Looking for Good Practices of Teaching and Learning with 3D Print in Primary School

Margherita Di Stasio[1], Lorenzo Guasti[2], Jessica Niewint-Gori[3],Giovanni Nulli[4]

Abstract

This paper describes the research "Primaria 3D" as part of "Maker@School", a project led by INDIRE. The project is focused on the introduction of the 3D printer in the classroom, involving different areas of expertise. The structure (previous tested in another research project in pre-school) is based on a storyline that is organized as a quest with different tasks to solve. The objects that have to be designed and constructed are key pieces for moving on with the story. All tasks assigned to the classes that take part of in our research with the 3D Printer are introduced as open problems and require a problem-focused, action-oriented participatory process. The problem has to be decomposed and processed for a specific situation. Not an unique solution is the goal but to thinking-through different options and to find a wide variety of possible solutions to fulfill the task. This is reflected in the TMI: a method of designs or project cycles, the Think-Make-Improve cycle.
Tasks are aligned with the Italian National Curriculum and teachers are free to decide to which skill and/or discipline to focus in class.
Primaria 3D is an experimental proposal to the schools and a research project, so, we have two different kind of aims. On one hand, we must identify a structure for sustain an experimentation of the 3D print based on the execution of the tasks through the TMI cycle with more than 50 primary schools. On the other hand, as a research result, our intention is to establish "good practices", that can be used a as a guideline the 3D printer as real part of the everyday didactic activity on a strict relationship with the curriculum and that are documented so to be useful example for other teachers. In order to achieve these aims, we try to propose an online environment oriented to self-evaluation, peer review, reflection and sharing. This model will be the object of the present paper.

Keywords: 3d printing, problem solving, national curriculum, documentation, primary school.

1. Introduction

This paper describes the research Primaria 3D as part of the project Maker@School led by Indire, National Institute for Documentation, Innovation and Educational Research.
The research aims to define good practices to use 3D printers in the classroom. We intend to propose a didactic use of a designs method: the Think-Make-Improve (TMI) cycle.
At the beginning of the project, there were no documented researches focused on the didactic use of 3D printer in the primary school. So, we assumed as a useful starting point the Indire experience gained during previous three years with the activities in the schools of childhood [4] [5].
We consider the 3D printer as part of a laboratory approach. Although, not all of the primary schools have polyfunctional spaces suitable for this type of "maker" didactics, the laboratorial approach should be promoted in primary school. Manual work is a task to be supported and accompanied by new educational practices [3].
The research project has been realized in collaboration with about fifty primary schools, distributed overall national territory. The required setting that schools must have to participate in the experiment was a space structured as an agorà, the availability of a 3D printer, a IWB and a good wifi connection.
We will describe this project inserting our activity looking to the maker movement as a possible landscape; further we will describe the structure of the project: first the tasks assigned in a narrative background and the TMI approach, then the structure of the environment that supports the experimentation.

2. The maker movement and the school: an interesting interaction

Many academic studies have analyzed different experiences of the use of the "maker" logic within the educational contexts.

[1] Indire - Istituto Nazionale di Documentazione, Innovazione e Ricerca Educativa (Italy),
[2] Indire - Istituto Nazionale di Documentazione, Innovazione e Ricerca Educativa (Italy)
[3] Indire - Istituto Nazionale di Documentazione, Innovazione e Ricerca Educativa (Italy)
[4] Indire - Istituto Nazionale di Documentazione, Innovazione e Ricerca Educativa (Italy)

We can mention the project FabLab@School, realized by the Transformative Learning Technologies Lab of the University of Stanford and widely documented through articles, conferences and studies.
Briefly speaking, they consider new technologies not only as a way to optimize the existing educational system, but as a force of transformation capable of generating radically new ways of knowing and learning. Looking at the italian context, the diffusion of the "maker space" in schools started some years ago and related research activities are in phase of development and deepening.
The following three characteristics describe the act and learn in these kind of spaces:

- an hacker approach to knowledge;
- a "tinkering" methodology, based on TMI cycle [6];
- the collaboration and sharing knowledge in perfect "open" philosophy.

