

Learning in the post-digital era. Transforming education through the Maker approach¹

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Abstract

In today's world, technology and digital media are no longer separate, "other" than "natural" human and social life. Technology has become pervasive, transparent, reaching a "stable" form, no longer revolutionary. A new concept, "the post-digital," is emerging and gradually taking hold in a wide range of fields. The resulting complexities call for overcoming the binary and hierarchical approach between theory and practice by rethinking traditional teaching patterns and remediating knowledge. Maker Education is moving in this direction. It is considered a technology-based extension of activism, developing STEAM and 21st-century skills. Its main exponents believe that it can "disrupt" or transform traditional educational methods. The Maker Movement, indeed, overlaps with the natural inclinations of children and the power of learning by doing. This contribution presents an ongoing research project that aims to outline a proposal for integrating this approach into the primary and lower secondary school curriculum. We detected its impact on students' school self-efficacy and attitude toward STEM and 21st-century skills. The results collected in the first part of the project look promising. The data underline the pupils' interest in STEM subjects and the improvement of their organizational and interpersonal skills.

Keywords: curriculum development; technology; primary education; learning process.

1. The post-digital era and the Maker Education

In today's world, technology and digital media are no longer separate, virtual, "other" than "natural" human and social life. Technology has become pervasive, transparent, and has therefore reached a "stable" form, no longer revolutionary. Paradoxically, this evolution results in a return to reality and a consideration of experience as increasingly hybrid (Giannandrea, 2021). A new concept, "the post-digital," is emerging and gradually taking hold in a wide range of fields: arts (Bishop et al., 2017; Monoskop, 2018), music (Cascone, 2000), architecture (Spiller, 2009), humanities (Hall, 2013), social sciences (Taffel, 2016), and many inter-, trans- and post-disciplinary fields (Berry & Dieter, 2015) to arrive also in academic contexts (Bayne & Jandrić, 2017, p. 204; Coventry University, 2018). Post-digital can be defined as a critical reflection on the current condition of culture after the digital revolution. The distinction between old and new media is no longer considered significant. On the contrary, they are used combined focusing mainly on processes related to experience and action and less on purely conceptual aspects (Andersen et al., 2014).

The transformations of contemporary society inevitably have repercussions on the school world. The student population appears increasingly heterogeneous in terms of social and cultural background and communication modes. Space-time coordinates lose their clear boundaries and physical or defined connotations. Knowledge is becoming increasingly fragmented and sectoral. These elements of complexity impose the overcoming of a binary and hierarchical approach between theory and practice (Rossi, 2019) through the rethinking of traditional teaching patterns and remediation (Bolter & Grusin, 2000) of knowledge. Teachers are required to carry out innovation processes based on multimodal, flexible, and

¹ Francesca Gratani is the author of paragraphs 1, 2, and 3. Lorella Giannandrea and Pier Giuseppe Rossi are the authors of the Conclusions and supervised the drafting of the article and the development of the research project.

open activities and active methodologies. In this way, they will be able to research, produce, and re-elaborate knowledge and stimulate processes of communication, sharing, and exchange (Giannandrea, 2021).

Maker Education, based on the *Think, Make, Improve* cycle, is considered a technology-based extension of activism, developing STEAM and 21st-century skills (Binkley et al., 2012). It develops from the innovative Maker Movement (Dougherty, 2013), and its main exponents believe that it can “disrupt” or transform traditional educational methods (Dougherty, 2016; Martinez & Stager, 2013). Halverson and Sheridan (2014, p. 503) highlight its potential to transform the way we understand “what counts” as learning, as a learner, and as a learning environment, marking a bold step toward equity in education.

