DIGITAL MAKING AS A MEANS TO IMPROVE EDUCATION

C. Bruno, G. Salvia, M.R. Canina

Politecnico di Milano (ITALY)

Abstract

Contemporary education faces the challenge of teaching and learning key competences for students to strive as the next generation workers in the contemporary world characterised by rapid and profound transformation. In particular, the current societal trend of 'making' for laypeople especially enabled by rapid manufacturing and digital technologies is questioning the role of professional designers in a world where – as also design literature reports – 'everybody is a designer' (Manzini 2015; Cross 2011).

The objective of this paper is presenting our reflections about the digitally enabled self-production trend (aka digital DIY) as a means for students to develop and improve the key competences to face the complexity of contemporary age.

This set of cognitive, interpersonal and intrapersonal skills generally recognised of fundamental importance for the next generation labour market, social cohesion and active citizenship comprises not only technical and engineering knowledge, but also creativity and critical thinking, effective communication and collaboration, plus a range of personal qualities such as motivation, curiosity, self-development and management.

Such key competences have been widely defined and work programmes have been activated to promote their application among the educational and work fields. In Europe, key competences represent the pillars of the Lifelong Learning programme edited by the European Commission (2006/962/EC). Across the United States some promoter (i.e. the Partnership for the 21st century skills, National Research Council) are trying to merge education, business, community and government leaders around these competences, mainly known as 21st century skills (The Partnership for 21st Century Skills, 2008).

Since the last decades of the 20th century, research in learning processes have suggested the importance of making and doing as a means to foster the acquisition of these skills, especially the creative ones. Digital DIY is here envisaged as a creative practice in which people – including design students – may increase their self-confidence and empowerment. Rooted in design and construction, these digital making activities often emphasise the acquisition of problem-solving, critical thinking, creativity, cross disciplinarity and collaboration.

Within the framework of the EU funded project 'Digital Do-It-Yourself (DiDIY), we are exploring the dynamics facilitating the acquisition of the key competences in this practice. We introduce a model representing the dynamics and factors for learning and skilling in this context. As design researchers, we aim at contributing by developing (co)design-driven tools facilitating the identification of the skilling dynamics where digital DIY practice takes place.

In this paper we will firstly define such competencies as a result of a comparative study from literature analysis and then argue why they are developed through digital DIY. Finally, we will conclude with the proposal of transferring the skilling dynamics identified in digital DIY to education system.

Keywords: Education, Learning process, Making, Digital DIY.

1 INTRODUCTION

The current educational system was shaped during the Industrial Revolution, and it was created to efficiently convey information from the instructor to the students in the traditional classroom setting. This system was based on linearity, conformity and standardization. Now, since the Information Age took over from the Industrial Age, the educational models are being forced to follow that changeover. In the last few decades, with the progressive development of technology and its use at all academic levels, we have gone through phases where technology in school has been defined as the following (Foster,1997):

- as content - where it is a teaching tool for teachers;

- as a process - in which a method for supplying information and knowledge and/or to maximise specific students' potential, like the ability to problem solve is defined;
- as a method - where a set of strategies are established to improve the learning process, "academic amplifiers" as it were.

It is important to consider that, while the impact of computers and social media (often called "digital literacies") in education has been thoroughly investigated by scholars and has been used in education at all levels, due to the novelty of the technologies involved, digital making in education is much less a subject of research.

The advent of new digital technology and social media is fundamentally reshaping our living and learning, and its combination with digital making technologies such as 3D printers, DIY electronics such as Arduino, Raspberry Pi or Galileo and other forms that give way to the creation of some physical output can have consequences on education and the skills acquisition.

The modern set of skills is considered fundamental for people to face the complexity of contemporary age. It comprises not only relevant knowledge and skills, but also a range of personal qualities and the ability to perform adequately and flexibly in well known and unknown situations. Creativity and the ability to produce ideas, knowledge and innovations is a key player. It represents the intangible substrate for innovation (Kozbelt et al. 2010), however its management requires the development of specific techniques and educational programmes.

Since the last decades of the 20th century, research in learning processes have suggested the importance of making and doing as a means to foster the acquisition of skills, especially the creative ones. Several researches has highlighted the educational potential of a maker-like learning spaces and the usage of such tools in learning settings and some learning programs inside and outside school have already adopted it.

Therefore, observing and understanding the dynamics of making-based activities could shed more light on how skills are acquired.

Digital fabrication-based DIY – or simply digital DIY – is here envisaged as a creative practice in which people may increase their self-confidence and empowerment through the development of new skills and knowledge. Rooted in design and construction, these digital making activities often emphasize the development of 21st century skills, such as problem-solving, critical thinking, and collaboration.

Such complex phenomenon calls for a transdisciplinary research methodology able to enhance people latent needs and visions. One of the foundational pillars of DiDIY is codesign, a transdisciplinary and collaborative process in which people are directly involved in the research and production of knowledge.

