EasyChair Preprint

№ 2338

Officina degli Errori: an extended experiment to bring constructionist approaches to public schools in Bologna

Sara Ricciardi, Stefano Rini and Fabrizio Villa

EasyChair preprints are intended for rapid dissemination of research results and are integrated with the rest of EasyChair.

January 8, 2020

Officina degli Errori: an extended experiment to bring constructionist approaches to public schools in Bologna

Sara Ricciardi[1] Stefano Rini[2] and Fabrizio Villa[1]

[1] INAF-OAS, via Gobetti 101, 40129 Bologna, Italy
[2] IC12 Bologna, Via Bartolini 2, 40139 Bologna, Italy
sara.ricciardi@inaf.it

Abstract. In this contribution we will describe an extended experiment to bring constructionist approaches to the public schools in Bologna and in particular our latest project called *Officina degli Errori*, i.e. an extended teacher training for primary school teachers based on tinkering activities. In this paper we highlight our motivation, the structure of *Officina degli Errori* and the lesson learned co-designing the activities and implementing them in the reality of public schools in Bologna. We also interviewed teachers to understand criticalities in the implementation of constructionist approaches in public primary school.

Keywords: constructionism, tinkering, primary public school, teacher training

1 Introduction

The basic goal of *Officina degli Errori* is to provide a teacher training and a strong support to constructionist practices in the classroom through tinkering. Moreover, within this project, we are interested to explore and understand what changes in the school organization are needed to allow a true implementation of those practices with a teacher in charge of a true pedagogical innovation. In Chapter 2, we describe hereafter how the idea started and the associated values carried out from a tight collaboration between researchers (science) and teachers (education) in co-designing activities for school. Chapter 3 reports the description of the activity carried out from September 2018 to June 2019, thus lasting the entire School Year. Conclusions and future perspectives are addressed in Chapter 4.

2 Values, aims and first round of co-design

Officina degli Errori was born after more than 5 Years of involvement in science education and outreach activities by the 3 authors. To better explain our approach, we briefly describe the process for which we have been engaged in constructionist practices. The starting point was a quite usual lecture at Scuola Primaria Marella Istituto

Comprensivo 12 (IC12) Bologna requested by S. Rini, at that time teacher at the School. The lecture, by the author S. Ricciardi, was focused on Cosmology. As researcher at INAF (Istituto Nazionale di Astrofisica) of Bologna, S. Ricciardi at that time was deeply involved in ESA Planck Satellite data analysis and paper release [1]. She prepared a lesson for seven years old children about the CMB (Cosmic Microwave Background), the first light of our Universe, about the Planck satellite and her personal involvement in research. The lesson went very well, kids were amazed, and everybody felt satisfied. It should be noted that this outcome was expected because of the attractive subjects like for instance Dark Matter and Dark Energy, origin and fate of the Universe. Since similar experience was obtained by the third author F. Villa, researcher at INAF of Bologna, we discussed if the pupils really and deeply learned something from similar lectures. Specifically, we were wondering if the "wow effect" (intended as the feeling of wondering and excitement happening when people get to explore experimental Cosmology or more generally in Astronomy) was something really positive in science education for everyone in the classroom.

We discussed with teachers and we concluded that kids already interested to STEM (Science Technology Engineer and Mathematics) were certainly inspired. We noticed that the same was not true for all the kids. We believe self-stereotype (socio/economic conditions, gender issues, family cultural levels) is already strong in elementary school's pupils [2], so kids could feel they are not smart enough to be involved in STEM. One of the consequences is that kids could feel they are not smart enough to be involved in STEM activities.

With all this criticism, we started to rethink our work in classroom and hopefully to find a better way to express our values such as the basic concepts of trials and fails in science research, the sharing of knowledge and skills.

In our perspective, we identified top level characteristics to be fulfilled by education activities – whatever they are - devoted to Astrophysics and in general STEM:

(i) **Democratic:** activities should be designed to be truly inclusive.

(ii) **True/real/honest:** during activities, we have to tell to students the truth about our research work that imply trials, errors and failures, especially when we do real frontier research. Moreover, we have to admit that scientists cannot know everything, and they could be ignorant in the explanation of natural phenomena: researchers are constructing knowledge as well.

(iii) **Meaningful:** activities should be relevant for students, so that they have to care about it.

(iv) **Empowering:** the learning process must be designed in a way the students feel a sense of belonging in STEM because they feel empowered by the process itself.

Frontier research is based on new ideas, on exploration of new techniques and technologies. Obviously, there is no recipe to follows towards reaching the final goal, since most of the things are not developed yet and researchers use their literacy to build and develop what is needed from scratch. In our experience, based on a more than 15 years in developing the ESA Planck satellite and more than 20 years in developing new instrumentation and codes for Astrophysics, the creativity is one of the major drives especially at the beginning of a research project.

Even though there is no doubt that (frontier) research needs creativity, kids have in general a different perception of research (and researchers). Conclusion is that an additional characteristic should be added to the list:

(v) **creativity:** activities should be designed in order to stimulate creativity and inventions.