This approach impacts on the purpose of schools and the needs of today’s socio-cultural contexts. It meets the current demand for a new way of teaching and learning that is future focused, project based, and learner centered, in which technology and handicraft are combined to make tangible students’ ideas and interests. Moreover, one of the recognized strengths is the ability to engage young people in deeper STEM learning (Gilbert, 2017), making scientific knowledge more accessible (Martin, 2015). Indeed, students are asked to transfer content to solve open and authentic problems, rather than closed and simulated problems, as in traditional education (Doppelt, 2009). The Maker Movement overlaps with the natural inclinations of children and the power of learning by doing. In the “learning by making” concept, *making* refers to working with tools and materials; *tinkering* refers to a playful, problem-solving mindset; and experimentation, discovery, and *engineering* refer to the application of scientific principles to design, build, and invent (Martinez & Stager, 2013).

In the Italian school landscape, making experiences are still mainly linked to out-of-school projects or occasional activities. The recent increased investment in technological equipment clashes with the rigidity of the curricula and inadequate teacher training in technical and methodological terms.

2. The Project

This contribution presents an ongoing research project based on the following questions:

- How can Maker Education be integrated into the curricular activities of primary and lower secondary schools?
- What is the impact on students’ self-efficacy, attitude toward STEM and 21st-century skills?

It thus aims to outline a proposal for integrating Maker activities into the curricular programs of primary and lower secondary schools and detecting their impact on the above variables.

The project lasts about a year and is divided into two parts. This article reports on the first part, which took place from January to June 2021.

Specifically, the next sub-paragraphs describe the context and participants (2.1), the methodology (2.2), the activities (2.3), and the assessment instruments (2.4).

2.1 Context and participants

The first part of the project involved 50 primary school students and three teachers from the “S. De Magistris” Comprehensive Institute² of Caldarola (MC) in the Marche region, Italy. The context and the sample were necessarily limited due to the coronavirus disease 2019 (COVID-19) health emergency. Before starting the activities, we administered an entry questionnaire to collect personal information about the students (see Table 1). Students are evenly distributed in terms of gender and grade. They are also divided into three classes belonging to three different schools and towns. Specifically, 30% attend a fourth class, 42% a fifth class, and 28% a multi-grade class with fourth and fifth graders.

The three curricular teachers (one per class) teach mainly the same subjects, which vary among math, science, technology, English, music, and physical education.

Table 1. Summary of data concerning the sample.

	Index	Value (%)
Gender	F	54
	M	46
Nationality	Italian	94
	Indian	2
	Peruvian	2
	Cuban	2

² In the Italian school system, a comprehensive institute includes kindergartens, primary, and lower secondary schools located in the same territory.

	Index	Value (%)
Age	9 years.	36
	10 years.	58
	11 years	6
Grade	Fourth	42
	Fifth	58

In the entry questionnaire, we also wanted to find out the level of pupils' experience with technological tools. Most of the pupils stated that they had never programmed an object built with a Lego kit (60%) or used a 3D printer (88%).

We also investigated the use of technological tools at school (see Fig. 1). We, therefore, noticed that the use of classical/traditional technological tools still prevails (computers, search engines like Google, programs to create text or images).

