D4.1. RESEARCH SPACE AND AGENTS

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Executive summary

Deliverable D4.1, “Research Space and Agents”, consists in background research on European educational and research institutions, as well as on DiDIY cultural movements, and aims at exhaustively listing the current uses of DiDIY-related technologies in European education and research, and creating a map of these uses. On this basis, this task is also directed towards selecting representative samples of the different agents implicated in the application of DiDIY-related technologies in European education and research (e.g., students, teachers, researchers, etc. from different disciplines and countries)..

This deliverable is coordinated and submitted together with D4.2, “Complementing background knowledge”.

Note on contributors

This deliverable is the result of a collaborative work and, besides partners, leader Ab.Acus would like to acknowledge the contributions received by Maria Assunta Zanetti and Davide Natali.

Revision history			
Version	**Date**	**Created / modified by**	**Comments**
0.0	13/06/15	ABACUS	First draft, resulting from several online documents to which all partners contributed. Informal distribution to partners via Hackpad.
0.1	15/06/15	FKI	Extensions (in particular the section on the Hackers) and fixes.
0.2	16/06/15	ABACUS	First formal distribution to TB.
0.3	22/06/15	POLIMI	Extensions (in particular the section on the Makers) and fixes.
0.4	25/06/15	ABACUS	Second formal distribution to TB.
1.0	30/06/15	LIUC	Approved version, submitted to the EC Participant Portal.

Table of Contents

1. Introduction

DiDIY in education is currently being used in many different ways, and for the sake of the Project, and trying to give shape to a magmatic movement that so far has not been fully explored, D4.1 will be structured starting from the pedagogical framework of the use of DiDIY in schools, then on the policies expressed by high level politicians regarding education. From the theoretical field, the document will then explore uses of DiDIY in real life education institutions, from holistic experiences to more specialized ones, and also taking into account some special groups that have benefited from DiDIY education.

On the basis of the Project Grant Agreement, for the sake of D.4.1 and D.4.2 the area of analysis is focused on Atoms and Bits Convergence (ABC) and expressly excludes further areas such as new literacies (such as blogs, websites, social media, etc) as well as self-made videos or educational tutorials, which represent tools exploited by DiDIY and DiDIYers in education, but are also better known and already well analysed by scholars.

1.1 Terms and acronyms

CAD	Computer-Aided Design
CSS	Cascading Style Sheets
DIY	Do-It-Yourself
DiDIY	Digital Do-It-Yourself
FLL	First Lego League
GA	Grant Agreement
HTML	HyperText Markup Language
ICT	Information and Communication Technologies
LCD	Liquid Crystal Display
MIT	Massachusetts Institute of Technology
PHP	PHP: Hypertext Preprocessor
RCJ	RoboCup Junior
STEM	Science, Technology, Engineering, Mathematics
STEAM	Science, Technology, Engineering, Arts, Mathematics

2. 21st Century Challenges in Education

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.

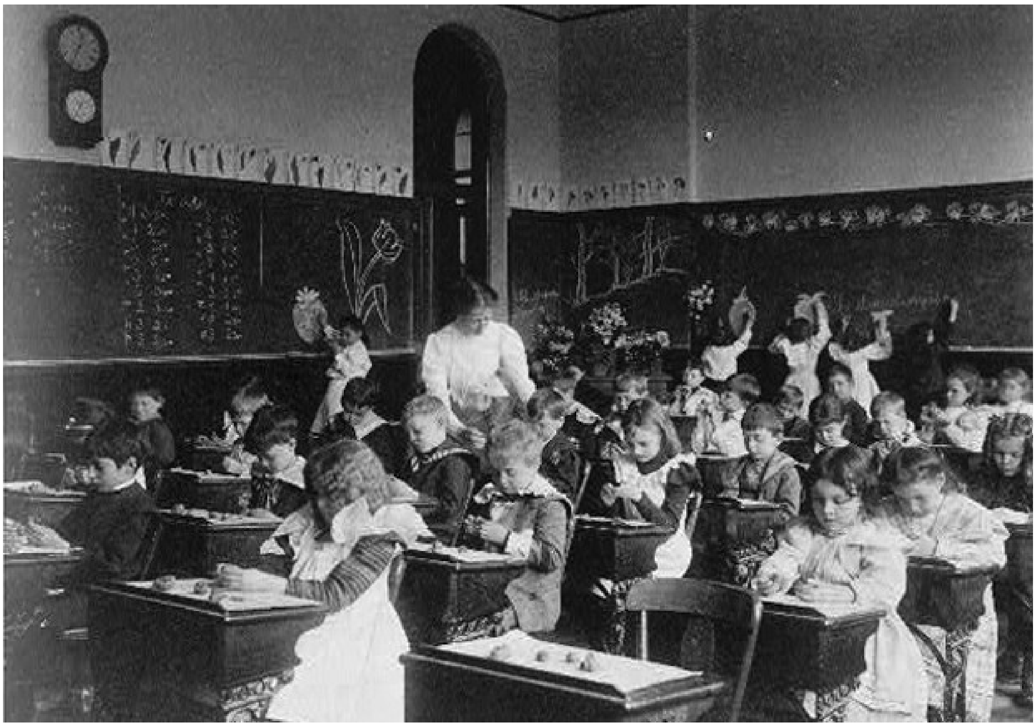

Figure 1 – An Italian class at the turn of the century.

Now, since the Information Age took over from the Industrial Age, the educational models are being forced to follow that changeover. Unfortunately, the role and the form of higher education have hardly changed; aside from PowerPoint presentations replacing most writing-on-a-blackboard styled ones. In the digital age the learning environment is completely blown open.

The advent of new digital technology and social media is fundamentally reshaping our living and learning, and its combination with 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 huge consequences on education.

While the impact of computers and social media (often called “new literacies”[1] or “digital literacies”) in education has been thoroughly investigated by scholars and has been hugely used in education at all levels, due to the novelty of the technologies involved, DiDIY in education is much less a subject of research, and the following paragraphs represent a merging of studies separately

1 First appeared in Buckingham, D. (1993), pp. 20-25.

conducted on how to use computers, social media, new literacies, Arduino, 3D printers, etc as learning tools.[2]

It is important to notice that the segment of society that usually first adapts to the "new" is the young, as they tend to be most open to new experiences. We see youth becoming much more involved in exchanging information and knowledge over the web than ever before. Consequently, we are finding that students are learning much more in these informal environments because they are voluntarily engaging in information, which they find interesting[3] and the creation of physical outputs reinforces their interest in engaging in such activities.

According to a 5 year old US survey[4] (thus we should expect daily time spent on new media to be even higher), the average 8- to 10-year-old kids devotes approximately 8 hours a day to a variety of different media contents, while older children and teenagers devote >11 hours per day.

Adolescents now spend more time with media than they do in school – it is the principal activity for children and teenagers other than sleeping. TV still remains the predominant medium of choice (>4 hours per day) but almost 1/3 of the TV programming gets viewed on non-TV platforms such as computers, tablets, or cell phones.

Practically all youngsters have access to the Internet (84%), usually high-speed, and 1/3 have access in their own bedroom. The time spent on a computer amounts to 1.5 hours per day; out of which half is spent in social networking, playing games, or viewing videos. New digital technology has made a huge impact on the life of youngsters: 75% of 12- to 17-year-olds now own cell phones, up from 45% in 2004. Teenagers mostly access social media sites from cell phones. They are also avid multitaskers, often using several technologies simultaneously.

According to Eurostat, the percentage of European young (from 16 to 24 years old) that are proficient with the internet is high: statistics say 95% have browsed, 88% sent an email, 70% posted messages to chat rooms or blogs, 34% shared files peer-to-peer.

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.[5] 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: they compete with a more fluid learning that takes place in recreational space.

On the other side, for its very practical nature, DIY, and then DiDIY, has been and is used as a learning tool in education, from kindergarten to higher education. When students are making something, the object they create is a demonstration of what they have learnt to do, providing evidence of their learning. The opportunity to talk about that object, to communicate about it, to tell a story about it is a way to learn, while at the same time we teach others[6]. This learning strategy is

2 In general, 21st Century pedagogy is more focused on the learning than on the teaching.

3 Mladen Milicevic (2015).

4 Rideout (2010).

5 Papert (1992), p. 86.

6 Dougherty (2012).

one of the positive aspects of the maker movement to education that John Dewey, a psychologist and education reformer, called “learning by doing” approach.[7]

The basis for the use of DiDIY in education is mainly related to constructionism, which uses Piaget’s theories of *constructivist* learning as a foundation (learners actively construct knowledge from their experiences in the world) but builds on that foundation by recognizing that new knowledge is constructed more effectively when the learner is engaged in making things that are personally meaningful.[8]

Seymour Papert, one of Piaget’s protégés at the University of Geneva, is internationally recognized as the seminal thinker about ways in which computers can change learning. Dr Papert pursued mathematical research at Cambridge University from 1954-1958. He then worked with Jean Piaget at the University of Geneva from 1958-1963. It was this collaboration that led him to consider using mathematics in the service of understanding how children can learn and think, which he called *constructionism*.[9]

In the early 1960’s, Papert went to MIT where, with Marvin Minsky, he founded the Artificial Intelligence Laboratory.

In Papert’s constructionism the construction of knowledge happens remarkably well when students build, make, and publicly share objects (Blikstein, 2013).

Constructionism is based on four pillars that represents four important dimensions that must be carefully investigated in order to better understand and improve the role of DiDIY in education.

The four pillars of constructionism are:[10]

- learning by designing meaningful projects and sharing them in a community;
- manipulative objects for supporting the development of concrete ways of thinking and learning about abstract phenomena (object to learn with);
- powerful ideas from different realms of knowledge;
- self-reflective practice: documentation is a wonderful vehicle for making self-reflection concrete and being able to share its products with others.

Constructionist approaches to learning are characterized by three “ways of knowing”, as Martinez & Stager[11] described:

- making as an active construction that entails working on a planned “product”;
- tinkering as a “mindset” involving a playful approach to solving problems through “direct experience, experimentation, and discovery”;

7 An example is: KitHub Designed to Empower Young Innovators, http://dmlcentral.net/blog/howard-rheingold/kithub-designed-empower-young-innovators .