2 NEW KEY COMPETENCES FOR STUDENTS

As the world moves into the 21st century, a massive economic and technological changes are affecting frames of reference about the ways of life, work, and society, and how they are viewed and organized. Since the ways in which we build and access information are important and continue to change, the intellectual capital of citizens is envisaged has the driving force for the 21st century. (Sahin, 2009).

Advanced economies, innovative industries and firms and high-growth jobs require more skilled and empowered workers with the ability to respond flexibly to complex problems, communicate effectively, manage information, work in teams and produce new knowledge (The Partnership for 21st Century Skills, 2008). People need new competences also to master a whole new digital world by gaining a deeper understanding of the opportunities, challenges and even ethical questions posed by new technologies.

To cope with the demands of the 21st century, people need to acquire the knowledge and skills they need to thrive as tomorrow's leaders, workers, and citizen in a world where change is constant and learning never stops. They need to know how to use their knowledge and skills — by thinking critically, applying knowledge to new situations, analysing information, comprehending new ideas, communicating, collaborating, solving problems, making decisions. (Sahin, 2009).

In this climate of rapid change, there is also an increasing concern about our social cohesion. There is a risk that many people feel left behind and marginalised by globalisation and the digital revolution. “The knowledge, skills and aptitudes that everyone needs must change as a result” (Figel, 2007).

To be up to date, the concept of learning must be understood in the same broad sense, and therefore traditional learning theories must be revised.

With this constantly changing landscape education should become less institutionalized and more personalized and we should see in education a move from students that are just consumers to students that are producers of knowledge (Papert, 1992). Digital technologies and social media allow students to learn from each other in informal settings anywhere and anytime, making learning in and out of school "increasingly porous." Therefore, the institutions have a problem, because they compete with learning that takes place in recreational space and is more fluid.

From here the need of European politics to focus on the long term development and implementation of some key skills that one should consider in terms of objectives and organizational strategies for the entire school system. Acquiring skills is crucial to reaching European development objectives for citizens and social inclusion. Education in its dual role, both social and economic, has a key role to play in ensuring that Europe’s citizens acquire the key competences needed to enable them to adapt flexibly to such changes and by ensuring equality and access for people with disabilities and disadvantages.

The Council and the European Parliament adopted, at the end of 2006, a European Framework for Key Competences for Lifelong Learning (2006/962/EC). The Framework identifies and defines the key competences that citizens require for their personal fulfilment, social inclusion, active citizenship and employability in our knowledge-based.

The Member States’ initial education and training systems should support the development of these competences for all young people, and their adult education and training provision should give real opportunities to all adults to learn and maintain these skills and competences.

The spreading of organizations focused on infusing 21st century skills into education system is defining a powerful vision providing tools and resources to help facilitate and drive change (Soland, Hamilton, Stecher, 2013). An example from United States is “The Partnership for 21st Century Skills”[1] that identified three broad categories of these learning skills, which include:

- Information, i.e. technical skills enabling the confronting of the technology and media-driven environment.
- Learning and innovation, i.e. skills focusing on creativity, critical thinking, communication and collaboration.
- Life and career, i.e. skills that give people the ability to navigate the complex life and work environments in the globally competitive information age.

The 21st century skills do require the development of an ad-hoc education system that change the roles of the involved people and is often related to a learning approach that sees the learner as an active constructor of its knowledge by working collaboratively with other peers. As noted by E. Y Do, and M. Gross (2007) in their Creativity and Cognition paper describing environments for creativity, when students define their own problem statement, figuring out what they want or need, they are greatly motivated to engage in just-in-time learning to achieve their project goals. Students draw on their personal experience and needs as a primary source for creative exploration in the design environment. Creativity, one of the most valued 21st century skills, is greatly about the ability to make things, whether physical or virtual. Engendering creativity will require blurring the boundaries between disciplines and between formal and informal learning environments.

We envisage that significant benefits may be gained if the development of this system is based on constructionism a theory developed in the 1980s by Seymour Papert – one of the founders of MIT Media Lab – which bases learning on creativity, tinkering, exploring, building, and presentation (Papert, 1980), thus covering a significant number of the 21st century skills. Learners apply concepts, skills and strategies to solve real-world problems that are relevant and personally meaningful. In this process, they engage with problem-solving, decision-making, and collaboration (Bers, Ponte, Juelich, Viera, Schenker, 2002). We are natural constructivist. That is, we came into this world building our

[1] http://www.p21.org/

own meaning and explanation for occurrences, based on our own findings, as well as through socializing with others. Therefore, including activities that ask the learner to construct their own meaning and then reflect their understanding off of other learners goes along way in creating understanding (Clapper, 2009).