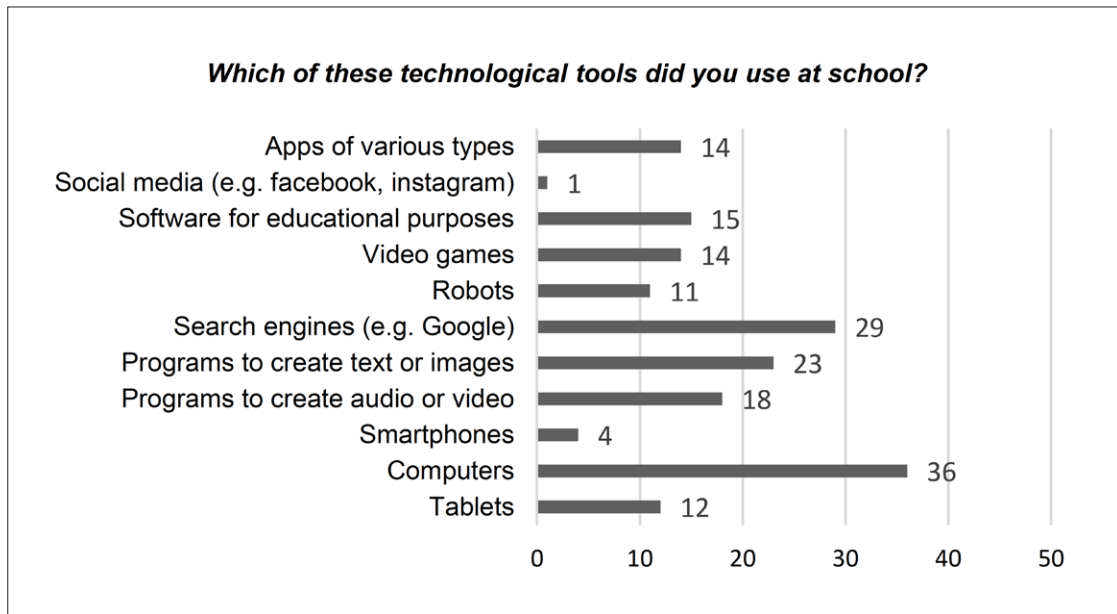


Fig. 1. Use of technological tools at school.

Finally, we asked the pupils whether they thought it would be useful to invent and/or construct something to understand better the subjects studied (see Fig. 2). As we can see, almost all students (92%) recognize the potential of constructing artifacts for learning.

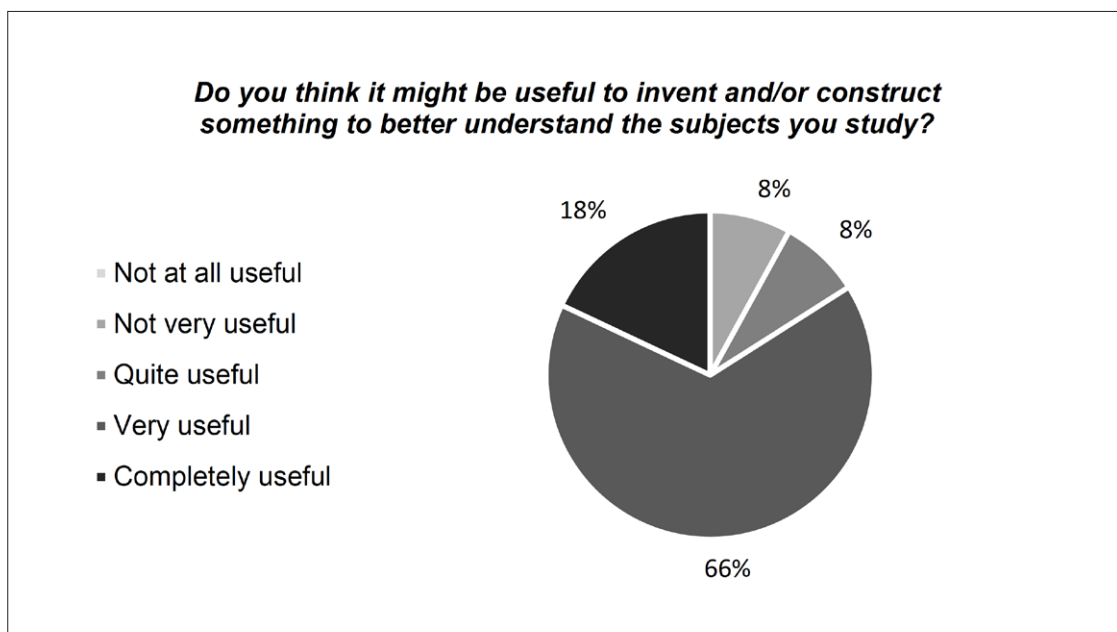


Fig. 2. Pupils' belief in the usefulness of inventing and/or constructing something to better understand the school subjects.

2.2 Methodology

The project is developed according to a multidisciplinary and longitudinal approach as it is planned to cover different subjects and involve students for about 1 year, including the transition from primary to secondary school for some of them.

Moreover, the project adopts the Design-Based Implementation Research (DBIR) as its main reference methodology (Fishman et al., 2013).

The first step was to identify and focus on a shared problem; in this case, we noticed little or no use of modern technological resources due to a lack of training and sustainable day-to-day proposals.