8 Resnick (1994).

9 http://web.media.mit.edu/~papert/ .

10 Bers, Ponte, Juelich, Viera, Schenker (2002).

11 Martinez, Sylvia Libow; Stager, Gary S. (2013).

- engineering as extracting “principles from direct experience,” bridging intuition and formal aspects of science.

By using this constructionist approach, students are engaged in learning by applying concepts, skills, and strategies to solve real-world problems that are relevant and personally meaningful.[12]

In the process, learners engage in problem-solving, decision-making, and collaboration[13] and do not fall into the so-called “banking education” described by Freire: *Instead of communicating, the teacher issues communiqués and makes deposits which the students patiently receive, memorize, and repeat. This is the "banking" concept of education, in which the scope of action allowed to students extends only as far as receiving, filing, and storing the deposits*.[14] Papert stated “The computer is the Proteus of machines. Its essence is its universality, its power to simulate. Because it can take on a thousand forms and can serve a thousand functions, it can appeal to a thousand tastes”.[15]

He also considered that computers could be the origins of a major change in education, and later,[16] Papert highlighted the two major causes that, according to him, hampered the full exploitation of the potential of computers in education:

- computers were secluded from classrooms into so-called “computer labs” and informatics was taught as a subject in itself and not as a cross-cutting tool to be exploited in other subjects. This resulted in very little impact (computer aided instruction vs progressive educational technology);
- the purchase of computers was centralized at the level of administration, thus taken away from innovative teachers and computers became a sort of status symbol rather than an educational tool.

Besides, the presence of FabLabs in schools and the exploitation of technologies such as 3D printers and related graphic software as well as electronic DIY boards such as Arduino and Raspberry Pi, allows to move away from this direction.

12 This is also in line with the Reggio Children approach, cfr. Rinaldi, Carlina. (2006) or Edwards, Carolyn, Gandini, Lella, & Forman, George (eds.) (2012).

13 Bers, Ponte, Juelich, Viera, Schenker (2002).

14 Freire, Pedagogy of the Oppressed, p. 58.

15 Papert (1980), p. 46.

16 Papert (1993), p 62.

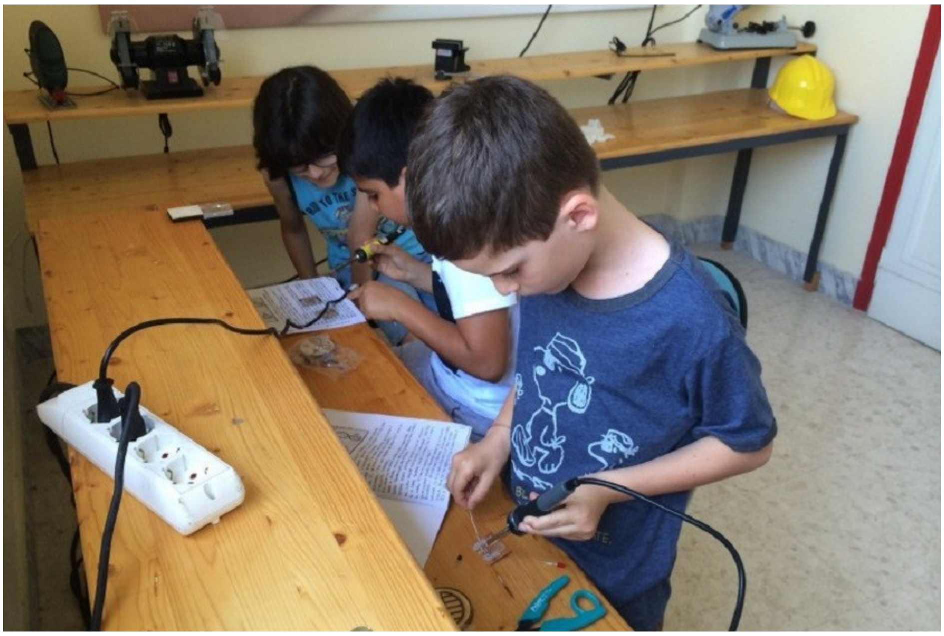

Figure 2 – A FabLab in primary school (www.innovaitongym.org).

In this framework the Make-to-Learn effort leverages DIY culture, digital practices, and educational research to advocate for placing making, creating, and designing at the core of educational practice. The broader vision of Make-to-Learn is an educational ecosystem that incorporates these practices as a means to engage and inspire all young people towards lifelong collaborative learning, experimentation, and invention.

A related aspect to be taken into account concerns how the learning process takes place during Make-to-Learn activities and which is the role of the different stakeholders involved. The learning process and the stakeholders involved are different according to the activities, the space and the tools used.

For example, in communities of practice members have a shared discipline or domain about which they share ideas, insights, and experiences – participants learn from others' prior frustrations.[17] The community served to alert members to false paths and unproductive approaches when trying a new project.

In other learning environments, such as schools or after-schools, teachers and educators have the important role of facilitators.

Brahms and Crowley suggest that effective facilitation involves: "skill and knowledge of the materials, tools, processes, and practices of making; strategies for facilitating children's development of accurate knowledge, skill, and progressive engagement in the learning practices of the making community; and an understanding of the child as a learner, his or her prior experiences, interests, intentions, and temperament. […] children, adult family members, and educators must work together as learning partners in order to foster young children's meaningful learning experiences through making in designed informal learning environments.".

17 Wenger (1998).

Based on a range of examples of family learning in the museum makerspace, Brahms and Crowley speak of the distinct and potentially complementary roles played by educators and family members in supporting children's making.

"As informal learning environments and opportunities are designed for learning through making, we must be thoughtful about how the relative expertise of consequential adults in a child's learning experience is drawn upon and positioned relative to others' expertise. This suggests that children, adult family members, and educators must work together as learning partners in order to foster young children's meaningful learning experiences through making in designed informal learning environments.".[18]

Finally, creativity, one of the most valued 21st century skills, is greatly about the ability to make things, whether physical or virtual, and is one of the targets of DiDIY in schools. Engendering creativity will require blurring the boundaries between disciplines and between formal and informal learning environments. To fully exploit the potentials of the use of DiDIY enabling technologies in schools, they are matched with student-to-student teaching, project-based learning, and self-centred learning environments and technology can be included into every subject and at all grade levels, which allows unprecedented levels and types of collaboration and learner to learner connectivity.

As noted by E. Yi-Luen Do, and M. Gross 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.[19] Students draw on their personal experience and needs as a primary source for creative exploration in the design environment.

18 Brahms and Crowley, 2014.

19 Do and Gross (2007), p. 29.

3. Educational policies

Most industrialized Countries consider that STEM subjects have to be incorporated in curricular activities at school. Still, most of the discussion that emerged when computers were "incorporated" in education, can now be seen in DiDIY, also taking into account that in 1999, the United States National Research Council issued a report stating that technology was changing too fast for the "skill-based" approach to be effective and instead called for a "fluency" approach. Besides the risk that national education systems and school have in investing in rapidly obsolete technologies is high, and this is the reason why they suggested technological education to include the development of adaptive, foundational skills in technology and computation, in particular "capabilities to empower people to manipulate the medium to their advantage and to handle unintended and unexpected problems when they arise".[20]

3.1 USA

"Teachers and principals in schools from Tennessee to Washington, D.C., are making big strides in preparing students with skills for the new economy – problem solving, critical thinking, science, technology, engineering, and math. Some of this change is hard…But it's worth it – and it's working" – President Barack Obama January 2014.

Redesigning high schools to teach real-world skills: President Obama has called for a comprehensive effort to rethink the high-school experience, challenging schools to scale up innovative models that personalize teaching and learning so students receive the rigorous and relevant education needed to graduate and transition into postsecondary learning and careers.[21]

Among the challenges launched by President Obama, The High School Redesign initiative will promote a rethinking of the high school learning experience, also exploiting the potentials of DiDIY, notably to:

- redesign academic content and instructional practices to align with post-secondary education and careers and to foster deep understanding and mastery, with student-centered learning in a culture of high expectations;
- personalize learning opportunities to support the educational needs and interests of individual students, optimize the pace of learning, and customize content and practices for students to master challenging academic content and pursue their interests;
- provide career-related experiences or competencies such as organized internships or mentorships; project- or problem-based learning; real-world challenges developed in consultation with employers or service organizations; and structured work-based learning opportunities;

20 National Research Council (1999).

21 http://www.ed.gov/news/press-releases/fact-sheet-redesigning-americas-high-schools .

- strategically use learning time in more meaningful ways, which could include effective application of technology, redesigning school calendars, and competency-based progression.

3.2 Europe

In Europe, also following a strong attack by Google's chairman,[22] the UK Government has launched a very ambitious plan to make the country the most advanced in the use of technologies for educational purposes. ICT curriculum has been changed and made more in line with the DiDIY perspectives: From the age of 5, children will learn to code and program, with algorithms, sequencing, selection and repetition; from 11, how to use at least 2 programming languages to solve computational problems; to design, use and evaluate computational abstractions that model the state and behaviour of real-world problems and physical systems; and how instructions are stored and executed within a computer system. Besides, after a pilot across 21 schools in 2012 to 2013,[23] a new scheme was launched, inviting teaching schools all over England to apply for a 3D printer and up to £5,000 funding – for use not just in design and technology lessons, but across the sciences, computing, engineering, mathematics and design.[24]

France too has launched a variety of initiatives within schools calling for the wide use of technologies in education,[25] though most of it is centred on computational sciences rather than on DiDIY, while the new minister of education in Italy, in her presentation of the guidelines before the Parliament called for the use of Arduino, 3D printers, etc.[26] The Italian Ministry of Education was also supporting schools that wanted to include one hour of coding in their activities, as part of the coding international movement.[27]

22 Robinson, James. (2011).

23 Results of the pilots can be found at https://www.gov.uk/government/publications/3d-printers-in-schools-uses-in-the-curriculum .

24 https://www.gov.uk/government/speeches/michael-gove-speaks-about-computing-and-education-technology .

25 http://eduscol.education.fr/cid59743/les-sites-ressources-pour-le-numerique-par-discipline.html .

