.
5. *Presentation*: The children present their prototype and explain its main characteristics and benefits.

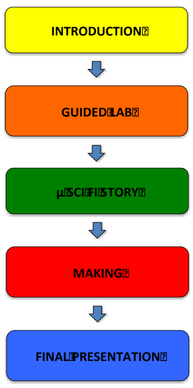

Fig. 1. The methodology used during the workshops consist of 5 steps. Each step requires the active participation of the students

4 Preliminary Results

The Dream Mexico Academy has been operating successfully in León Guanajuato, since 2016. It has attracted children and young people between 8 and 15 years of both sexes, who have participated actively in the workshops. The feedback received has been extremely satisfactory, and the topic and methodology has proven able to motivate them to develop low-cost prototypes with basic technology (cardboard chassis and simple electrical wiring). So far different themes (called detonators in SFP jargon) have been used for the workshops, including "*the house of the future*", "*robots and my family*", "*special orchestra*", "*space travel*" and "*robotic hands*". Figure 2 presents a collage of the student drawings (as part of a preliminary prototype) showing the children's interaction with their robot.

Fig. 2. The participants build their portfolio with a first prototype, in this case a drawing of themselves interacting with their robots.

From observations of the children it is clear that, being able to get involved in a workshop that creates a product from their own hands, students have a sense of empowerment. The physical prototypes are very simple, being just paper/cardboard bodies augmented with simple electronics involving elementary skills such as trimming, drawing, colouring, screwing etc. The children are generally very proud of what they have achieved and the low costs involved, allows them keep it their home to show their family and friends (see Figure 3).

Fig. 3. Participants of Dream Mexico Academy with their cardboard prototypes and basic technology.

Figure 4 is a drawing where participants have shown how they visualize their home in the future (when they become adults). In this case, the use of alternative energies was emphasized, encouraging savings and reducing pollution.

Fig. 4. *Participants are invited to detail as much as possible their drawings, in this case with the theme The House of the Future*

Figures 5 and 6 show participants working on the inclusion of LEDs in their cardboard robots. While the science is relatively simple it generates a lot of enthusiasm in the participants, as well as introducing them to the fundamentals of electrical science (circuit theory).

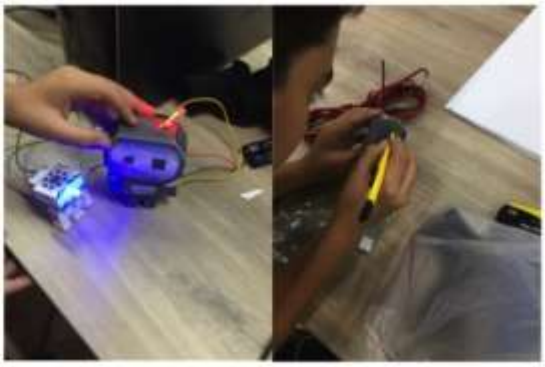

Fig. 5. *Participating children and youngsters enriching their cardboard prototypes with low cost basic technology, in this case a simple circuit with an LED and AA batteries.*

Fig. 6. *The inclusion of LEDs in their robots generated a lot of enthusiasm in the participants.*

Figure 7 shows the children constructing a robotic hand from low cost materials.

One of the characteristics of this methodology is that it fosters collaborative work among the participants, favouring the development of tolerance, respect, listening skills, etc. In Figure 8 the participants develop a science fiction story with the theme '*The House of the Future*':

"It will be a 3 story orange home, with four bedrooms; clapping 2 times the music and lights are turned on; the chimney is turned on; the house has six toilette, and when you go to the toilette it flushes automatically; the windows will be connected in such a way they can show the images you want; with a swimming pool and a Jacuzzi; everything is bullet-proof; the door bell recognizes your footprint and let you in; it has an automatic crystal lift".