We thus moved on to an iterative and collaborative planning process, starting from the classes' curricular programs and project paths of the classes to define possible integration proposals. To this end, we identified three guiding criteria: linking activities and curricular content, working for/on competences, and evaluating processes for their inclusion in student assessment. In line with the Maker approach, we, therefore, designed challenges based on devising, planning, building, and solving to be carried out in pairs or groups of three pupils. Specifically, we followed the following guiding principles:

- activating students at home through the flipped classroom strategy (Bergmann & Sams, 2012) (doing research, reviewing topics, watching introductory materials, etc.);
- giving each session the same structure: anticipation (Ausubel, 1968), brainstorming and presentation of the challenge, planning and implementation, debriefing;
- proposing tasks that are authentic (of interest to the pupils), challenging (in the zone of proximal development), and open (more possible solutions to ensure creativity and personalization) (Rossi et al., 2021).

For the first part, in addition to the recycled or everyday materials, we used the following tools: Lego WeDo 2.0 kit and app, TinkerCAD software, Thinglink web app, Ultimaker3 3D printer, and Qr code generator website.

In the third step, related to the implementation, the modeling action operated by the researcher toward the teachers was crucial, assuming also the role of trainer in the didactic action.

Lastly, the final step envisaged by the DBIR concerns the ability to support change in the systems. The pilot project aims, in fact, to define guidelines as a shared result between the researcher and teachers through a process of co-explicitation (Vinatier, 2007). The aim is, therefore, to promote system change starting with training and sharing of practices and then impacting on the school's curricular practice.

2.3 Description of the activities

The project started with an introductory phase to define the activities, administer the two questionnaires, and present some of the tools. Pupils could discover the kit composition, the app and its programming language and build some basic constructions to understand how the sensors and motors work. Then, we introduced the pupils to 3D printing by experimenting with 3D pens and TinkerCAD software and watching a 3D printer in action.

Then, we proposed activities starting with a challenge to encourage the pupils to plan, share, and reflect, experimenting with new tools and ways of learning and making connections with various subject contents. We chose the 17 Sustainable Development Goals outlined by the United Nations (UN, 2015) in the 2030 Agenda as an integrating background theme, dedicating about 1 month to each selected goal. The selection of the goals was guided by the possible points of contact with the class programs. We planned sessions of 2 h/week for each class divided into three modules corresponding to the three goals addressed.

Through Goal 7 *affordable and clean energy*, we took up and deepened renewable energy. We first proposed solar and wind energy experiments using mini solar panels, mini motors with propellers, light-emitting diodes (LEDs), *abat-jours*, and colored filters (made from sheets of transparent plastic). The students were able to hypothesize, observe, and evaluate the variation of the rotation speed or light intensity of the LEDs according to distance and inclination to the light source, power (amount of heat) of the light source, and color of the filter placed between the panel and the light source (yellow, red, or blue). Then, to reinforce the concepts explored, we asked each group to reproduce creatively a specific experiment/variable with Lego kits. The Lego kits are particularly suitable for this activity due to the presence of some electronic parts: tilt sensor, motion sensor, motor, and smart hub with an LED. Pupils could take inspiration from some guide models provided by the app, but the construction was fully customizable to promote maximum creativity and collaboration of the pupils. Finally, we addressed hydropower, starting with the functioning and structure of a hydroelectric power station to discuss its advantages and disadvantages. We then asked the pupils to reproduce the functioning of a hydroelectric power station by integrating recycled or everyday objects/materials brought by them and the robotics kits.

A detailed description of this module and the preliminary results are reported in Gratani and Giannandrea (2021).

For Goal 11 *sustainable cities and communities*, we chose to make pupils think about the concepts of safety, sustainability, and accessibility. Specifically, we asked them to identify and take pictures of public places, green spaces, and transport systems in their towns that were problematic in one or more of the aspects mentioned above. After examining and selecting them together in the classroom, each group then devised an improvement project, defining it in detail (before and after draft, problems, solutions, materials needed, etc.). Then, they moved on to the implementation phase by building

models of their projects with Lego kits. Finally, they promoted and exhibited their work through Thinglink. This web app makes it possible to create multimedia presentations that can also be viewed through virtual reality.