26 www.istruzione.it/allegati/2014/linee_programmatiche_giannini.pdf .

27 http://hubmiur.pubblica.istruzione.it/web/ministero/cs230914 .

4. Applied Policies in schools

Although there seems to be a common vision in most industrialized countries on the importance of the inclusion of DiDIY in education, there are many different approaches that are currently being implemented. Indeed what follows is a tentative categorization that has all the limits of categorizations, with particular reference to the fact that the phenomenon we are observing is very fluid and the different (and interrelated) aspects of DiDIY can again reshape it. Just to give a tentative shape to this magmatic movement, the following chapter is divided in three main categories:

- DiDIY activities that take place in schools as curricular activities (and often involving multiple subjects);
- DiDIY activities that take place in schools as extracurricular activities (and often linked to competitions that were purposely designed as learning experiences);
- DiDIY activities that were envisioned outside schools (also through Manifestos) and are often linked to Movements but are now becoming (or could become) part of school activities.

As in all real-life experiences, in most cases DiDIY activities are a mix of those categories.

4.1 Holistic Curricular Activities

The recent installation of FabLabs in a growing number of schools has extended the constructionist approach into formal education institutions, thereby enabling a pioneering community of children and young adults to build new literacies that help them shape their digital and physical worlds. The effective integration of DiDIY in schools has so far allowed students to follow their natural curiosity about how things work and their natural interest for making things they want or need, scaffolding them on a journey through Science, Technology, Engineering, and Math (STEM).

In particular, 3D printers are gaining popularity internationally across STEM education. In many countries like the UK, Italy, France, Germany, the technology has been firstly made available to Design and Technology classrooms, where the use of 3D printers was immediately perceived as useful to curricular activities. There is considerable potential, however, for them to be used within a range of STEM subjects, particularly for cross-curricular work. The 3D printer is ideally suited to project work, where learning arises naturally as part of an investigation or construction project. Technical teachers were more familiar with this type of teaching, where pupils spend time on individual project work. In technical schools it is common for pupils to be given a design brief and be expected to make personal choices about the design, which they then test out for themselves.

Figure 3 – 3D printing in school.

This contrasts with common teaching practice in science and mathematics. Here the focus is frequently on teaching concepts discretely and in depth. Where physics and maths teachers engaged with use of the printers successfully, they did so to promote thinking, reasoning and understanding of their subject, although in schools such as the Italian Liceo, the lead engagement of 3D printing in the schools frequently came from the technical staff, who organised the printing for mathematics and science teachers. This allowed teachers from other STEM areas to see how their subject could make use of the printer.

This approach is gaining momentum also internationally and is exploited in Africa by the Youth for Technology's 3D Africa Program to encourage girls in Africa to get into science and engineering through 3D printing.[28]

4.2 Curricular non-holistic activities

4.2.1 3D printing in Math

Most commonly 3D printing has been used to help students envision graphs and mathematical models. This is the case of many shapes, fractals, as well as graphics. Most importantly though, 3D printing brings a "cool" factor into a subject which is perceived as boring.[29]

28 http://techcrunch.com/2015/01/26/3d-africa/?ncid=rss&utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+Techcrunch+%28TechCrunch%29 .

29 http://www.ms.unimelb.edu.au/~segerman/papers/3d_printed_visualisation.pdf cfr. the Simon Foundation video [http://www.simonsfoundation.org/multimedia/3-d-printing-of-mathematical-models] on this.

(a) The gyroid, a triply periodic minimal surface discovered by Alan Schoen.

(b) A Seifert surface with boundary the Borromean rings.

Figure 4 – Mathematical visualizations (designs by Bathsheba Grossman).

4.2.2 3D printing in Geography/Geology

3D printing is an excellent way for students to better understand geological formations on a scale that is not presentable through 2-dimensional images. There are many interesting 3D printed geological forms that come to the aid of those studying geography and geology.[30]

Figure 5 – 3D printed geological formations.

4.2.3 3D printing in History

30 http://andrewshears.com/2015/02/18/3d-printing-topographic-map-from-dem .

History is a subject that has a lot to gain through 3D printing technology. Museums all over the globe are exploiting the potential that 3D scanning and printing can have on not only making replicas of ancient artefacts, but also backing them up and providing a more hands-on feel of them.

Figure 6 – From pictures to 3D printing.

4.2.4 3D printing in Art

3D Printing provides a brand new method of creating art. With 3D printing available in art classes around the world, our future artists will be the ones to really help the technology reach its potential in many of the different fields of art out there.

Figure 7 – "Zootrope" by student Michael Lainég.

4.2.5 DIY electronics such as Arduino, Raspberry Pi, etc

Raspberry Pi and Arduino were both originally designed to be teaching tools, which is why they have become so popular, both devices being very easy to learn to use. "Programme or be programmed" is the recent rhetoric arguing for the education system to shift the curriculum balance away from generalised use and consumption of IT applications to the design and construction of IT systems, specifically to computer programming.[31]

The development of several highly affordable single-board computers, such as the mentioned Raspberry Pi and Arduino, running standard operating systems and language compilers, often open

31 Grover, Pea (2013).

source and open hardware, and capable of interfacing easily with motors and sensors, suddenly makes this eminently practical and allows schools and universities, at practically every level, to engage in authentic software tasks and projects.

In many cases, the use of DIY electronics in school is also related to the so-called “flipped classroom” a popular term and a pedagogical strategy that replaces the standard lecture-in-class format with opportunities for students to review, discuss, and investigate course content with the teacher or lecturer in class. The underlying premise is that students review lecture materials outside the classroom and then come to class prepared to participate in learning activities guided by the lecturer or teacher. Whatever the specific context, “flipping the classroom” relies heavily on technology, both popular technology and learning technology.[32] The flipped classroom concept attracted considerable professional attention around 2012. Now research continues and may continue to inform subsequent developments. It represents an easy and coherent concept around which to attempt to optimise the value of personal contact between learners and teachers.

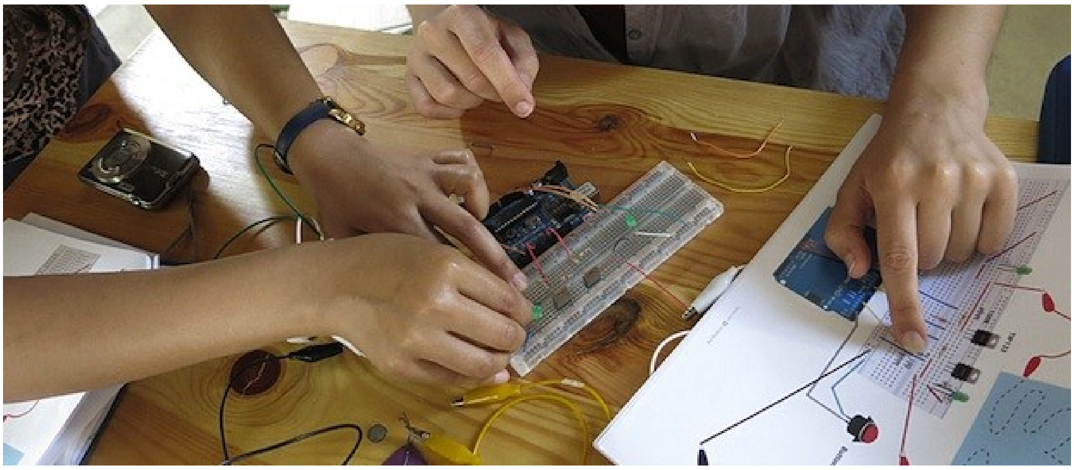

Figure 8 – Students working with Arduino.

4.3 Extracurricular activities – holistic approach

Among the many initiatives that deal with DiDIY in education, RoboCup Jr, and First Lego League seem to be the most interesting, as they both rely on the participation of teams that represent schools (thus, although in many cases extra-curricular, they rely on schools as primary venue for those activities).

4.3.1 RoboCup Jr[33]

More than twenty years ago, the birth of personal computers spawned a new era in the age of technology, and educational applications began to infiltrate classrooms. At the same time, Papert published these ideas in his book Mindstorms and introduced the notion of constructionism which

32 Shrestha, Moore, Nocera (2011).

33 http://rcj.robocup.org/index.html, http://www.rcjcommunity.org .

states that children learn best when they are actively involved in building something that is meaningful to themselves.

Figure 9 – RoboCup Jr final competition.

Meantime, his book Frames of Mind has been extremely influential in the field of education and has helped drive the trend in classrooms towards teamwork and projects that encourage and motivate different children with different needs.

RoboCup Junior aims at bringing together Seymour Papert ideas (a simple programming language that allows young students to learn geometry through computer-based exploration) with Howard Gardner's "theory of multiple intelligences" (which describes each human mind as a unique combination of talents expressed across a wide range of cognitive spheres), promoting project-oriented, team-based education, giving children with a variety of interests and abilities an opportunity to pick their own challenges while contributing to the progress of the whole.

RoboCup Junior is a project-oriented educational initiative that sponsors local, regional and international robotic events for young students up through age 19. It is designed to introduce RoboCup to primary and secondary school children, as well as undergraduates who do not have the resources to get involved in the senior leagues of RoboCup. The focus of RCJ is on education.

RCJ stands apart from other robotics programs for young students for several reasons. First, RCJ is focused more on *education* than competition. Second, the RCJ challenges remain the same from one year to the next, providing a scaffolded learning environment in which students can develop more sophisticated solutions as they grow and expand their knowledge. Third, the RCJ challenges – soccer, rescue and dance – are familiar; spectators can watch and understand what they are observing, without needing explanations of complicated rules. Fourth, RCJ delves more deeply into computer science and programming due to its emphasis on *autonomous* robots. Fifth, RCJ sits at the entry-level of the international RoboCup initiative, which is strongly committed to education and involvement of young people in technology.

RCJ parent, RoboCup, is an international effort whose purpose is to foster Artificial Intelligence (AI) and robotics research by providing a standard problem where a wide range of technologies can be integrated and examined. As well, the initiative serves as a basis for project-oriented education at all levels. The ultimate goal of RoboCup is that by the middle of the 21st century, a team of fully autonomous humanoid robot soccer players shall play (and win!) a soccer game against the (human) world champions.