3 DIGITAL MAKING AS A MEANS TO DEVELOP NEW COMPETENCES

The current trend of self-production (i.e. Do-It-Yourself or DIY) (Anderson, 2012) is emblematic of the contemporary attitude to making and its investigation may represent an opportunity for a better understanding of the dynamics underpinning the acquisition of the 21st century competences. The spreading of digital fabrication technologies and infrastructures are sustaining a self-production trend re-emerged over the last decade (Atkinson, 2006) thus leading to what has been defined as 'the new DIY age' (Hoftijzer, 2009) or also a new industrial revolution (Anderson, 2012) and even a paradigm shift (Fox, 2010). Collaborative self-production is one of the ongoing social innovation phenomena in which people reinvent their ways of living, especially thanks to ubiquitous digital technologies, connecting people on a global scale (e.g. Internet 2.0) and bringing production closer to consumption (e.g. digital fabrication and distributed systems) (Manzini, 2015).

A number of researchers and educational leaders see in the current socio-technical trend of self-production and making facilitated by digital media, the potential to engage young people in personally compelling, creative investigations of the material and social world (Vossoughi and Bevans, 2014).

The contemporary making attitude is considered creative, innovative, inventive, collaborative, resourceful and empowering. Makers and digital DIYers play with technology to learn about it, to figure out how things are made, how to fix them, or how to use them in a whole new way. They are non-linear thinkers, curious inventors and problem-solvers. According to Thomas Kalil, deputy director of the White House's Office of Science and Technology Policy, the maker movement really "begins with the Makers themselves — who find making, tinkering, inventing, problem solving, discovering and sharing intrinsically rewarding." (Dougherty, 2010).

The potential of a digital making environment as a way for more effective learning, inside or outside school, has been increasingly sustained over the last decade for several reasons.

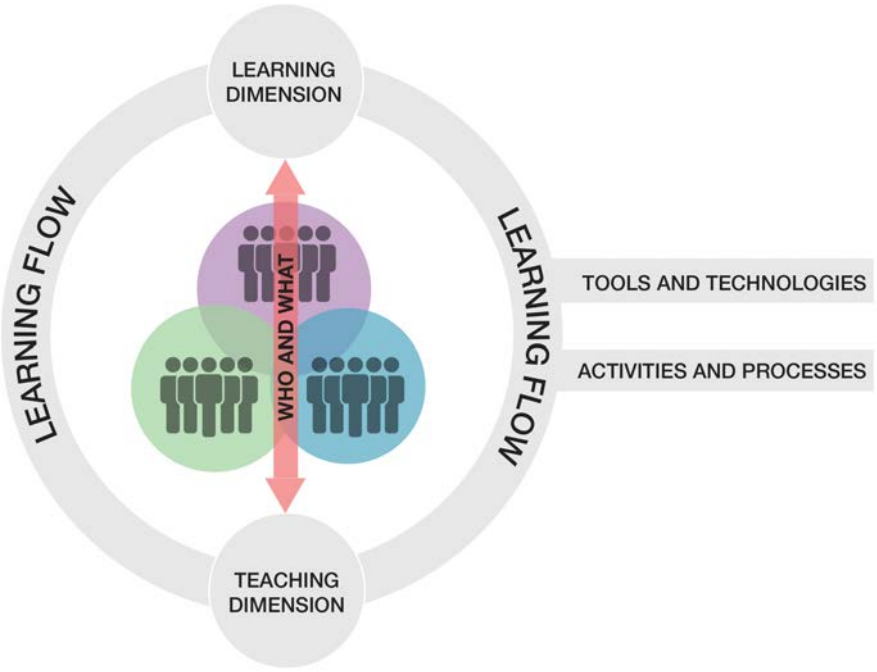
According to the literature, digital making activities can provide a powerful context for broadening interest and engagement of young people in STEM subjects, for example by contextualizing STEM concepts and practices in meaningful activity using maker tools (Vossoughi, 2013). Connecting making with existing practices creates more powerful and equitable learning experiences (Blikstein, 2013). This allow from one side the increasing of student motivation and from the other the democratization of tasks and skills previously available only to experts (Blikstein, 2013). Students today grow up with digital technologies (Ebner et al., 2013) and using modern digital tools connected to everyday problem is in general a way to meet their expectations and prior knowledge.

Making as constructionist activity, fosters lifelong learning by encouraging learning by doing (Peppler and Bender, 2013). Constructionist philosophy of education asserts that people learn better when they are engaged in designing and building their own personally meaningful artefacts and sharing them with others in a community (Papert, 1980). By constructing an external object to reflect upon, people also construct internal knowledge. Papert theory is at the very core of what "making" and digital fabrication mean for education and describe precisely the relationship between making and learning. Making encourages a deep engagement with content, critical thinking, problem solving and collaboration (Peppler and Bender, 2013), while considering the impact of their creations on society, ecology, and the environment (Schön, Ebner, Kumar, 2014).

