Officina degli Errori: a Tinkering Experience in an Informal Environment

Sara Ricciardi1, Fabrizio Villa2 , Stefano Rini3 , Matteo Boni4 , Sara Venturi5 ,Annalisa Bugini6 , Miriam Masini7
1INAF-OAS Osservatorio di Astrofisica e Scienza dello Spazio Bologna, Italy
2INAF-OAS Osservatorio di Astrofisica e Scienza dello Spazio Bologna, Italy
3IC12 Istituto Comprensivo 12 Bologna, Italy
4INAF-OAS Osservatorio di Astrofisica e Scienza dello Spazio Bologna, Italy
5INAF-OAS Osservatorio di Astrofisica e Scienza dello Spazio Bologna, Italy
6Museo del Patrimonio Industriale Italy
7Museo del Patrimonio Industriale Italy

Abstract

Since 2012 we have been working together with teachers to design, promote and deliver hands-on,self-directed and playful activities to engage children with STEM. The most powerful method we used is tinkering, which is a holistic way to engage people with STEM disciplines mixing them with art and combining hi-tech material with low-tech and recycled material. Knowledge is not simply transmitted from teacher to learner, but actively constructed by the mind (and the hands) of the learner.
Constructionism (Papert 1980) 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. Our labs are now mature and ready to be brought in a larger arena. For this reason, in the past months (Oct-Dec 2017) we brought tinkering into the Museo del Patrimonio Industriale under the name of “Officina degli Errori”, a set of 4 tinkering activities in this informal environment. We engaged a group of 20 kids, from 6 to 12 years old, during 4 workshops held on Saturday afternoon in the conference area of the museum. We expect this successful test will open a new branch of activities in this museum that is already offering lessons and experiences to the pupils in the Bologna area. These experiences are democratically free of charge. Our idea is to offer a tinkering lab and a learning opportunity to the pupils, a fruitful form of training to the teachers and some guidance in the collection of materials.
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1. Our goals and our path

INAF, the National Institute for Astrophysics in Italy, is making an effort to design a series of educational techniques and to communicate with society involving a large audience with the aim of disseminating scientific and astrophysical culture and of stimulating interest in space exploration, in scientific research as well as in its mechanisms, technologies and challenges. Within this framework special consideration is given to the Italian public school at all levels. The INAF activity with the primary school and with the K12 students inside and outside the classroom is well known and established [1] [2] [3].

Our exploration, begun in spring 2012, started basically from scratch reviewing the work of colleagues from other INAF Observatory and Institutes. At the same time, we interviewed primary school teachers to understand with their help what INAF-OAS could do for the students in order to promote among them a scientific culture and interest in STEM disciplines, in a word to make them feel they can play an active role in STEM activities. Later on, we had some meetings with a second-grade class (IC12) with the purpose of better understanding the students of that age, of planning what we could do for them, and, of course with the teachers' support, of designing the building blocks of our research. The goal of our deep and sustained collective meditation was to establish the best way to make students internalize procedures and values of scientific research: that is, to make them share the core of our work as researchers and scientists, and the irreplaceable role of technology inside it and in general in the scientific development. Along this path we discovered very soon that we were moving from the idea of education as a transmission of knowledge to the view of learning as discovering by doing. The young people learning mimics the same processes as the scientific community.

2. Constructionism and Tinkering in Bologna

Starting from our disciplinary expertise we were looking for a different way to engage and empower students, so we focused on the methodology digging deep into current best practices in STEM education and pedagogical studies. Abandoning the formal lesson and the idea of transmission of knowledge we embraced the principles of Constructivism (Piaget 1950 [4]). This theory of learning claims that knowledge is not simply transmitted from teacher to learner but instead actively constructed by the mind of the learner. Later Papert, Piaget ‘s student, suggested that learners are more likely to develop new insights and understandings while actively engaged in making an external artefact. Papert is the father of constructionism, which is now carried on in different fashions all around the world [5]. The constructionism and the tinkering approach are fundamentally similar to our work as scientists, so we decided to engage in this activity. One interesting realization of this theory is represented by the work of The Tinkering Studio, a vital part of the Exploratorium in San Francisco. It developed a series of workshops and practices based on constructionism and it is also engaged in the dissemination of them with the goal of making them become fertile seeds able to transform pupils’ learning experience. We studied, tailored and used those tools to test ourselves in the facilitation of the workshops; we experienced the power of this method in class and we use those workshops to start to build a community of teachers and educators interested in a hands-on approach to STEM, mentoring them in the tinkering sessions with students and providing some formal teaching in dedicated classes. These tools are particularly useful for our aims because they let us obtain good results also working on the spot (2 hours’ workshop in a class) even if more durable and profound results are achieved when this methodology is embraced by the teacher. The best way to promote this approach with the teacher is to show tinkering at work in their own classes. After a preliminary phase of study, design and preparation, we ran the tinkering workshops from 2014 up to now mainly in collaboration with the schools of IC12 but also networking with teachers and educators of other schools.