RCJ offers several challenges, each emphasizing cooperative, problem-solving and task-achievement aspects. In the soccer challenge, 2-on-2 teams of autonomous mobile robots play games in a highly dynamic environment, tracking a special light-emitting ball in an enclosed field landmarked in shades of gray. The rescue challenge engages robots to identify victims quickly and accurately within re-created disaster scenarios, varying in complexity from line-following on a flat surface to negotiating paths through obstacles on uneven terrain. The robot dance challenge encourages creativity, bringing one or more robots together with music, dressed in costume and moving in harmony.

For children, the RCJ initiative provides an exciting introduction to the field of robotics, a new way to develop technical abilities through hands-on experience with electronics, hardware and software, and a highly motivating opportunity to learn about teamwork while sharing technology with friends. In contrast to the one-child-one-computer scenario frequently seen today, RCJ provides a unique opportunity for participants with a variety of interests and strengths to work together as a team to achieve a common goal.

RCJ is targeted for primary and secondary school students. There is no fixed minimum age, but primary students are expected to be able to read (and hence write programs for their robots) on their own, without significant help from adult mentors. Students over age 19 are not allowed on RCJ teams. The division between the primary and secondary age categories is 14 years old:

- teams with all student members age 14 and under are considered primary;
- teams where any student member over age 14 must be secondary.

RoboCup is held in Europe in the following countries:

Austria	http://robocupjunior.at	Alexander Hofmann alexander.hofmann@technikum-wien.at
Belgium	http://www.robocupjunior.be	Joachim Mathieu Vrije Universiteit Brussel Pleinlaan 2, B-1050 Brussel Tel: +32 2 629 12 63 joachim.mathieu@vub.ac.be
Croatia	http://www.robofreak.hr	Ivica Kolaric, uito@net.hr
Denmark	http://www.robocup.dtu.dk/junior	Ole Ravn Associate Professor, Head of Group, Head of Studies E.E. DTU Electrical Engineering Email: or@elektro.dtu.dk Tel: +45 4525 3560
Finland	http://www.robocupjunior.fi	Markku Tukiainen, markku.tukiainen@uef.fi
Germany	http://www.robocupgermanopen.de/junior	Martin Bader, martin_bader@gmx.de
Hungary	http://pingvin.nyf.hu/robojun/index_a.php	jelentkez.mirk@gmail.com

Italy	http://www.robocupjr.it	Giovanni Marcianò dirigente@robocupjr.it
Netherlands	http://www.robocupjunior.nl/en	
Portugal	http://robotica2015.utad.pt	President: Fernando Ribeiro University of Minho (Board of Trustees) fernando@dei.uminho.pt
Slovakia	http://robotika.sk/rcj/index.php?page=home	National Coordinator: Ing. Miro Kohút, kohut@skse.sk Link to the main organizer: Slovak Society of Electronics http://www.skse.sk/
Slovenia	http://www.robobum.uni-mb.si	robobum.feri@um.si izr. prof. dr. Aleš Hace Univerza v Mariboru Fakulteta za elektrotehniko, računalništvo in informatiko Inštitut za robotiko Smetanova 17, SI-2000 Maribor E-mail: ales.hace@um.si Tel.: +386 02 220 7301
Sweden	http://www.robocupjunior.se	Fredrik Löfgren, Tävlingsansvarig/Projektledare/Nationellt Ansvarig fredrik@eaproduktion.se frelo223@student.liu.se Tel. 070-35 71 658
United Kingdom	http://www.robocupjunioruk.org	John O'Neill, john_o_neill@live.co.uk or aterruli@gmail.com

4.3.2 First Lego League[34]

FIRST® LEGO® League (FLL) is a program that supports children and youngsters (of 10-16 years) in order to introduce them to science and technology in a sporty atmosphere.

The objective is to:

- make children and youngsters enthusiastic about science and technology;
- equip the participants with the idea of team spirit;
- encourage children and youngsters to solve complex tasks in a creative way.

The basis of FLL is a robotics tournament in a cheerful atmosphere, where kids and youngsters need to solve a tricky "mission" with the help of a robot. The competition consists of a research project (theoretical part) and the Robot Game (practical part), which the kids have to deal with as a team. Kids are researching a given topic within a team, they are planning programming and testing an autonomous robot to solve the mission.

The FLL Teams take the opportunity to experience all steps of a real product development process: solving a problem under time pressure with insufficient resources and unknown competitors. FLL is a small microcosm of real business life in all its respects.

34 http://www.first-lego-league.org/en/general/what-is-fll.html

Figure 10 – First Lego League contest.

The first edition was held in 1998, while the first European edition took place in Germany in 2001. In 2013 it was held in more than 70 Countries.

Austria	www.hands-on-technology.org	Stefanie Hauffe sh@hands-on-technology.de
Belgium	http://firstlegoleague.nl	Sander Ezendam S.J.B.Ezendam@techniekpromotie.nl
Bulgaria	http://firstlegoleague.gr	Kostas Vasileiou vasileioukostas@yahoo.com
Cyprus	http://firstlegoleague.gr	Kostas Vasileiou vasileioukostas@yahoo.com
Czech Republic	www.hands-on-technology.org	Stefanie Hauffe sh@hands-on-technology.de
Denmark	http://hjernekraft.org	Nina Sivertsen nina@firstscandinavia.org
Estonia	http://www.robootika.ee/fll	Heilo Altin heilo.altin@ut.ee
France	http://www.multimedia-meudon.fr/firstlegoleaguefr/index.html	Erwan Gallee sciences.asso.medio@gmail.com
Germany	www.hands-on-technology.org	Stefanie Hauffe sh@hands-on-technology.de

Greece	http://firstlegoleague.gr	Kostas Vasileiou vasileioukostas@yahoo.com
Hungary	www.hands-on-technology.org	Stefanie Hauffe sh@hands-on-technology.de
Ireland	http://firstlegoleague.theiet.org	Richard Pering RPering@theiet.org
Italy	http://fll-italia.it	Francesca Maffei maffeifrancesca@MuseoCivico.rovereto.tn.it
Latvia	http://fll.robotiem.lv	Heilo Altin heilo.altin@ut.ee Edgars Skruodis edgars.skruodis@gmail.com
Lithuania	http://www.bora.lt/mod/page/view.php?id=47	Ieve Jonaityte robotiada@gmail.com
Luxembourg	www.firstlegoleague.nl	Sander Ezendam S.J.B.Ezendam@techniekpromotie.nl
Netherlands	www.firstlegoleague.nl	Sander Ezendam S.J.B.Ezendam@techniekpromotie.nl
Poland	www.hands-on-technology.org	Stefanie Hauffe sh@hands-on-technology.de
Portugal	http://firstlegoleagueportugal.org	Ana Raquel Silva firstlegoleagueportugal@gmail.com
Slovakia	www.hands-on-technology.org	Stefanie Hauffe sh@hands-on-technology.de
Slovenia	www.fll.si	Natalija Premužič natalija@oranzno.si
Spain	www.firstlegoleague.es	Montse Bover mbover@learnbydoing.eu
Sweden	http://hjernekraft.org	Nina Sivertsen nina@firstscandinavia.org
United Kingdom	http://firstlegoleague.theiet.org	Richard Pering RPering@theiet.org

4.4 Outside the school – holistic approach

In recent years many activities regarding the use of DiDIY for educational purposes have proliferated in most industrialized countries, as well as in many developing ones. Interdisciplinarity is also a potential benefit of making as an educative practice. Sheridan et al. (in press) found that disciplinary boundaries are "*inauthentic to makerspace practice*" and that the "*blending of traditional and digital tools, arts and engineering can create a learning environment with multiple entry points that foster innovative combinations, juxtapositions and uses of disciplinary content and skill*" (Brahms & Crowley, 2014b; Sheridan et al., in press).

The most interesting movements are those of the Makers and those of the Coders, which both fall squarely within the object of our Project, still, the first tends to work within educational institutions, while the latter expressly works outside schools.

4.4.1 Makers[35]

Interestingly, the Makers have created a MakerEd Manifesto[36] that is very much in line with the pedagogical framework that has been illustrated in chapter 2 of this document.

The main characters of a maker are:

- intrinsically motivated;
- takes risks and iterates from “failures” to achieve success;
- collaborates and gives advice and guidance to her peers. Makers are often more interested in open sharing and exhibition, not simply competition.

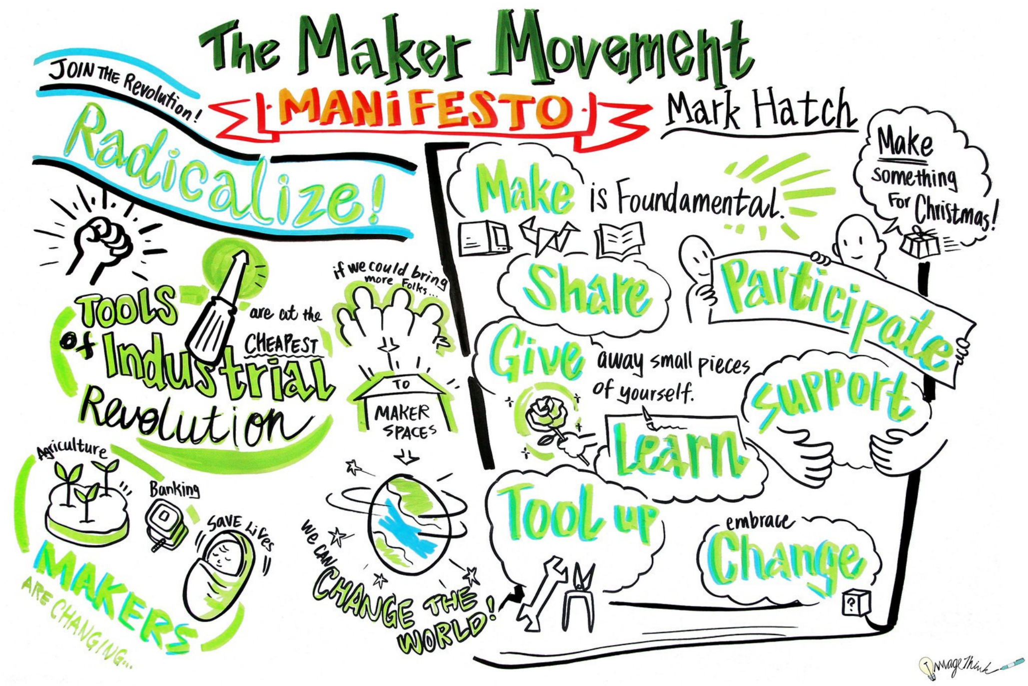

Figure 11 – The Maker Movement Manifesto - On McGrawHill Education Business Blog by ImageThink.

