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A coding lab to increase science capital of school dropout teenagers

Simona Cerrato, Francesca Rizzato, Lucia Tealdi and Elena Canel

Abstract

We explored the potential of science to facilitate social inclusion with teenagers who had interrupted their studies before the terms set for compulsory education. The project was carried out from 2014 to 2018 within SISSA (International School for Advanced Studies), a scientific and higher education institution in physics, mathematics and neurosciences, and was focused on the production of video games using Scratch. The outcomes are encouraging: through active engagement, the participants have succeeded in completing complex projects, taking responsibilities and interacting with people outside their usual entourage, within a background in which they have been valued and respected.

Keywords Informal learning; Science education; Social inclusion

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Introduction

A group of young people excluded from the traditional school path and at risk of marginalization has been involved in a coding lab aimed at the production of simple video games. This activity took place in Trieste (Italy) at the international post-graduated university and research centre SISSA (International School for Advanced Studies), specialized in physics, mathematics and neurosciences, within its programme of school visits *SISSA for schools*. The project started in 2014 as a collaboration with the SMAC (San Martino Al Campo) school in Trieste — an alternative school for pupils who have abandoned school before complying with Italian compulsory education laws — and ran until 2018. The SMAC school has a deep understanding of the most disadvantaged part of the city (new immigration, poverty, social exclusion, etc.), and aims at the mitigation of early school leaving, which is a relevant issue in Italy as reported in Cederna and Rebesani [2012], and Iadecola and Salvini [2017].

Despite a commitment to diversity and the adoption of participatory practices, the school visit programme *SISSA for schools* remains for "some" and not "for all": not all schools are able or willing to reach SISSA, and even in the most public occasions (festivals and science fairs in the city centre, etc.) only a certain kind of families participates. Acknowledging an increased awareness of the need to be more open to diversity, also due to our SiS Catalyst[1] experience [SiS Catalyst, 2015], we decided to turn to an audience that we had not been able to reach through the usual channels.

Context: social inclusion and science capital

Science and science related activities, including informal science learning initiatives — even if meant for everybody — are in fact enjoyed by a restricted share of people [Merzagora, Mignan and Rodari, 2015]. This situation does not concern science only, but all dimensions of culture. The *Save the Children* report [Save the Children, 2017] showed dramatic inequalities in terms of life conditions and future expectations for children among different countries and within each country. According to an analysis by the British Department of Culture Media and Sport [Wilson, Gross and Bull, 2017] based on the *Taking Part* survey, only the 8 per cent wealthiest, whitest and most formally educated part of the population makes regular use of Arts Council funded organisations. Also, many of the newest and less traditional forms of communication are even less accessible than the traditional ones to disadvantaged and marginalized publics [Dawson, 2018].

Science and technology embed social, economic, symbolic values and are powerful tools to understand contemporary life and become an active, responsible and world-aware citizen. Moreover, informal learning activities are able to be inspiring, relevant and educational in both affective and cognitive terms. Many studies have been conducted to understand how to tackle social inclusion in science and technology, many projects have been carried out, and a considerable amount of money has been spent [Dawson, 2014, and references therein], however science participation continues to show an uneven pattern. For all these reasons, there is a need of new ideas and positive experiences on how to be more diverse and open to different approaches, cultures, values, styles, and how to ultimately make our institutions and activities more socially equitable.

The SMAC coding project

Starting from 2014, a team of scientists, educators and science communicators planned and organized a series of activities to involve groups of teenagers who had abandoned the traditional educational path, involving them with both coding and direct interaction with science and scientists. The project was carried out at SISSA and, in the school year 2014–2015, it was evaluated through focus groups and interviews with pupils, educators and facilitators (see section 4).

3.1 The participants

The participants were young people signaled by the social services for early school-leaving and integrated in the SMAC school. No further selection was done to include them in the project. These participants can be considered socially disadvantaged, with a very low confidence in science and technology, distrustful of authority, school, adults in general, and higher education. We write these words

[1] SIS-CATALYST: Children as Change Agents for Science in Society, FP7-SCIENCE-IN-SOCIETY-2010-1 Mobilisation and Mutual Learning Actions. The project aimed to identify how children can be change agents in the Science and Society relationship, and from this starting point, to indicate how they can be catalysts in the longer term solutions to the grand challenges faced by society.

with a certain uneasiness, and we share the concerns of Emily Dawson [2014] regarding the language we use in defining our audiences: the identification as “difficult”, “excluded”, “hard to reach”, “at risk of marginalization and deviance” can have strong negative implications — even if used respectfully and carefully — and can be perceived as discriminating and diminishing. Nevertheless, it is important to be aware of a truly existing disadvantage to step in to reduce or mitigate with actions the consequences on people’s lives. One of the aims of the SMAC coding project was to increase the science capital [as defined by Archer et al., 2013; Archer et al., 2015] of the participants, giving them opportunities to acquire new knowledge, skills, behaviors, practices, attitudes, visions, and to meet “science people”.