3. The schools in Bologna and the impact of the PNSD about STEM teaching

For years, the Italian school system has undergone paradigm shifts that were led more by political and economic demands than by philosophical ideas. A different approach is evident since the publication of the PNSD (Piano Nazionale Scuola Digitale) and the reform called

“buona scuola” (107/2015). In both of them there is a direct link to 21st century skills (action #16 of the PNSD) so that the educational framework for schools has become clearer. Since the PNSD and subsequent documents (“biblioteche innovative”, “atelier creativi”, “in estate si imparano le STEM”) there has been noticeable reference to the constructivist and constructionist approaches and the policy makers are asking the schools to build an educational network in tune with this perspective.
The new approach has fused together the philosophical background and the practical activities run in the schools. A project or problem based approach can immediately activate strategies that bring back the attention to the center of the teaching/learning process. The starting point of which must no longer be the amount of knowledge to be taught, but the actual kid with his needs, cognitive style and preferences. In this light – particularly in the primary school where the teacher is not tied to a particular subject - it is clear how abstract and unnatural is the shredding of knowledge into disciplines and subjects. It is also fundamental for an institution such as the public school that workshops and activities push towards a solution of the gender gap problem in STEM, which is already present in the primary school [6]. It is for these reasons that IC12 in Bologna and more schools every new school year are building a digital curriculum from kindergarten to lower secondary schools that includes tinkering as an important educational practice. For the first four years in partnership with INAF-OAS the workshops have been proposed to the primary school classes involving at least 800 students overall; since 2018 - after some training specifically dedicated to kindergarten teachers - they have been offered to kindergarten kids (3-6) and to lower secondary schools as part of specific STEM projects.

4. A democratic place to learn in Bologna: Museo del Patrimonio Industriale
After 3 years of co-operation at IC12 we were ready to move forward and increase our impact offering those workshops to a larger audience. We were looking for an inclusive entity, a place where all kids of all social classes can discover STEM with their peers and possibly with their teachers. In Bologna, the Museo del Patrimonio Industiale (hereafter PAT) was perfectly suitable for us. In this Museum, all the classes, from kindergarten to University, have guaranteed access free of charge to the workshops and to the collections. The relevance of our work for museum activities, the broad intertwining of our
and its aims and goals and the overlapping of our and its interactive approach to children led as to a fruitful co-operation that gave birth to the “Officina degli Errori”: a series of 4 workshops described in section 5. The museum’s paths aim to involve the users through storytelling and interaction in order to let them understand physical processes following the innovation and excellence of local industry. The museum is already the main reference point for STEM education in public schools of the area around Bologna: during last year the museum hosted about 1000 classes. Our idea was to test our workshops
in the museum to check their feasibility and efficacy.

Fig. 1 Kids at work with facilitators at PAT; close-up picture of tinkering workshops
5.” Officina degli Errori”
From October to December 2017 we decided to bring a set of four laboratories, named “Officina degli errori”, into the conference hall of PAT. In this informal environment, on Saturday afternoons, we engaged kids (from 6 to 12 years old) in tinkering activities open to anyone in a playful setting. In each meeting, we worked with a group of 20 kids and some facilitators coming from the staff of the museum. We proposed tailored workshops originally

developed by the Tinkering studio in San Francisco such as Scribbling Machine, Paper Circuits, Chain Reaction and Paper Automata already tested and operated in class [7,8,9]. Instead of presenting an activity or an experiment related to STEM, which for some kids can be intimidating, we basically ask the kids to freely play with our material. This way the self-prejudice that can affect kids because of their gender, census category, ethnicity or family cultural level doesn't play any role because all feel they can play! The children start to be engaged with the material and they get hooked by the challenge. We help them also when they get frustrated or face some difficult problem.
At the end of the day, when they overcome the challenge and physically build a complicated object, they come back home satisfied with the result.
Some recycled materials are used in these labs, so hi-tech material is mixed with low tech material. This helps to create a familiar and non–intimidating environment.

6. Outcomes and perspectives

This series of workshops was considered extremely successful by the proposing team (INAF) and by the museum curators because of the number of people interested, the level of engagement of children, the overall quality of the project and the number of teachers that showed a strong interest in participating as observers. We decided to combine our efforts to offer next year (2018/2019) a tinkering-experience at the PAT. The project will start with a course for about 20 primary school teachers. Then it will highlight the pedagogical principles of constructivism, explain the value of an inquiry based lesson and stimulate a meditation about some non-secondary aspects such as gender/social/census issues and strategies to design and operate a truly inclusive classroom workshop. We want also to provide practical help regarding materials, classroom organization and anything can help to launch the activity. We want also to evaluate the impact of this project. For the teachers that successfully participate in the course we will grant access to one (or two) tinkering workshops at the museum with our materials and our facilitators. We hope to deliver about 20/30 tinkering workshops next year; this experience will be an excellent basis for expanding and fully including the tinkering labs in the educational offering of the museum. Our hope is that this project will be a viable seed in many classrooms of our local community.

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