The aim of the Maker movement is not that of having some bits and pieces of DiDIY being included in curricular activities, while to transform education. Making creates a supportive community of learners that can leverage the interests and skills of each member of the group towards shared goals. Making has been organized to create supportive communities of practice and include encouraging collaboration and sharing.

Making as educative practice can support young people to participate in science programs and learning activities inspiring or creating experiences for others, advancing young people’s agency

35 Where Ed stands for Education. Full version at http://makered.org/resources/projects-learning .

36 https://docs.google.com/document/d/1mJogicg-SCdVTROgJnHzGjLC4jt2lACQiIAHpRoptuE/edit?pli=1 .

and authorship. Some researchers explicitly connect this dimension of making with the development of critical literacies.

According to literature Makers learning approach is studied from different points of view. Some researchers are concerned about the ways in which making activities relate to existing curricula while others are understanding if and how making can support student engagement in the scientific and engineering practices.

Vossoughi and Bevan[37] grouped the Maker Movement activity into three categories (Vossoughi, 2013).

- *Making as entrepreneurship and/or community creativity*. Learning is mostly based on Community of Practice – members have a shared discipline or domain about which they share ideas, insights, and experiences (Wenger, 1998) that help to extend, apply, and integrate skills and knowledge. Activities and interactions in Makerspaces are characterized by collaboration and innovation and are often highly valued resources in local settings. They provide individual entrepreneurs with access to the means of production. Industry leaders have championed such programs for developing the workforce of tomorrow by building young people's creative problem-solving capacities and positive STEM learning identities.
- *Making as a STEM pipeline and workforce development*. It generally engages high school and university students in engineering and design projects (Blikstein, 2013). Here, the focus is largely on providing opportunities for young people in school environments or as part of an extended high-school/university STEM curriculum. The goal of these programs is generally to support the development of engineering and other STEM skills, capacities, and interests emphasizing the development of skills such as problem-solving, critical thinking, and collaboration. Industry leaders have championed such programs for developing the workforce of tomorrow by building young people's creative problem-solving capacities and positive STEM learning identities.
- Making as inquiry-based educative practice. These programs may take place in classrooms, libraries, museums, after-school or community settings that have been pedagogically transformed into "making settings" as groups of individuals participate side by side or collaboratively in making a range of artefacts while drawing on interdisciplinary tools and modes of inquiry. It doesn't need to be located in spaces outfitted with expensive technologies and tools.

In order to bring the Maker movement to education, some specific ways have been individuated:

- creating the context that develops the Maker mindset, a growth mindset that encourages us to believe that we can learn to do anything;
- building a new body of practice in teaching making, and a corps of practitioners to follow it;
- designing and developing Makerspaces in a variety of community contexts in order to serve a diverse group of learners who may not share the access to the same resources;
- identifying, developing and sharing a broad framework of projects and kits based on a wide range of tools and materials that connect to student interests in and out of school

37 Vossoughi and Bevan (2014).

- designing and hosting online social platforms for collaboration among students, teachers, and the community;
- developing programs especially for young people that allow them to take a leading role in creating more Makers;
- creating the community context for the exhibition and curation of student work in relationship with all makers. Making sure that new opportunities are created for more people to participate;
- allowing individuals and groups to build a record of participation in the Maker community, which can be useful for academic and career advancement as well as advance a student's sense of personal development;
- developing educational contexts that link the practice of making to formal concepts and theory, to support discovery and exploration while introducing new tools for advanced design and new ways of thinking about making;
- fostering in each student the full capacity, creativity and confidence to become agents of change in their personal lives and in their community.

4.4.2 Hackers and Hackerspaces

While hackers may have a bad name in mainstream media, the term is actually referring to a person "who enjoys the intellectual challenge of creatively overcoming and circumventing limitations of programming systems and who tries to extend their capabilities".

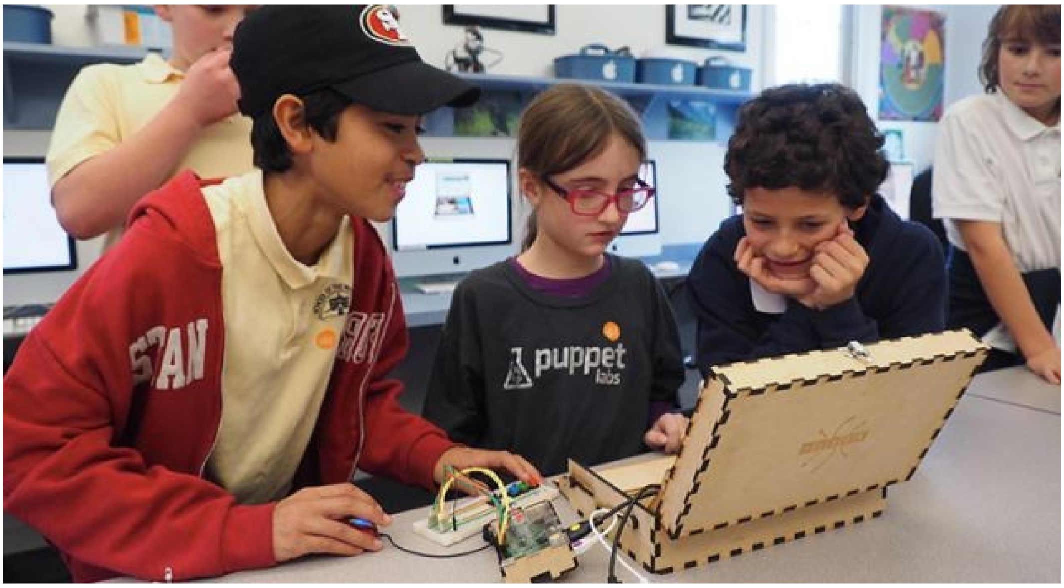

Figure 12 – Kids playing with hacker toolbox that teaches young people to build real electronics.

The idea of a "hacker ethic" is perhaps best formulated in Steven Levy's 1984 book, *Hackers: Heroes of the Computer Revolution*. Levy came up with six tenets:

- access to computers – and anything which might teach you something about the way the world works – should be unlimited and total. Always yield to the Hands-On imperative!

- all information should be free;
- mistrust authority – promote decentralization;
- hackers should be judged by their hacking, not bogus criteria such as degrees, age, race, or position;
- you can create art and beauty on a computer;
- computers can change your life for the better.

While hackers may work alone or from their homes, they also built so called Hackerspaces, being community-operated physical places, where people can meet and work on their projects. At the Hackerspace.org wiki the worldwide community maintains a list of all active spaces, and relevant projects. There are currently 1921 active hackerspaces listed on the site.

Hackerspaces teach classes on a wide variety of topics. Often people create their own pedagogy (class materials, teaching methods) for topics that have been well treated elsewhere.[38]

4.4.3 CoderDojo[39]

A Dojo is a local, independent, volunteer-led programming club that is a part of the global CoderDojo community. Topics covered in Dojos vary, based on the influence of the volunteer technical mentors in each Dojo, but commonly Dojos cover Scratch, an introduction to programming for young people and website development using HTML, CSS and PHP. Dojos also work with JavaScript, Python, Ruby and Node.js, work on game development, Minecraft mods and experiment with hardware and robotics such as Raspberry Pis, Arduino boards and Intel Galileos.

There is no typical Dojo and the activities run vary from club to club however they all show young people how to code and develop software, as well as themselves, and explore technology by working with others and presenting their work.

CoderDojo is a global movement which was originally founded by James Whelton and Bill Liao. It all started in James Whelton's school in early 2011 when James (then an 18 year-old coder) received some publicity after hacking the iPod Nano and as a result some younger students expressed an interest in learning how to code. He set up a computer club in his school (PBC Cork) where he started teaching students basic HTML and CSS. Later that year he met Bill Liao, an entrepreneur and philanthropist, who was interested in growing the project into something bigger.

In July 2011 the first CoderDojo was launched in the National Software Centre in Cork (Ireland), soon after a Dublin Dojo was launched, followed by more clubs across Ireland, before expanding outside the region. Through making the movement open source, thousands of dedicated Champions and Mentors have set up more Dojos across the world, making the CoderDojo movement a global phenomenon. As of May 2015 there are now over 675+ verified Dojos in 57 countries and growing every day. [40]

38 https://wiki.hackerspaces.org/Education .

39 https://zen.CoderDojo.com .

40 https://CoderDojo.com/about .