In order to integrate these specific features in the italian schools' didactic practices, we have to consider the crucial role of the teachers to enhance innovation of the process.
"Tinkering" is a methodology that prioritizes creativity and collaboration among peers. This approach, which is expressed through application of the TMI cycle, raises the awareness that by studying, trying, and making mistakes, you will eventually achieve the desired result.
The logic of Tinkering creates a cycle, since the finished object can always be improved by going back to the initial project. From an educational point of view, the object creation process become a pretext to apply analyses and self-analyses.

3. The philosophy behind the tasks

In the research project with the pre-primary schools it could been observed a better approach to TMI with the on-going storytelling to achieve an object with a better purpose [4] [5]. We are expecting that during the process of planning and creating, the children's work will be getting more and more engaged and as a result the children will pay more attention in class and on the evolution of the created tools.
For Primaria 3D we choose the integration of the assigned tasks in a narrative background - that is also the timeline to be followed in the classroom during the activities - organized like a classic adventure that takes place for tests that must be overcome in order to proceed to the next step.
The tasks presented in the storytelling, are connected in a logical context while maintaining their own meaning in the implementation phase. The story leads to the realization of the objects that will be used in order to continue the adventure.
As guidelines we proposed to the teachers to consider the following idea based on our previous experiences and maker philosophy:

- be confident with technology: teachers must train themselves and the class with the tools (both hardware but mostly software) because just in this way they will be prepared to solve the constructions problems with creativity and self-confidence, and no other difficulties due to softwares.
- preparatory activities: can be useful before each task if related mainly to the sharing of the meanings and common goals of the terms proposed in the situation.
- freedom to experiment: the teacher task is to support pupils in designing what they consider appropriate for the purpose of solving the problem.
- fulfilling the expectations: is important to leave the necessary spaces for testing, reflection and the creation of further improvements.
- improvement: is a very important moment for collaboration and knowledge sharing.
- copy peers is not cheating: must be promoted as activity to practice, it leads to favoring the dialogue between peers, be corrected by their comrades or to design a whole new approach to solve the problem. This form of collaboration helps all the players involved, both the transferor of knowledge, who must rationalize it and break it down to share it, and the learner, who had to pay attention.

4. Applying the TMI cycle

The experimentation is focused on the TMI cycle, an adaptive decision making process (ADM) that is a problem focused activity.

In our approach the 3d printer adds value in this kind of processes:

- let's the students works on objects they created;
- works with a structured methodology that permitted to divide project phase, from making and testing.

- let's the students create objects so the debugging process can be done on real objects.

The method we suggested, TMI, helps to understand the process and works as well as a designing approach for teachers to define the lesson structure to and for the students it is a way to organize their work. The TMI stages can be characterized in the following way:

- THINK: The problem is described, the teacher allows the children to come up with a design on paper and share his/her or their ideas, helping with the exercises prepared using various materials.
- MAKE: The project itself is created by using a design software. At this time is when we see the challenge that comes from making the object in the way it was assigned in the previous stage.
- IMPROVE - This stage focuses on the object itself, the children reflects on the object being worked on, making sure if it relates to what was thought of during the previous phase

We ask teachers to include as more as possible the tasks into curricular path: from our point of view the introduction of 3D print using the TMI cycle to accomplish tasks, gives the opportunity to rethink curriculum with a focus on practical activity of students. For these reasons we ask teachers to insert the process in their pedagogy and to highlight the relation with national curriculum.

5. Identifying a model

Primaria 3D has an high level of complexity due to its particular nature: it is a research project that engage very different primary schools' classroom through a common experimental proposal.
On one hand, we must identify a structure to sustain the experimentation with continuously increasing number of primary schools' classes. On the other hand, as research result, we want to identify some "good practices".
How can we do it?
In order to handle schools from all countries of Italy we choose to operate in an online environment.
Schools have different backgrounds and different expertise on the 3D printer use; how to use this diversity as a value?
In the construction of our model, we have three focal points:

1. we identify an epistemic landscape looking to Wittgenstein's [10] idea of the social construction of knowledge, in which the learning process is possible by virtue of the participation into the community. From this point of view, our model is grounded in the tradition of collaborative construction of knowledge [1] [8].
2. as Ranieri and Manca [7] highlight, in online learning environment, we find new kind of structure - crowd and network [2], for instance - marked by weaker ties, if compared with a properly called community of practice.
3. we consider teachers involved in the experimentation reflective practitioners [9], that through documentation, sharing and reflection can achieve a professional growing and a teaching/learning improvement.