We had the chance to study and improve our understanding thanks to the Tinkering Studio at the San Francisco Exploratorium [3], [4], [5], through the accessible online material and MOOC (massive online open courses). Another reference is the work of Mitch Resnick and the Life Long Kindergarden group, we embraced completely the vision of a pedagogy of STEM that aimed to be highly inclusive (low floor), democratic and at the same time provide the possibility to let projects evolve (high ceilings), allowing kids to build a personal and meaningful knowledge (wide walls) [6], [7].

Tinkering is a holistic way to engage people with STEM disciplines mixing them with art and combining hi-tech materials with low-tech and recycled materials. Knowledge is not simply transmitted from teacher to learner, but actively constructed by the mind (and the hands) of the learner. Constructionism [8] suggested that learners are more likely to develop new insights and understandings while actively engaged in making an external artifact. This method supports the construction of knowledge within the context of building personally meaningful artifacts, and the more self-directed the work is, the more meaningful the learning becomes.

From 2014 we proposed to the pupils of our local community several workshops based on the activities originally developed by the Tinkering Studio We have been working together with teachers to design, promote and deliver hands-on, self-directed and playful activities to engage children with STEM with a particular focus on gender inclusion [2].

In 2017 our labs were mature and ready to be brought in a larger arena. For this reason, in Oct-Dec 2017 we brought tinkering into the Museo del Patrimonio Industriale in Bologna under the name of *Officina degli Errori*, a set of four tinkering activities in this informal environment. We engaged a group of 20 kids, from 6 to 12 years old, during four workshops held on Saturday afternoon in the conference area of the museum [9], [10] [11], [12]. In the school year 2018/2019 we opened a teacher training for primary school teachers of Emilia Romagna at the museum to help them to be more autonomous with tinkering in their classroom but also to develop new insights in how those practices can work in the ecosystem of the Italian public schools. With these activities, we reached around 16 teachers and around 400 pupils. We also hosted a shorter version of this teacher training at Istituto Comprensivo 12 di Bologna involving 20 teachers and their pupils (about 500).

3 Officina degli Errori: tinkering goes to school

Officina degli Errori was extended teacher training from September 2018 to June 2019. We organized this experience in three blocks:

experiencing: We organized three intensive sessions where we developed the building blocks. In those three sessions, held in early September, we presented the constructionist framework, from the pedagogical point of view as well as similarities with the way scientific research community works, discussing the ideas of constructivist epistemology following the path of Piaget [13] and Khun [14].

We hosted three hands-on workshops where teachers experimented the constructionist approach through tinkering. We had a group of 15 teachers and three facilitators and we proposed some classic workshops originally developed by the Tinkering Studio and tailored for our audience (e.g. scribbling machines, paper automata, marble machines);

engaging: we provided the teachers with a kit containing 9 motors, 20 cables, 20 battery holders to try the scribbling machine with their class and hopefully continuing to use those materials in other creative ways. We invited the teachers with their classes and mate teachers at the museum where we set up a workshop for their pupils facilitated by at least three experienced facilitators. We also invited another teacher that already participated to the class workshop as facilitator. This way we had a good ratio pupil/facilitator of about 6 to 1 and we created a relaxed environment where teachers can facilitate a challenging workshop, maybe for the first time, without feeling overwhelmed. At the same time, we provided some space where teachers could just observe their own pupils and reflect without the urge to intervene;

reflecting: we allowed more than four months to try different things in the classroom providing feedback and help for the teachers' actions. We also posted genuine questions to help them and ourselves to reflect. We asked to recall their feelings when they first tried tinkering as "students". Specifically, we discussed about group composition, how they prepared the groups and how it went with a particular emphasis and care for girls participation. At the end, we proposed to reflect about possible organization of tinkering in their schools in terms of spaces, time, human resources. We also asked to report their activity to the other teachers in a final session in late June. As a final step from our side, we recently interviewed some of the teachers.

Our goal was mainly to bring tinkering and constructionist approaches to public schools in Bologna, especially in areas where there is a higher risk for students to drop out or difficulty to integrate STEM hands-on workshops in formal school activities. This means to support teachers far beyond the workshops, helping them with all they need to start. For this reason, these experiences were democratically free of charge and hosted in the Museo del Patrimonio Industriale in Bologna; we also provided a kit that teachers can use in their classroom and the possibility to facilitate a couple of tinkering sessions in relaxed conditions, we also gave them some guidance in the collection of materials and in the design of new settings. The main differences respect to previous teacher trainings we held or organized are the time scale (very extended), the possibility to provide material for free and the commitment to facilitate at least one workshop for each teacher trained with their pupils.