Lastly, we addressed Goal 15 *life on land*. Also, in this case, we wanted to keep the perspective on the surrounding area. Considering the geographic location of the towns, we focused on ensuring the conservation of mountain ecosystems, including their biodiversity, to improve their ability to provide services that are essential for sustainable development. Specifically, we asked the pupils to research the main problems with natural or man-made causes affecting their area and, after discussing them together, each group chose the problem to work on. The groups had initially to design and represent with Lego kits a strategy to prevent or act in such circumstances. Afterward, they had to conceive and design a logo to symbolize their territory, based on the information they searched for and collected before (typical places, animals, plants, emblems, etc.). The logo was then represented in 3D with TinkerCAD software and 3D printer to create gadgets (key rings, decorations for water bottle, wallets, clothes, etc.). The last activity was to design a board game of their choice to promote sustainable tourism in their area. The students were able to enrich their game by printing 3D pawns, dice, or other items and generating Qr codes to insert virtual insights.

2.4 Assessment instruments

For the assessment, we planned both quantitative and qualitative analyses. First, we selected two validated questionnaires to investigate the following:

- Students' attitude toward STEM and 21st-century skills (Q1): original version by the Friday Institute for Educational Innovation (2012), translated and validated version by Screpanti (2020). The questionnaire is divided into four subscales that measure changes in students' confidence in STEM subjects (mathematics, science, engineering and technology) and 21st-century learning skills.
- Students' perceived school self-efficacy (Q2): original version by Bandura (1993), translated and validated version by Pastorelli and Picconi (2001). The scale is divided into two subscales. The first one investigates perceived self-efficacy in learning seven school subjects (mathematics, geography, science, Italian, grammar, history, foreign languages). The second one examines self-efficacy in regulating motivation and performance of school activities and finding support and ways of study that promote learning.

The two questionnaires are administered at the beginning and end of the project's two parts. They also present a 5-point Likert-type response scale: "strongly disagree" to "strongly agree" for Q1 subscales and "unable at all" to "fully capable" for Q2 subscales.

Moreover, during each meeting, students are required to fill in logbooks to keep track of what has been done and highlight their progress in planning, solving challenges, and self-assessment. Each logbook is structured in three sections: introduction (goal number, date, challenge), development/planning (project drafts and annotations), and conclusions/final reflections. The last section consists of eight closed-ended questions and two open-ended questions related to the following areas: understanding and solving the challenge, using information/materials, working in groups, testing and improving the solution, communicating one's ideas, managing emotions during the discussion, enjoyment of the activity (with related reason), and improvement intentions for the next activity. Closed-ended questions present a 4-point response scale represented by four different Lego pieces.

Based on these questions, we co-designed an evaluation rubric with the teachers to assess the processes underlying the activities. Its dimensions, thus, reflect the areas of student self-assessment and are assessed according to the four levels (first acquisition, basic, intermediate, advanced) outlined by the new Italian assessment system for primary schools (MIUR, 2020). Finally, at the end of the two parts, the teachers are involved in a focus group.

3. Results

In this contribution, we will present the results of the pre-post comparison of Q1 and Q2. In general, they showed an overall improvement in the various fields investigated.

Regarding Q1, the highest scores emerge from 21st-century skills (Fig. 3). Specifically, the areas of greatest improvement are leading others to achieve a goal, considering the points of view of others when making decisions, setting my own study goals, and organizing my time well when working alone. These data suggest an impact on pupils' organizational and social skills.

Among the STEM subjects, students showed a higher overall attitude toward engineering and technology (Fig. 4). In particular, pupils improved their attitude toward considering these fields for their future employment (Designing products will be important in my future; I believe I can be successful in a job in the field of engineering). We also found a higher score in being good at building or repairing things and imagining creating new products.