Fig. 7. *One of the prototypes developed was a robotic hand, using paper, straws, tape and rope.*

Fecha: ________ Escuela: ________________

Integrantes del Equipo

1. Karina Vega Hinojosa
2. Christian Gerardo Vega Muñoz
3. [illegible]
4. [illegible]

Describe brevemente como será tu casa en el 2050

Sera una casa de tres pisos color naranja con 4 cuartos que con tan solo dos aplausos las luces y la musica se encienden; [illegible] un timbre que reconozca tu huella y sepa que eres la dueña de la casa y se abra la puerta. Con un [illegible] cristal automatico.

En la hoja adicional que se te entregará realiza un dibujo de la casa en el 2050

Fig. 8. *Example of a* ***μSFP*** *where the participants visualize the house where they will live in the future.*

4.1 Feedback and perception of the participants

During the term January-May 2017, 13 sessions were scheduled. Six kids where enrolled during this period (although some of them enrolled late). Two students participated 100% of the sessions. The details are shown on Table 1.

Table 1. Assistance Report during the term January-May 2017

Student No.	% Of Assistance
x_1	*100*
x_2	*100*
x_3	*30.77*
x_4	*69.23*
x_5	*46.15*
x_6	*53.84*

During the first 4 sessions only two students attended the workshop; however from session 5 onwards the group stabilized around 5 participants. The details are shown on Fig. 9.

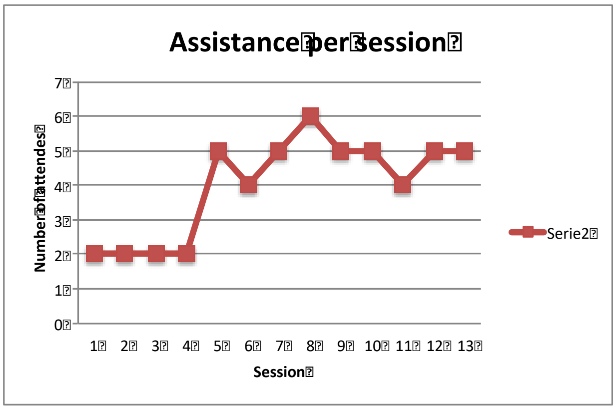

Fig. 9. From January to May 2017, thirteen workshop sessions (1 per week) were scheduled. During the first sessions 2 kids attended the sessions; at the beginning of the second month 3 more students joined the workshops, reaching a maximum of 6 students on the 8th session.

In order to obtain information and feedback from the participants, short interviews were performed focusing on 4 axes: a) perception of the work (before and after the course), b) learning, c) enjoyment and d) motivation and engagement.

a) Perception of the workshop

Question: ***Before the beginning of the workshops, what did you think about the advertised activities?***

- *"I thought they were going to be fun"*
- *"I was really scared, and I didn´t want to come. I thought I was going to be told off by the teacher; now I am very happy as I am learning many things about the space, robots, but sometimes building things is not easy for me."*
- *"I was sure the sessions were going to be fun; I love robots and I like the workshops."*
- *"I was very excited, as I was sure the workshops were going to be Ok"*

Teacher observation: during the first session the participants were very quiet, and a little bit nervous. Some of the kids were escorted to the classroom by their mothers.

Question: Having attended the workshops **What do you think about them?**

- *"I really enjoy the workshops, especially because I like to build prototypes."*
- *"I like the challenges (building prototypes)."*
- *"I like to build things using recycled materia*ls."

Teacher observation: Children taking part of the workshops enjoy active participation, specially building things, using different materials, and sharing tools (scissors, rules, etc). Long lectures can be boring for them (which is very understandable).

b) Learning

Question: ***What have you learned from the workshops?***

- *"I have learned about robots and basic electronics."*
- *"I have learned about robots, LEDs, which are small bulbs. "*
- *"I have learned about the space, robots, electronic circuits (LEDs and batteries)"*

Teacher observation: Children taking part of the workshops learned different topics including space, electric energy, robots, circuits. They show more interest when the topic is linked to a task or problem they could solve using the knowledge acquired.

c) Enjoyment

Question: ***Have you enjoyed the workshops?***

- *"Yes, for many reasons. I like building things."*
- *"Yes, because I like robots."*
- *"Yes, because I like to build robots, and put them LEDs."*
- *"Yes, I like the classes very much."*