In a maker setting, as well as in a typical constructionism environment, a traditional teacher-centred teaching does not fit and teachers change their role becoming facilitators. In this context, teachers are asked to design a learning environment to support students in their explorations in order to make projects to share with others in the community (Bers & Urrea, 2000). Students are active learners with a high need to explore, to discuss and to share experiences and ideas. They co-create their own knowledge by applying concept, skills and strategies supported by teachers that are seen as inspirational partners.

The openness of the setting and the creative results within this approach may lead to situations, where the students may be better as the teachers. When people are making something, the object they

create is a demonstration of what they have learned to do, providing evidence of their learning and teaching others at the same time (Dougherty, 2012).



In general, the skills of creating and innovating can have a broad impact on students' lifelong learning and ultimately for education and society. The current challenge is to encompass learning at all ages in both formal and informal situations with a practice that must involve a wide variety of the digital tools that form the landscape of students' future learning and work environments (Donaldson, 2014).

4 INVESTIGATING THE SKILLING DYNAMICS

Within the framework of the EU funded project 'Digital Do-It-Yourself (DiDIY), and supported by the literature, we believe that the exploration of the digital DIY phenomenon constituted by tangible resources, motivational aspects and (especially creative) competences, may generate beneficial insights for the facilitation of the 21st century skills development relevant for the contribution in innovating the education system.

The DiDIY project, aims at developing a human-centric and multi-perspective approach to the scientific study of current self-production trend enabled by digital fabrication, in order to better understand its impacts on all areas of society and to support both education and policy making on Digital DIY, through models and guidelines driven by social and cultural strategies.[2]

The project will study how DiDIY is reshaping work and education fields, creative society and legal system. In the specific case of education field, the DiDIY project will explore how this trend will generate new teaching and learning approaches and opportunities, from primary schools to universities, in order to produce useful results primarily for European policy-makers dealing with education and research systems.

We, as partner of the project, are leading a transversal research to explore the dynamics facilitating the acquisition of skills and 21st century competences in this practice.

Starting from the case studies analysis we defined a model to understand how the learning process take place during making activities, what kind of competences are developed and which is the role of the different stakeholders involved. This model will be used for enabling the replication and adaptation of such dynamics into the education system and other environments related to the project.

The defined research model takes into account the interplay of digital DIY main expressions enacting on different levels also addressed above, which include:

[2] http://www.didiy.eu/

1 Digital DIY as a phenomenon of social innovation for the fundamental role of collaboration and sharing;

2 Digital DIY as a practice carried out by the individual connecting materials, meanings and competences;

3 Digital DIY as a creative process, developed through cognitive tasks.

Following the literature research and the debates on DiDiY as a skilling practice we propose that three are the main factors which influence such learning and skilling process across the three levels above:

- Technology, both facilitating the connection of people and the accessibility to tools with appreciable results in a relatively short-term
- Motivation, in terms of willingness to participate and to collaborate (either for the rewarding sensation of being with the others or for social impact) and of self-organization (commitment to the practice)
- Collaboration, both with peers (i.e. other digital DIYers) and with facilitators (who are acknowledged as so by the digital DIYers).

The interlink of this factors and the three levels above, are of fundamental importance for the facilitation of dynamics that we will observe in the places where digital DIY is carried out, in order to deliver the model above.

We suppose that each dynamic will display the specific skills performing in that crucial situation and each skill will be identified by using ad hoc (co)design-driven tools specifically developed by the research team.

We propose co-design as methodology to investigate the DiDIY project due to its collaborative nature and for the ability of this method to explicit people's tacit needs, desire and aspirations for the construction of new possible futures. Co-design is a research approach which involves non-trained designers in activities, or collaborations, for the development of solutions that aim at improving their lives with the support of professional designers or, as in this case, with design researchers. Collaboration is key element of the process and knowledge is produced and shared as a collective action.

In this perspective, people are considered all the way as co-design researchers and companions. The division between expert designers and the laypeople becomes blurred and so do the borders between research and practice. In order to do so, Scheldeman (2012) suggests that the designers should allow for "meaningful relation… design should not prescribe or predict, but enable."

Enabling may result a challenging task for professional designers and this calls for suitable toolboxes and modes of experimentation, which may not still exist. In our case, we planned to use co-design methods and tools to facilitate the skilling process and then to make use of human-centred co-design workshops for the transfer of the research model and its dynamics in the education field and the other thematic area of the DiDIY project. Two series of four workshops each one per area of the project, will be held in two different European countries (one in Northern Europe and the other in Southern Europe).

The first set of workshops will be explorative, aiming at exploring and understanding the skilling dynamics in the selected area on investigation, while the second set of generative workshops will aim at delivering solutions for implementing the skilling processes. For instance, a teaching module for primary school or a toolkit for professionals.

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