Finally, concerning math and science, we reported them together in Fig. 5, selecting the most relevant questions. The majority of questions are, indeed, very similar and deal with feeling good in that subject, prospects for improvement, and prospects for future study or employment. Math and science showed lower scores than the other fields since Q1-pre. However, we noted an improvement in considering these areas for future studies or jobs.

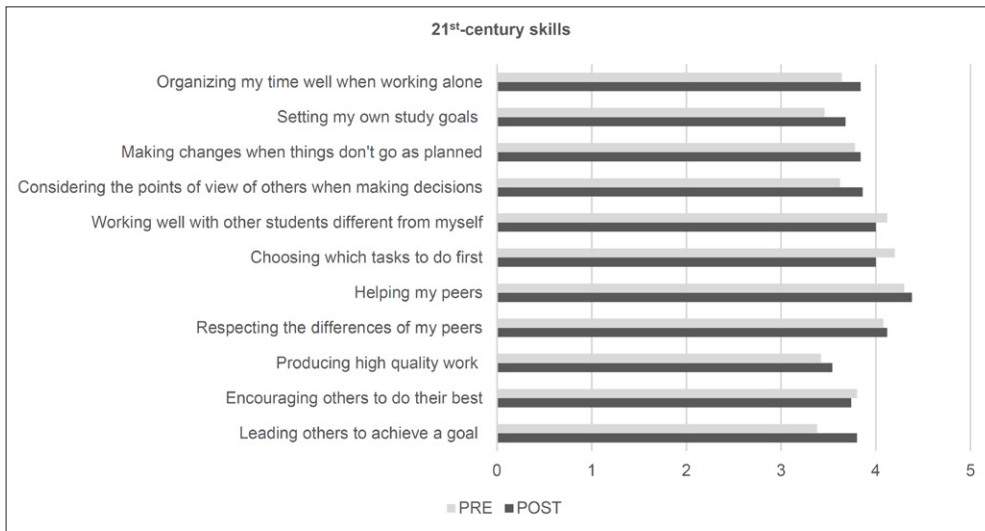


Fig. 3 Histogram showing pre–post data of Q1-21st-century skills.

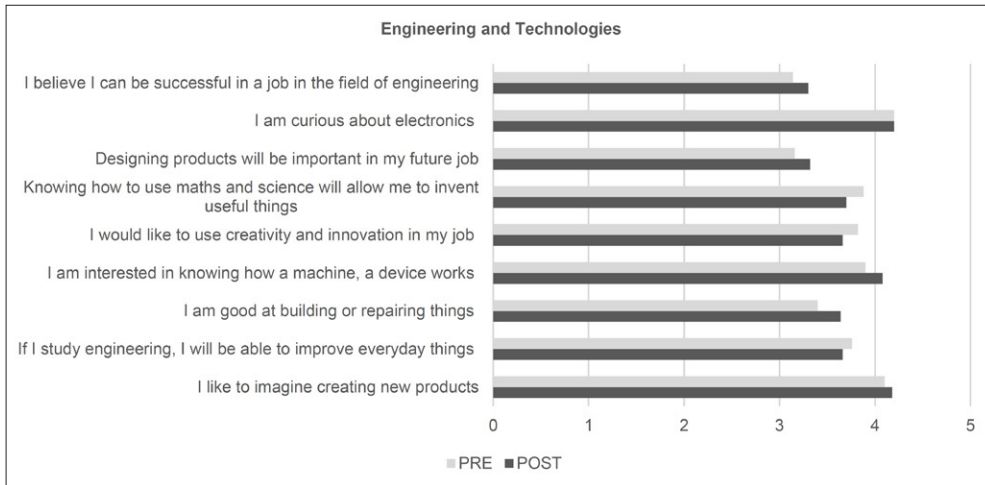


Fig. 4 Histogram showing pre–post data of Q1-Engineering and Technologies.