Table 1 summarizes the numbers of participants and workshops in each school year.

Table 1. Participants and sessions of the coding project in each school year.

School year	Pupils in the SMAC school	Pupils in the training	Age	Sessions
2014–15	13	6	12–15	3 workshops + CoderDojo event for children
2015–16	13	13	12–16	two series of 4 workshops (4 for all + 4 on voluntary basis) + CoderDojo event for teachers (all)
2016–17	12	12	12–16	two parallel series of 3 workshops
2017–18	/	6	15–19	4 training sessions dedicated to cognitive empowerment and public speaking for some of the former participants

3.2 *The making*

The SMAC coding project was conceived by two of the authors (Rizzato and Tealdi), who at that time were PhD students at SISSA and volunteers for the programme *SISSA for schools*. Both of them had been math volunteer teachers at the SMAC school and had experienced a sense of powerlessness in front of the students’ refusal to deal with formal math classes, books, exercises, numbers, formulas. Thus, the idea of a coding project centered on video games was born: coding allows to present many mathematical and logical subjects in a less formal and traditional framework, while video games, loved by many participants and not associated to school or adults, could be a Trojan horse to catch the participants attention.

Why SISSA. The natural environment where to deliver such workshops had also to be different from their school environment. SISSA, the research centre where Rizzato and Tealdi were doing their PhD, could provide the logistic support (rooms and computers), but, above all, it differs the most from the kind of schools that the participants had experienced before. PhD students in SISSA, coming from many different countries, choose to continue their studies even after a university degree, and in any corner one can find people quietly talking about science while having lunch, having a walk or playing table tennis.

Why coding. The project was designed after a series of meetings with the SMAC educators and pupils. Coding was chosen because of its many advantages. First of all, coding develops logical and critical thinking, it is fun, flexible and applicable in many different situations, can reveal unexpected capabilities and involves teamwork [Papert, 1980; Papert, 1993; Resnick, 1997]. When the project started in 2014, coding was completely new in Italian educational curricula: this was a big opportunity for us to propose an activity that had nothing to do with traditional schools and standard curricula, which did not enjoy a great consideration among the SMAC pupils. In addition, video games are much connected to fun and are strongly related to smartphones, tablet and the likes, which they deem important and are very present in their daily life. Moreover, this kind of knowledge could be used as an exchange currency in the social bargaining with their most fortunate peers ("I know something that you haven't even heard of"). Finally, coding could be a natural way to introduce concepts in mathematics without them realizing it, as programming necessarily implies the use of mathematics and logic.

We chose to work with Scratch — the free programming language developed by MIT to create games, interactive stories, and animations [Resnick et al., 2009]. Scratch has been used in many educational projects around the world with positive results [Moreno-León and Robles, 2016, and reference therein].

Feeling welcomed and comfortable. As pupils were the real protagonists, we first of all created the conditions to *listen* to them [as defined by Welty and Lundy, 2013, Figure 1], choosing a welcoming venue where they felt comfortable, not judged, free to express their views. These views were subsequently included in shaping the specific workshops. The pupils were hosted in the most prestigious room of SISSA reserved for meetings with distinguished guests. The facilitators were open to dialogue, always available for a chat or a tea at the bar. Initially a bit shy and reluctant to be engaged, the pupils got more and more involved and learned to concentrate on their work.

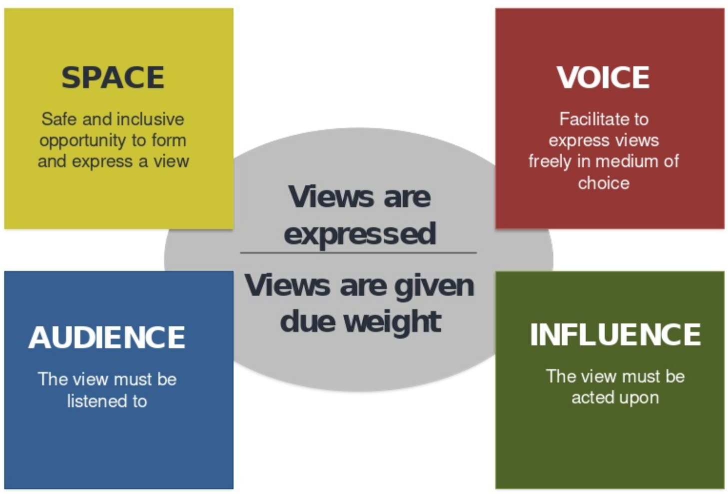

Figure 1. Different aspects required in a listening process [adapted from Welty and Lundy, 2013].