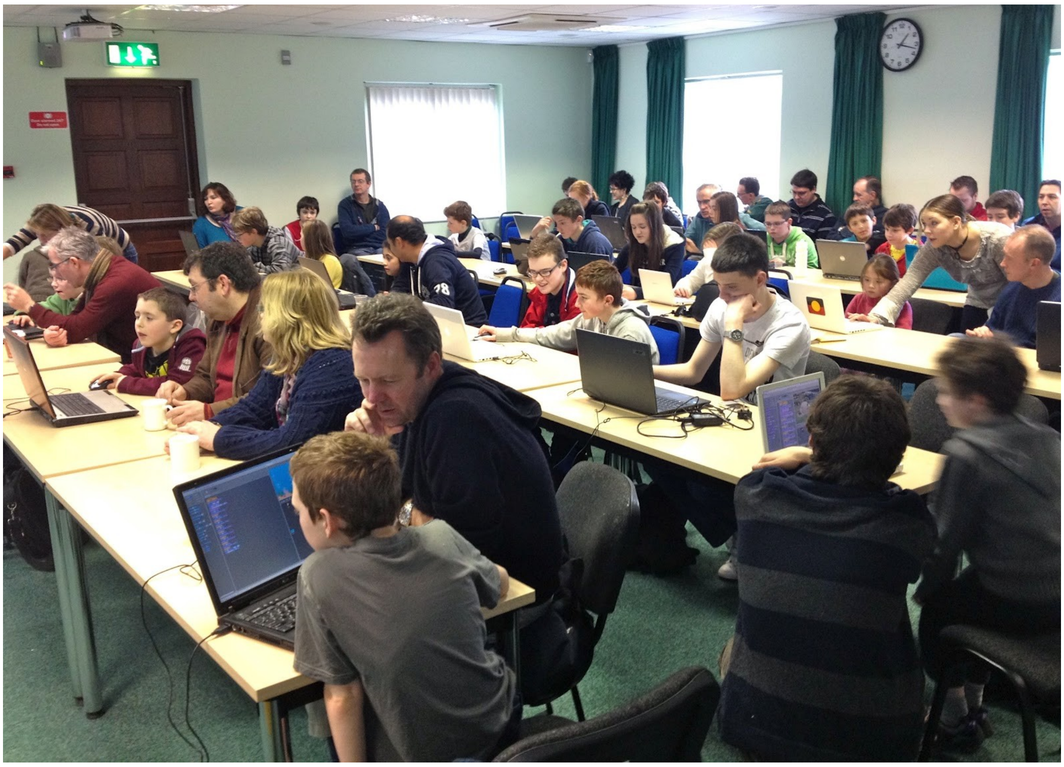

Figure 13 – CoderDojo in Buccinasco (Italy).

4.5 DiDIY in higher education and research

It has to be highlighted that the role of DiDIY in higher education and research has yet to be fully exploited, due to the novelty of the technologies involved (most students at this level did not have the opportunity to experiment the use of DiDIY technologies, nor are yet very proficient with the coding required. Besides, it is questionable whether the students at this level can still be regarded as DiDIYers or it would be better to define them as professionals or semi-professionals. Considering that the question is still unanswered, below is a very brief overlook on the possible uses of DiDIY in higher education and research.

For many universities, 3D printers have become an indispensable asset for promoting learning and education. This is particularly true for students that go to universities or higher education schools that deal with creative subjects such as architecture, design, fine arts. During presentations most students have models as well as renderings to show the design process, it shows the students and professors what works structurally and what just looks good, and 3D printers are considered a regular tool in student's everyday lives. Most students come from an educational background where they learnt how to use CAD, and this makes them fully DiDIYers.

A similar case can be found at engineering universities and schools, where students create their 3D model of specific parts and print them to see if and how it works. At the MIT, for example (and similar experiences are becoming common in many universities), students are using 3D printers in cutting edge ways that go beyond simple models. The mechanical engineering student describes 3D printers as a valuable research tool because they can help accelerate projects that would normally take time using conventional modelling methods. The technology also helps democratize processes that may be too technical for the average person when done the traditional way.[41]

For other subjects 3D printing is mainly used to visualize (atoms for chemistry, pathogens for biology, blood vessels or cancer cells for medicine, etc.) what is too small or hard to understand. In these areas, though, at least for the time being (this could well be the only generation of students that is not proficient with 3D designing, while the next generation in most cases will), it is hard to define the use made by students as fully fledged DiDIY, as they just replicate designs made by others.

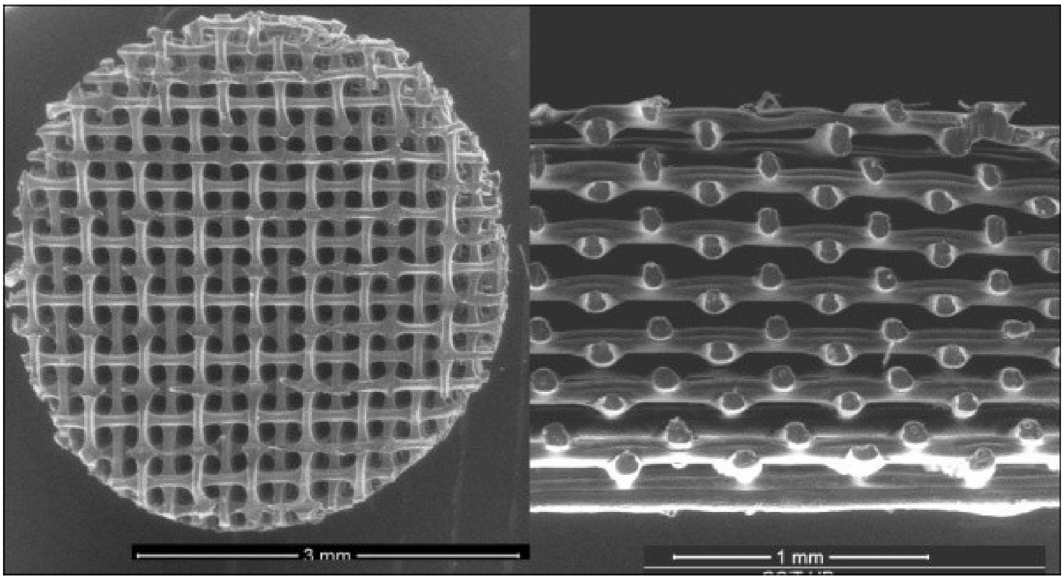

Figure 14 – 3D printed Bio-scaffolds.

In other very innovative cases of the use of 3D printing for research purposes, again it is hard to describe them as DiDIY due to the fact that the 3D printer is used as a professional tool by professionals, such as a joint research by Harvard-MIT Health Sciences and Technologies, where 3D printing used to produce proteins and human body tissues.[42]

The role of DIY electronics at this level is confined mainly to technical universities, and is often linked to an approach of the universities towards “open hardware, open software”.[43] Within these schools, industrial projects are currently using Arduino as a prototyping platform for modular robots and many prototypes are powered by Arduino including robotic fishes, drones, quadcopters, etc. Thanks to the introduction of Arduino as learning tool, students are involved with realistic problem settings and scenarios that reflect real application perspectives. Besides, in the framework of the “open hardware, open software” movement, students are also engaged in the construction (thanks to 3D printing combined with DIY electronics) of hardware to be used in labs.

41 http://www.engadget.com/2012/10/19/reshaping-universities-through-3d-printing .

42 https://hst.mit.edu/news-and-events/events/memp-thesis-defense-mark-scott .

43 http://en.wikipedia.org/wiki/Open-source_hardware .

4.6 DiDIY for special groups

Already in 1999, it has been mentioned by the Working Committee on Quality Indicators of national experts among the five major challenges with regard to quality and education in the European countries, stating: "All European education systems aim to be inclusive, to offer children and young people the opportunity to benefit from school education and to prepare them for life after school".[44]

Supported by scientific research in pedagogy and educational psychology, by legislative recommendations and directions (inclusion and participation are the main paradigm of the UN Conventions), by Ministries of Education directions of many nations, inclusion has become in the past twenty years one of the main focuses in teaching and learning. Appropriate methodologies have been created, curricula and didactic tools have been established to change the educational institution towards mainstreaming and integration.

In this context, the particular features of DiDIY makes it a very good tool to help students with different forms of disabilities overcome both their daily challenges as well as to better integrate them in their classes (or, as often referred to "special education").

At present the bibliography on the internet is almost non-existing, and tests and trials are being carried out in these very days. Still, there are already a few examples that are useful to highlight once again the versatility of the mind-set and technologies involved.

The most interesting example comes from the University of Warwick,[45] in the United Kingdom, which is helping students with physical disabilities from a local college become their own product designers so they can 3D-print personalised objects that help them in their everyday lives. By learning to use computer-assisted design technology through sessions with staff and students from the University of Warwick, a group of students with restricted physical movement have come up with solutions to every-day challenges such as eating and drinking which they can print out with the click of a button.

44 Working Committee on Quality Indicators, 2000 May http://aei.pitt.edu/42406/1/A6503.pdf .

45 http://www2.warwick.ac.uk/newsandevents/pressreleases/warwick_helps_students .

Figure 15 – Student Ollie Baskeran with the straw-holder he has designed and 3D-printed.

This example is of particular importance as it helps counter the fact that a large percentage of Assistive Technology devices that are purchased (35% or more) are subsequently abandoned: many studies have shown that the overall abandonment rate of Assistive Technology is high: 36% for dressing aids, 61% for crutches and up to 75% for hearing aids. High abandonment rates leave many individuals without the technology they need and waste time, money, and energy developing and purchasing technology that isn't used.[46] And to counter this very effect Hurst and Tobias called on the use of DIY: "A new generation of affordable rapid prototyping tools make it possible for individuals to build and customize physical devices such as wheelchair accessories, prosthetics, and tools to support activities of daily living such as eating, dressing, and accessing a computer. The success of online communities enables users to share designs, modifications, experiences and inspiration. By empowering individuals with the means and knowledge to create their own Assistive Technologies (and iterate on these designs as their needs change), they will have full control over most of the factors that are problematic in adoption (user opinion, speed of delivery, performance, and understanding user needs".[47]

Similarly[48] Buhler, E., Kane, S.K., and Hurst A. tried to apply DiDIY, and in particular 3D printing, to visually impaired people, and calling for the direct involvement of visually impaired and their assistant in the creation of materials (and not just the printing of something envisioned by someone else) that would also help them visualize shapes as well as Braille.

46 Phillips, B. and Zhao, H. (1993).

47 Hurst, A. and Tobias, J. (2011).

48 Buhler, E., Kane, S.K., and Hurst A. (2014).

Another example comes from Kochi, India,[49] where a group of girl students of BTech final year Electronics & Communication Engineering of Holy Grace Academy of Engineering, Mala, has developed a “Gesture Vocaliser” to help people with speech disabilities communicate through sound. S. Deepthi, Delna Domini, Minu Varghese and Nimya Varghese say their system enables people who are deaf and mute to talk with others.