We propose an online environment oriented to self-evaluation, peer review, reflection and sharing. To this structure underlies what we define, for a first approximation related to this peculiar experience, a "good practice" i.e. practice that use the 3D printer as real part of the everyday didactic activity on a strict relationship with the curriculum and that is documented so to be useful exemplum for other teachers.
Teachers must document all the accomplishment process of each task using a tool integrated in the online environment. The tool gives them the possibility to create their documentation, step by step, during the process using text, video, images. At the end of each task, the teacher analyses his work using specific rubrics. On this base, he can restructure the documentation or submit it and the checked rubrics to the researchers. Researchers analyse the documentation using the same rubrics; then they can re-submit the documentation for review to the teacher or publish it in the environment. When published, the documentation can be seen and commented by the community of peers in order to became a not only a posted but a "shared" practice.
We propose two rubrics:

- task rubric: oriented to analyse the task as the product of the research proposal and the teaching learning activity, focused on the coherence with the didactic plan and with the curriculum, the connection with the national curriculum, subjects and competence goals;

- documentation rubric: oriented to analyse the documentation in terms of usability and process description.

6. First results, trade-off and compromises

Analyzing the first experiences shared by the teachers we have feedbacks on the sustainability of the model that we can analyze with a SWOT matrix (Fig.1); we use them as insight in order to adapt the model itself.

strengths	weaknesses
• easy integration with didactic plan and curriculum • easy connection with subjects	• difficulty in set the relation with expected competence • requires high confidence with new technologies and new media
opportunities	**threats**
• professional growing • experiencing new approaches • using a TMI cycle as a metaprocess	• focus on the product and not on the process

Fig.1, SWOT matrix: sustainability of the model

From a technical point of view, the integration of 3D printing in the classroom is possible.
Regarding to the coherence with the didactic plan and with che curriculum, it seems easy for the teachers to integrate tasks with didactic plan with an adequate connection with subjects; but it is not so easy to set the relation with pulìpils' expected competences.
Regarding to the documentation, emerge the tendency to use tools personal proficiency tools (eg. Office package) instead of sharing oriented online tools. We also noted the tendency to document the result and not the process.
In this process rubrics are keystones: they are the path that permit to each teacher the possibility of growing through: reflection on his practice, self-assessment, peer assessment and dialog with the researchers. Therefore, in a TMI approach, we sustain teachers inviting them to reflect on these points using the rubric as guideline.
Using also in the research approach a TMI point of view and thinking to an increasing number of participant, we use these first interactions as bases for tutorials (text, video etc.) integrated in the online environment.

References

[1] Brown, A.L.; Campione, J.C. "Guided discovery in a community of learners", McGilly, K.(ed.), *Classroom lessons: Integrating cognitive theory and classroom practice*, MA: Cambridge, MITPress/Bradford Books, 1994.
[2] Dron, J.; Anderson, T. "Collectives, networks and groups in social software for e-learning", *Proceedings of world conference on e-learning in corporate, government, healthcare, and higher education*. Vol. 16. Chesapeake, VA: AACE, 2007.
[3] Freinet, C. *Le mie tecniche*, Firenze, La Nuova Italia, 1976.
[4] Guasti, L.; Niewint-Gori, J. *L'uso di Doodle3D con la Stampante 3D nella Scuola dell'Infanzia. L'esperienza di Indire*, Didamatica 2016. [Online]. Available at: http://didamatica2016.uniud.it/proceedings/dati/articoli.html
[5] Guasti, L.; Nulli, G. *The 3D Printers in Preschools. Pedagogical principles and technological aspects*. Paper presented at: Immersive Italy 2016, 6th European Immersive Education Summit.
[6] Martinez, S. L.; Stager, G. *Invent to learn: Making, tinkering, and engineering in the classroom*, CA: Torrance, Constructing Modern Knowledge Press, 2013.
[7] Ranieri, M.; Manca, S. *I social network nell'educazione*, Trento, Erickson, 2013.
[8] Scardamalia, M.; Bereiter, C. "Knowledge Building: Theory, Pedagogy, and Technology", *The Cambridge Handbook of the Learning Sciences*, 2006, pp. 97-115.
[9] Schön, D. *Educating the Reflective Practitioner*, San Francisco, Jossey-Bass Publishers, 1987.

[10] Wittgenstein, L. *Philosophical Investigations*, Oxford, Basil Blackwell, 1968.