To give the project an official recognition, each participant received a final certificate, a SISSA t-shirt and a leaflet about SISSA as a reward and a symbol of belonging.

3.3 The first edition (2014–15)

After an ice-breaking event at the SMAC school venue, the workshops at SISSA started. Together with the educators, we decided to dedicate the workshops only to the oldest students attending the third and last year of junior high school (6 people).

In the three workshops (15 January, 12 February, 12 March), we initially introduced the software, then the participants started to code their own games helped by the facilitators. At the same time, they became familiar with SISSA, with the scientists working there, and the world of science and higher education in general.

Then, we went a step further asking them to become mentors in a coding workshop organized in collaboration with the local CoderDojo Group [CoderDojo Foundation, 2018] on May 28th, 2015 for 30 children aged 9–10. Five out of six SMAC pupils accepted to be mentors, together with the facilitators, some SISSA PhD students, and CoderDojo experts. They participated in the briefing session before the meeting, and then took care of the children with utmost responsibility, sharing their expertise, helping and encouraging in case of difficulty so that almost no work was left for the other facilitators.

The immediate impression of educators and facilitators was extremely positive: they have completed a complex project, taken responsibility, interacted with people outside their usual circle, in a context in which they have been valued and respected. See sections 4 (*Evaluation of the project*) and 5 (*Results*) for a more formal evaluation and discussion.

3.4 The second edition (2015–16)

We organized two progressive series of 4 workshops at SISSA, which ended up in a CoderDojo training course dedicated to educators and teachers, where SMAC pupils were the mentors. The first four introductory workshops were compulsory for all 13 pupils. The attendance to the second series was on voluntary basis and pupils could choose among this workshop and a deejay course; seven pupils chose our coding workshops, and all the participants were actively involved in the training course for teachers and educators.

In the advanced workshops of this edition we added more complex games and some sessions to program Arduino modules using "Scratch for Arduino" (S4A) [S4A, 2018] to produce working circuits, moving objects, and simple robots.[2] To let pupils define their objectives, we offered them two choices: a set of small and fun games, one per workshop to be completed on daily basis, or a long, complicated project (the design of the famous Snake video game). Contrary to our naïve expectations, they all voted for the long, complicated project.

During the CoderDojo training course for teachers and educators, held at SISSA on April 28th, 2016 for 24 participants, the SMAC pupils took care of the participants with professionality and responsibility. Again, the outcomes were positive. This result is even more amazing if we think that the recipients of the workshop were teachers, the category most feared and hated by the SMAC pupils.

[2] This was possible thanks to the precious collaboration of Ana Maria Florescu, Marco Borelli and Matteo Gamboz.

3.5 *The third edition (2016–17) and follow-ups*

In the year 2016–17, due to organizational changes inside the SMAC school, we were able to organize only three workshops per class. As in the previous editions, the activities took place at SISSA and were appreciated both by the educators and the pupils.

In spring 2018, upon request of the educators of the SMAC school, we organized three sessions of a course in cognitive empowerment,[3] and one in public speaking. Some of the participants were the same pupils who attended the coding project in previous years. These courses had the purpose of empowering pupils — now grown-ups — to cope with different tasks in their everyday life at school or at their workplace.

Evaluation of the project

The analysis presented in this section refers only to the first school year 2014–15, while in following years a formal evaluation was not systematically carried out. Nevertheless, we think it is useful to present it as a partial evaluation of the project.

4.1 *Methods and questions*

The evaluation aimed at reflecting on general issues such as participants' perception of science and technology, familiarity with scientific institutions, and how informal learning projects can foster empowerment. Because of the low number of participants, we chose qualitative methods, that were designed as exploratory, and in particular:

- participant observation during the workshops and the CoderDojo event
- individual face-to-face interviews with the principal of the SMAC school
- focus groups with both classes of the SMAC school: the second-year class who did not participate in the project and the third-year class who participated in the project (no further selection on participants).