“The device-based body positioning technique (mainly hand gestures) is used here. The aim of this system is to make a simple prototype by taking the gestures and converting it into audio and visual form so that it can be understood by everyone,” said Minu Varghese.

The model consists of an input part, a control section and the output part. “A hand glove attached with sensors (bend sensor to determine the bending of fingers and accelerometer to measure the tilting of hand) contributes the input part. The obtained values from the sensors are given to the control section. Arduino UNO is the control section used to compare these values with the reference values of standardized sign language and produce the corresponding pre-recorded output messages, both the audio and display. An audio processor attached with a speaker and an LCD display contributes the output section for both audio and visual outputs,” says Delna.

Even for Autism, there is a variety of DiDIY applications that span from the passive use of a robot, to more challenging activities and interactions with different kinds of technologies where autists are better able to express themselves thanks to “neutral” interfaces with whom they better interact with.[50]

On the other opposite of the spectrum, DiDIY is also used to include gifted students, in particular at the primary and intermediate school level, where the risks of gifted students drop out from school is high. DiDIY are used as common learning tools where gifted kids are included in teams with their classmates (so to create an inclusive team spirit) and in most cases immediately become leaders.

The trial and failure approach, the opportunity to demonstrate their fast elaboration skills, combined with a closer relationship with classmates (and they also learn how to interact with each-other and appreciate each-other’s qualities) has proved very effective to avoid the risk of gifted students drop out.[51]

49 http://globalaccessibilitynews.com/2015/05/04/students-develop-gesture-vocaliser-to-help-people-with-hearing-disabilities .

50 Paris hosts the international conference on Innovative Technologies (IT) for Autism (ASD), an annual event entirely devoted to new technologies and authism: http://www.itasd.org/?lang=en .

51 http://www.lastampa.it/2015/05/17/italia/cronache/a-caccia-di-piccoli-geni-hacker-e-scienziati-gi-dai-tempi-dellasilo-C74MYtYLh3NTROOkh3R67J/pagina.html .

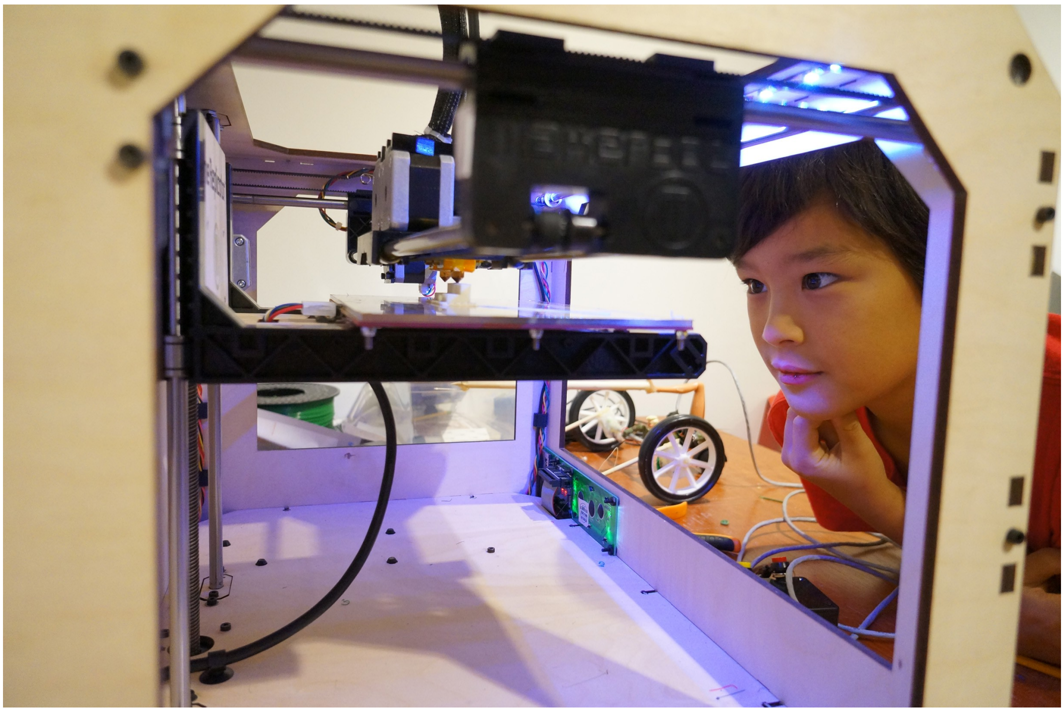

Figure 16 – Kid at work.

5. Google Trends

Researchers of the DiDIY deemed interesting to evaluate the search trends on Google of the major topics that have been described above as a tentative means to have a first evaluation of the interest of some DiDIY dimensions and technologies in education.

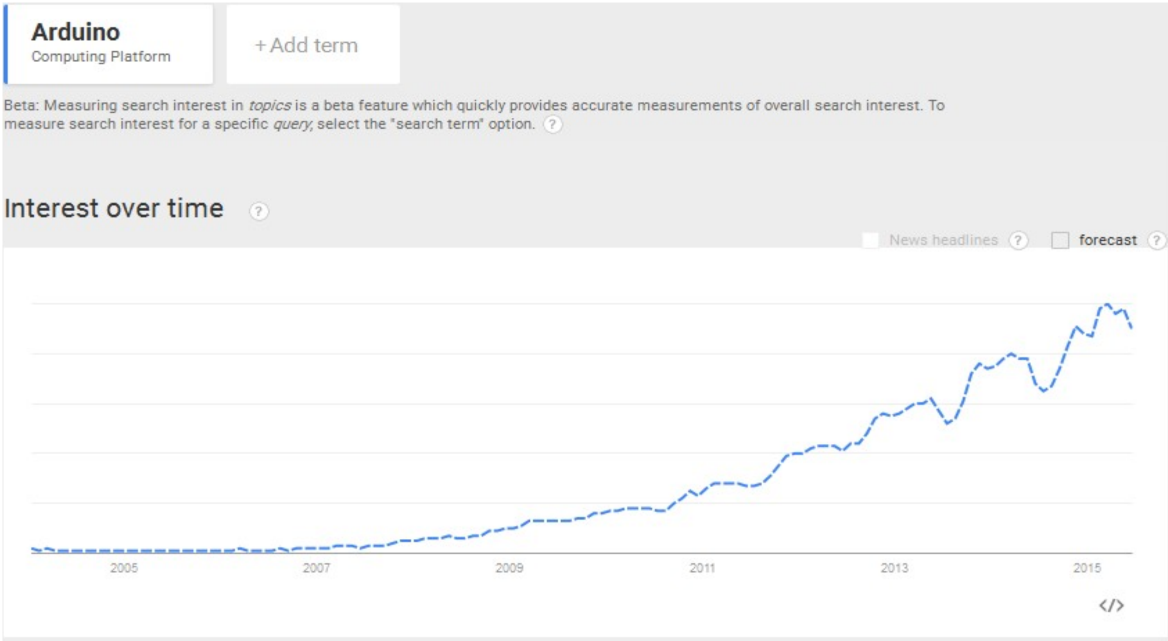

Figure 17 – Searching for “Arduino”.

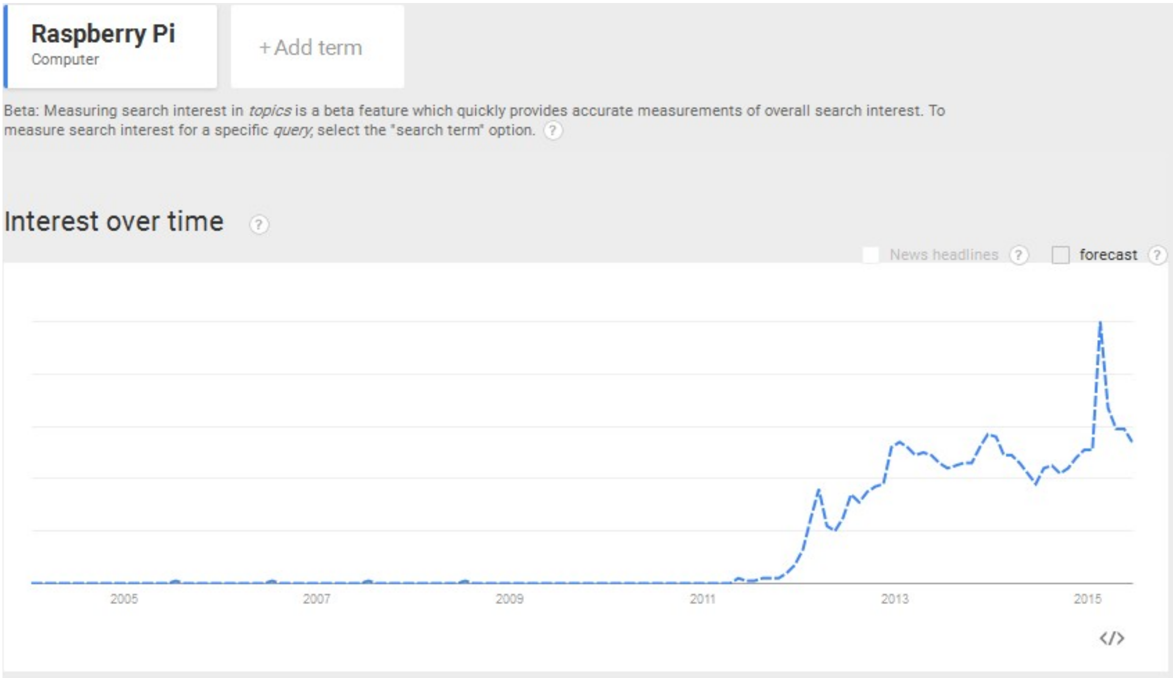

Figure 18 – Searching for "Raspeberry PI".