4 Conclusion and future perspective

From a preliminary analysis of the reports and interviews with teachers, it is evident that this experience was clearly successful in terms of engagement of the teachers, quality of the materials and support provided. We report that constructionist practices are difficult to be implemented at school and rely on special efforts by teachers. A common issue at schools is represented by the physical space available. In the schools where an *atelier creativo* (or a similar environment) is available and accessible, teachers do tinkering more often (everyday/ three times a week) and the practice is more easily incorporated in their everyday learning environments. When those settings are not available, sessions are more rare and concentrated (e.g. one full week of tinkering twice a year). To adapt a classroom to tinkering could be demanding even for a teacher that already uses cooperative learning and innovative teaching styles (e.g. *scuola senza zaino*), just because there is not enough space to store materials and tools. Teachers have to re-configure spaces every time. Another huge issue is the number of facilitators. We suggested to work in pair with the other class teacher (all the classes are organized with *tempo pieno* with two prevalent teachers, or modulo with at least three teachers) but this wasn't always possible. In this condition (one teacher and about 28 pupils) the workshop facilitation was extremely hard especially without a dedicated environment. On the contrary, the facilitation of this workshop was more relaxed and fruitful in schools with better ratio student/teacher or in schools where the general organization allowed co-teaching. Despite the teachers' motivation and their fertile attitude to overcome difficulties often the general constraint of the school organization could represent a deterrent.

As a positive fact some teachers reported that they believe they will integrate constructionist approaches anyway in their teaching not limiting to STEM but also applying them to other subjects (as language). Often the focus of teacher training on STEM and educational technology is on the devices and the literacy that could be associated to the proposed activities; instead with this extended training we had the chance to provide a more general "pedagogy" that hopefully each teacher can tweak in respect to their interests and class needs building real new knowledge beyond disciplines.

After this experience we need to further analyze the interviews with teachers highlighting what can really help establishing those practices to the public school without an excessive load on teachers. Our perspective is to continue to design and operate *Officina degli Errori* together with any partner that will help us to diffuse constructionist approaches and tinkering in the Italian public school. In the knowledge society [15] to have the chance to develop the 21st century skills (e.g. [16]) is a crucial matter of democracy. For us, teachers and researchers employed by MIUR it is a solid moral commitment to help schools to innovate themselves and to be able to offer the best practices in education.

During those years of practice, we developed a particular interest in tinkering as an effective way to engage girls with STEM. To help schools understand the value of those practices together with Università Alma Mater Bologna - Dipartimento di Psicologia we launched a preparatory work on students perception regarding science and technology with a particular emphasis on gender differences (190 pupils). INAF and

IC12 also co-designed a STEAM learning space, this environment was designed to tinker with technology (coding and robotics), tell stories and interact between pairs with dedicated areas to experiment, show and present, share. We were also interested to open up those approaches to secondary schools so during the school year 2018/2019 we worked together with IC12 also in the afternoon program "Girls code it better" where 18 girls (11-13yr) have been engaged in the ESA (European Space Agency) challenge "MOON BASE CAMP" working with INAF experts, a maker from Bologna FabLab and the teacher that coordinate the overall project on 3d modeling and printing.

We want to make *Officina degli Errori* available for teachers every year but to be effective we really have to deeply engage the teachers and deeply involve them in the design of the activities. Through our interviews we found that the external environment (mainly school organization and spaces) could be a huge deterrent to those practices. for this reason, we need also to provide together with tinkering tools and strategies also an "organization framework" to help them to bring those practices in the Italian public schools.

References

1. Planck Satellite https://sci.esa.int/web/planck
2. Bian L., Leslie S.J., Cimpian A.: Science Vol. 355, Issue 6323, pp. 389-391 (2017)
3. Wilkinson K., Petrich M.: The Art of Tinkering, Weldon Owen (2014)
4. http://tinkering.exploratorium.edu/
5. Petrich, M., Wilkinson, K., & Bevan, B.: "It looks like fun, but are they learning?" In Design, make, play: Growing the next generation of STEM innovators. Routledge (2013).
6. Resnick, M.: Lifelong Kindergarten: Cultivating Creativity through Projects, Passions, Peers, and Play. MIT Press (2017)
7. Presicce, C.: Thesis Master of Science in Media Arts and Science (2017)
8. Papert, S.: "Mindstorms: Children, Computers, and Powerful Ideas", Basic Books (1980)
9. Ricciardi, S., Villa, F., Rini, S.: Proc. of the Communicating Astronomy with the Public Fukuoka, Japan "Tinkering with the Universe: a primary school project" (2018)
10. Ricciardi, S., Villa, F., Rini, S.: Proc. of International Conference New Perspective in Science Education Firenze, "Officina degli Errori: a Tinkering Experience in an Informal Environment" (2018)
11. Ricciardi, S., Villa, F., Rini, S.:"Il tinkering va al museo" Scuola Officina numero 2 (2018)
12. Ricciardi, S., Villa, F., Rini, S.:"Tinkering la coraggiosa arte di sbagliare incontra un museo civico" in Città come Cultura ISBN 978-88-942824-6-7 Fondazione MAXXI (2019)
13. Piaget, J.: Genetic epistemology (E. Duckworth, Trans.). NY: Columbia University Press (1970)
14. Kuhn, T. S.: The Structure of Scientific Revolutions. Chicago: University of Chicago Press, (1962)
15. Lisbon's strategy, European Council (2000)
16. OECD Report 'New Vision for Education: Unlocking the Potential of Technology' (2015)