Within this general framework, we focused on the following goals:

1. explore and reflect on the meaning that they attach to the term science (as a discipline and as a profession)
2. understand the position that they feel they occupy with respect to this discipline
3. explore and reflect on perceived barriers, if any, in accessing the scientific world
4. understand the impact, if any, of the SMAC coding project on the above issues.

[3] This course was held by Olga Puccioni, former SISSA PhD student in cognitive neuroscience and now science communicator at Sissa Medialab.

We observed the basic rules of ethically responsible research, namely ensuring the confidentiality and anonymity of the parties, leaving the participation on an entirely voluntary basis, and adapting the activities to the response of the pupils.

Participant observation. Participant observation (done by two of the authors, Canel and Cerrato) allowed to come into direct contact with the pupils and to establish with them a human relationship. The principal of the school and the educators were aware of the purpose of the observers, while the pupils were not explicitly told, not to make them feel uncomfortable. The observers actively participated in the activities, working beside the pupils, and got to know them quite closely, witnessing the transformation of their attitude towards the place, the projects and the persons involved.

Interviews. Before the starting of the project, we met the educators and the principal of the SMAC school, asking them to depict the participants individually and to describe their group dynamics. We also met the pupils personally and interacted with them in a meeting at their school to introduce each other.

In addition, one of the authors (Canel) interviewed the scientists who conducted the coding activities (Rizzato and Tealdi) and the principal of the school at the end of the project. In this case, a semi-structured interview type was adopted, based on some questions of particular interest emerged during the workshops.

Focus groups. The focus groups aimed at understanding pupils' perception of science as a discipline, and of the scientist as a professional and as a person. We then tried to understand how they positioned themselves with respect to science and if science was perceived as a possible path for their future.

To assess the impact of the project, we carried out two parallel focus groups: one with the class who participated in the coding project (Class A, 6 pupils) and the other with those who did not participate (Class B, 7 pupils).

Both focus groups started with the creation of a conceptual map of the word "science", followed by three sessions of discussion facilitated by the use of photographs of three different categories: images from the world, science objects and scientists. Photographs, representing real situations and real people, worked as a good starting point for discussion and created a very informal, non-scholastic environment.

4.2 The level of science capital

The preliminary interviews showed that the SMAC pupils belonged to the *low science capital group* as defined by Archer et al. [2015]: they had a very low level of scientific literacy and had no access to science-related cultural and social resources. They did not do science-related activities after school, neither read science books or magazines (actually they did not read at all). They were not confident in their scientific skills and were not considered by others and by themselves a "science person"; actually, they did not like science at school, math was often their most hated subject, and nobody had encouraged them to choose a STEM-related career.

Some of them, who proved to be particularly passionate and gifted, were encouraged (for the first time in their lives) to choose a school specialized in computer science after participating to our coding project. All of them met scientists for the first time at SISSA and even two of us, who were already teachers at the SMAC school, were only considered "scientists" after they saw us at SISSA, among other scientists.

Results

5.1 Level of science capital after the project

We focused on the four dimensions for measuring individual science capital identified by Archer et al. [2015]: knowledge, attitudes, experience and social level.

Knowledge is here meant as the understanding of the utility and broad application of science's topics, qualifications and skills. For the first time in their lives, the participants were introduced to coding and programming, which are essential tools for most of the scientific and technological sectors and have their own disciplinary identity. They got to know a research centre and met some PhD students and researchers, discovering science as a possible career.

Attitudes and experience refer to the ways a young person sees science as relevant to everyday life, and to their behaviors and practices related to science. In this regard, the place and the personal relationship with scientists were two important factors. The place of the meetings contributed to increase the pupils' science capital by acting on the attitudinal and experiential spheres. They discovered a place that had never been part of their lives, populated by "brainy people" that they thought had nothing to do with their way of being and living. They were also able to establish personal relationships with young scientists and to associate faces and images to a place, SISSA, and to the disciplines that are studied there. This enabled to break the stereotypical idea of a scientist as an old crazy guy who works alone in his laboratory [D'Angelo, Rodari and Sgorbissa, 2008]. We observed that in the last meetings and during the CoderDojo events the pupils moved with great familiarity inside SISSA. They were interested in the research topics, laboratories, the daily life of the scientists, the selection mechanisms for accessing SISSA, etc.