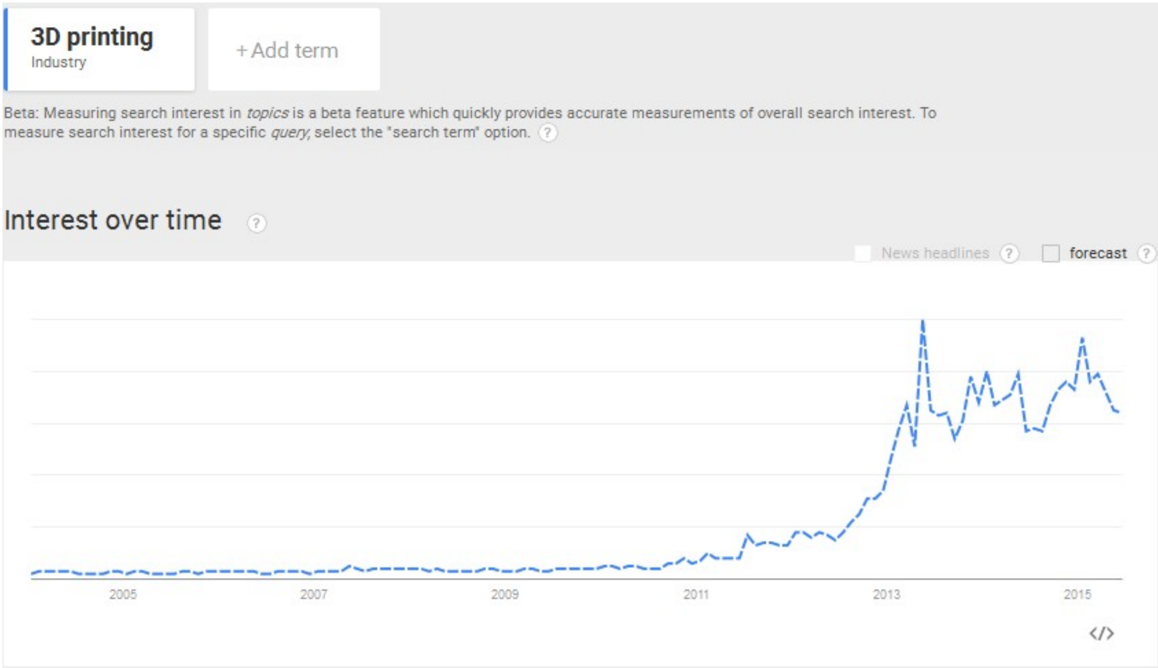

Figure 19 – Searching for "3D printing".

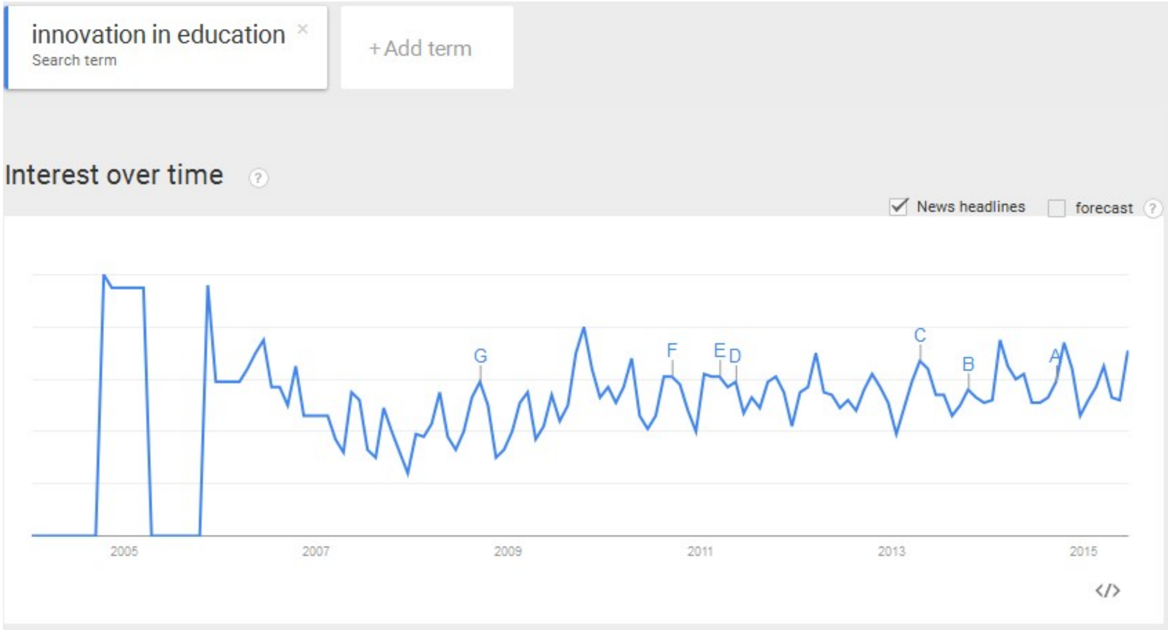

Figure 20 – Searching for "innovation and education".

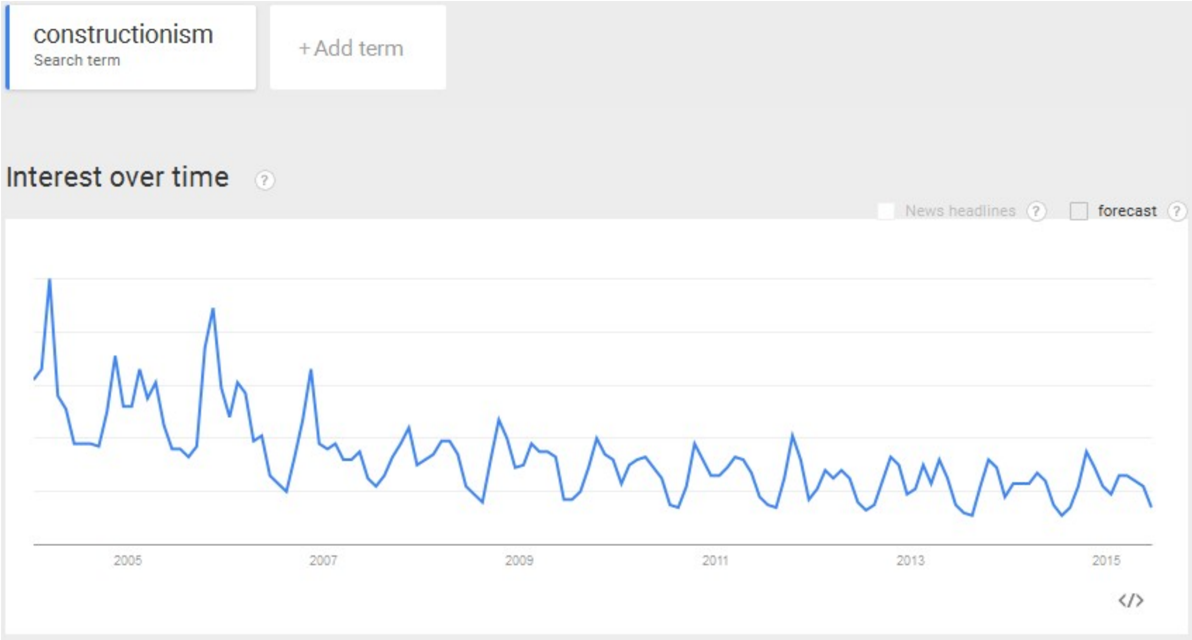

Figure 21 – Searching for "constructionism".

6. Areas of investigation

On the basis of the preliminary research hereby conducted, some areas of investigation seem very promising to better assess how DiDIY is used in education and research and to be better prepared for D.4.4. (Results derived from data collection and analysis).

a. The role of creativity

The many uses of DiDIY in education and research have one element in common: creativity has a crucial role and is often relieved from the burden of the actual “making” of the outputs (if you can imagine it, you can create it). Thus pupils really have the opportunity to work on their ideas, shaping them mostly in a non-physical environment, and even the last part of the process does not require them to have particular dexterity. How do teachers and students use this unique feature of DiDIY?

b. The role of sharing

Thanks to new social media and the growth of the Free Software and open source hardware movements (that are a fundamental component of DiDIY) pupils work on common projects and share working spaces with their colleagues-friends. Does this lead to new ideas or to conformism

c. The role of teachers

How can DiDIY be exploited to ease / emphasize the transition from a teacher / curriculum-centered school to a student / experimentation-centered education ("flipped classroom")? Is DiDIY also transforming the role of teachers accordingly? How? What new competences are expected from them? All these aspects need to take into account that DiDIY educational activities are also related to environments different from schools (such as labs, museums, robotics academies, etc.) and educators that are not teachers.

d. DiDIY and learning flows

How does the learning process happen during “make to learn” activities? Who are the stakeholders involved and which is their role in the process (teacher, students, educators, DiDIYers, etc)? What are the similarities with learning flows that happen in other fields (e.g., in companies)?

e. How is school as institution responding to the use of DiDIY?

Papert indicates that school as institution could have greatly benefited from the computer age, but was somehow reluctant to do so. Will DiDIY have better chances to allow for major changes within the educational system, also taking into account the concurrent existence of multiple forms of do-it-yourself aimed at substituting schools (such as MOOCs)? Are the Governmental funds to help schools acquire DiDIY technologies?

f. DiDIY in education and gender issues

Considering that DiDIY is used in many countries as a special tool to attract more students and make them study more STEM subjects, and considering that STEM faculties have a very low percentage of female attendance, one possible areas of interest could be that of evaluating if and how DiDIY could attract more women to STEM classes and faculties. Interesting (and worth studying if/how the same thing is happening in DiDIY) is the "When Women Stopped Coding" issue: "The share of women in computer science started falling at roughly the same moment when personal computers started showing up in U.S. homes in significant numbers.[52]

g. DiDIY and special education

There are many promising tests and trials on the use of DiDIY that are being applied to special groups of students (persons with motor and dexterity disabilities, visual impairment, mental and behavioural disorders). Will this help them better integrate in schools and also create something particularly relevant for their needs?

h. DiDIY: from STEM to STEAM

At present DiDIY in education is mainly used in close relationship with STEM subjects (and if other subjects are involved, they have an ancillary role). Is there a main role for DiDIY in other subjects, such as humanities, arts, etc?

52 See http://www.npr.org/sections/money/2014/10/21/357629765/when-women-stopped-coding and http://www.smithsonianmag.com/smart-news/what-happened-all-women-computer-science-1-180953111/?no-ist and http://jaxenter.com/when-women-stopped-programming-111998.html .

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