Teacher observation: The participants enjoyed the workshops very much; they seem surprised when the sessions were finishing as they were in "flow state". Some of the kids that during the first sessions were shy or nervous gained confidence in a couple of weeks.

d) Motivation and engagement

Question: ***Would you like to continue learning things about science?***

- *"Yes, because I would like to become a football player and doctor."*
- *"Yes, because I want to be a mechanical engineer and build and design cars."*
- *"Yes, as I want to become a builder as my father, and build and design a house for my family."*

Teacher observation: the participants are willing to continue with this workshop (they even want to have sessions during bank holidays). Kids have different building skills; however they ask for help and support when they struggle with specific tasks. They visualize themselves in the future using science and technology as part of their activities, and supporting their family using the skills gained.

Discussion of results

With only 6 students we have a very small sample. Statistics would not be meaningful with such a small group so, instead, we chose to give you the opinions of the students in their own words. From these words it can be seen that the students and the teachers focus is slightly different. The children are focused on, and excited by the activities (eg building robots), whereas the teachers have a much broader view, taking into account the acquisition of social skills and increasing the students aspiration for science. Clearly, this work is only in its early stages and more data will be required to come to more meaningful conclusions but we hope that this initial trial, while only having six students and one teacher will, nevertheless, act as encouragement sustaining and growing this project so that more evidence can be acquired regarding its performance and the methodology itself may be refined and improved. Perhaps readers of this paper might be motivated to deploy these ideas in other regions of the world, enriching our data while helping the numerous educationally disadvantage children of this world, and thereby helping their families and countries; if you are reading this paper and would like to deploy our methods, please contact the corresponding author, Victor Zamudio.

5 Conclusions and Future work

The paper describes a low-cost methodology aimed at connecting with children's imagination in order to motivate their interest in science, technology and innovation. It has a special focus on educationally marginalized children and youth, emphasising the importance of low cost material and basic technology. This project and methodology been developed in partnership with the Creative Science Foundation as an application of its Science Fiction Prototyping tool.

Using this approach Dream México Academy has offered a series of workshops for socially disadvantage children in León Guanajuato, Mexico, since 2016. In its first trial deployment, it has attracted 6 children between 8 and 15 years of both sexes, who have participated enthusiastically in the workshops. The data collected, while limited, is encouraging since it shows that the children have not only built and reflected on science and technology, but enjoyed the process, fostering an atmosphere of camaraderie and a safe place where to making mistakes is part of learning. We are inviting kids from a primary school in the area to increase the number of participants in the workshops. The student positive feedback seems to support our belief that SFP and low-cost cardboard prototyping has the ability to motivate children's interests in STEM topics but, clearly, this is only a small preliminary trial and so our next step is to expand this so as to acquire more convincing data and further hone our methods. To this ends, and as part of our plans for the future, during the summer of 2017, it is planned to use this methodology in an itinerant way. Two small communities in the northwest of Mexico have been chosen: *Teacapán* in the State of Sinaloa and *Nombre de Dios* in the State of Durango. Teacapán[2] is a small fishing village in the municipality of Escuinapa, with around 4 000 inhabitants, with a significant amount of indigenous population living in the town. Nombre de Dios[3] is in the state of Durango, and has a population of a little more than 5,000 inhabitants. We intend to apply our methodology in both locations, taking advantage of the fact that the children are on vacation during the months of July and August. One of the challenges is the lack of infrastructure (as we do not count with community centres); however we will intent to contact local churches in order to run the workshops in their premises. The objective will be to continue validating the methodology proposed previously in marginalized kids and youngsters in a less controlled environment compared to what has been currently implemented.

We hope in the future to be able to have access to funds and to make this project sustainable, and to allow us to share the material used with the academic community (teachers, institutions, students doing social service, community centres, etc.) who might be interested in using this methodology for the benefit of children and young people.

[2] https://goo.gl/maps/F3qidbHDd2t
[3] https://goo.gl/maps/An51V3mtZPs

This initiative is at an early stage, and we look forward to continuing to report our progress in future publications.

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