From the social level perspective, we looked at the level of scientific knowledge in the family, acquaintance with people involved in science, scientific discussions with friends and family. We observed that the group of pupils who had not taken part in the Coding project had a much more stereotypical and immature idea of a scientist. Indeed, when asked to identify scientists among photos of young adults, this latter group most frequently used the term "crazy" in all its forms, followed by "nerd": they were convinced that to become a scientist one needs to have the "scientist's face", also called "cucumber face", meaning a "crazy and nerd face". On the contrary, the idea of science and scientists of the participants in the coding lab had evolved already after few meetings, making them more curious towards science as a discipline and as a human and social activity.

5.2 Empowerment

In addition to producing an increase in science capital, the coding project contributed to a general empowerment. During the CoderDojo events, the skills acquired during the coding lab became operational. The pupils discovered, with amazement and pleasure, to have learned how to use Scratch above their expectations. Each SMAC pupil was able to deal with his/her own personal difficulties and abilities. Some showed unexpected patience and dedication.

The activity of CoderDojo has therefore helped the pupils acquire confidence in their learning abilities in general, while giving them the opportunity of developing new, unfamiliar skills such as programming. It was a transfer of power and trust from the world of adults to that of pupils, a particularly significant element in the case of this group of youngsters penalized by a strong social stigma.

The impacts on the participants are summarized in Figure 2.

Figure 2. Impact of the coding project on participants.

Discussion

In this section we discuss some positive elements that allowed us to activate energies, skills and relationships and at the same time highlight some critical aspects of the project.

6.1 Enablers

Infrastructure. Infrastructure can be a big barrier, which prevents people from participating in informal learning activities, visiting museums and exhibitions, enjoying theater and music performances. There are many experiences that have tried to overcome this obstacle, one of the most interesting is the *Knowledge rooms* of Vienna [Streicher, Unterleitner and Schulze, 2014], which are small temporary science centres set up in vacant shops of the suburbs of the city, often inhabited by immigrants or by a socially and economically disadvantaged population. They are designed to be open to all, and to become part of the life of the neighborhood. In our case SISSA has opened its doors and facilitated the access to a group of people who normally would have felt uncomfortable within such an environment. This effort was perceived by the SMAC pupils. The facilitators have witnessed the evolution of their attitude: from an initial distrust, which in some cases bordered on hostility, they became open and helpful, very engaged in doing the task and striving to achieve the best results.

What they/we are and what they/we know. From the very beginning, we made every effort to avoid being patronizing. Establishing a relationship of mutual trust was the key point of the entire project.

The SMAC pupils became the owners of the process and were able to develop their self-confidence and their interpersonal skills, to widen their perspectives on a world that was hitherto unknown, and considered distant and intimidating. Great benefits were gained also by the group of facilitators, who, beside the personal gratification, learned how to value and respect diversities, deal with unexpected situations, accept without judging lifestyles and experiences so close geographically, yet so remote.

6.2 Challenges

It is true that the project involved a low number of pupils, and this was due to its intensive and initially experimental character. Of course, it would be desirable that the project could have a wider impact on a larger audience, however the intensive nature allowed us to design and adapt each session (sometimes changing the format on the fly) to the specific needs of the participants, who were considered as a partner to constantly dialogue with.

The presence of people with different backgrounds and roles (educators, scientists, communicators, facilitators) has allowed us to offer a rich and complete experience because each one could deal with a specific dimension, relying on the support of the other professionals. At the same time, the project was highly reliant on some essential and highly motivated people, both from SISSA and the SMAC school, and once they left their position it was not possible to guarantee the continuity that we would have liked instead.

As said before, we do not have the means and the possibility to study the long-term impact on the people involved, except in a sporadic and anecdotal way. There has not been an institutional impact that has produced a profound change in SISSA, with the exception of those directly involved.

Conclusions

The described project has shown that even research institutions, which do not have outreach activities as their first aim, can reach usually neglected audiences. It has introduced a truly inclusive practice within an elite institution, which, although not being influenced in a structural way, has nevertheless been contaminated: even those not directly involved have got in touch with a reality of social exclusion, hopefully triggering a reflection.

In our opinion, the key features that made this coding lab successful are: an environment that valued and respected all participants, and a meaningful choice of the activities proposed made possible by a prior deep knowledge of the target audience and its needs. This prior knowledge was in our case embedded in the SMAC school, and made the project easy to start and carry on with no need of big resources and long preliminary studies.

Moreover, this project has shown once more the huge possibilities of coding labs, especially when associated with fun activities as video games, in the development of logical and critical thinking also with hard to reach audiences.

These activities and the experience as a whole taught us ways to design more inclusive programmes of public engagement. Therefore, we will continue to strive to make science a more inclusive environment and make our institution more open to diversity.

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