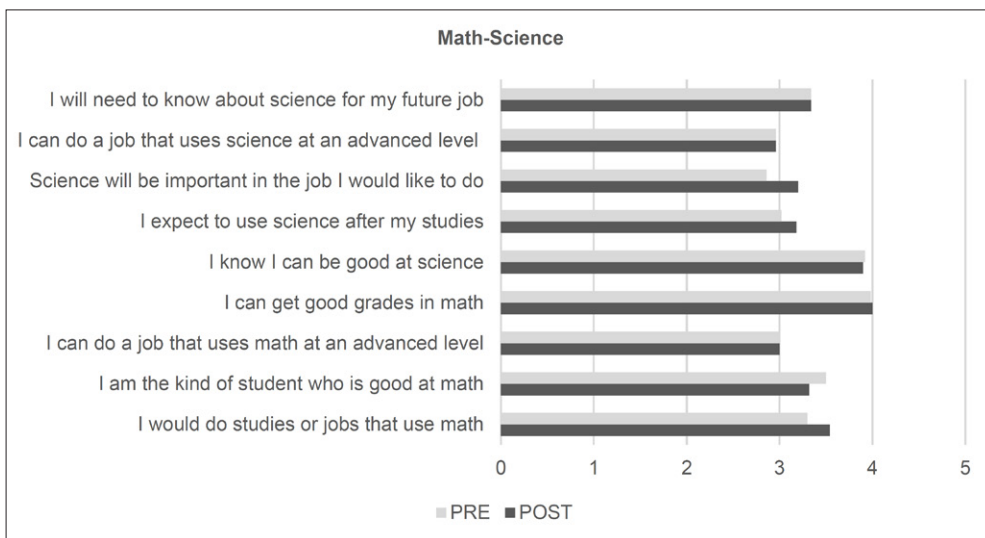


Fig. 5 Histogram showing pre–post data of Q1-Math–Science.

Analyzing the data from Q2, this also shows high scores and an overall increase in students' self-efficacy toward the school subjects and the skills investigated. Specifically, students expressed higher self-efficacy toward all the subjects (Fig. 6), including those not belonging to the STEM area.

Then, looking at Fig. 7, we can easily notice the general improvement in the various skills related to learning. The impact on organizational skills, also shown in Q1, is confirmed (organizing/planning school activities, finishing homework on time, finding a place to study without being distracted). Students also showed interest and relevance to the subjects and the expectations of teachers and parents. On the contrary, as areas for improvement, we can highlight taking notes, doing research by consulting external resources, and studying without getting distracted.

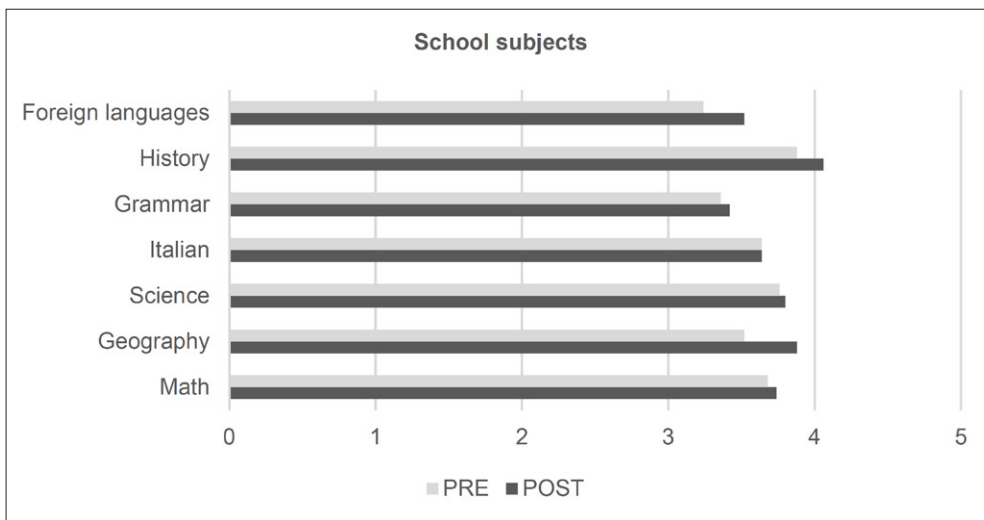


Fig. 6 Histogram showing pre–post data of Q2-School subjects.

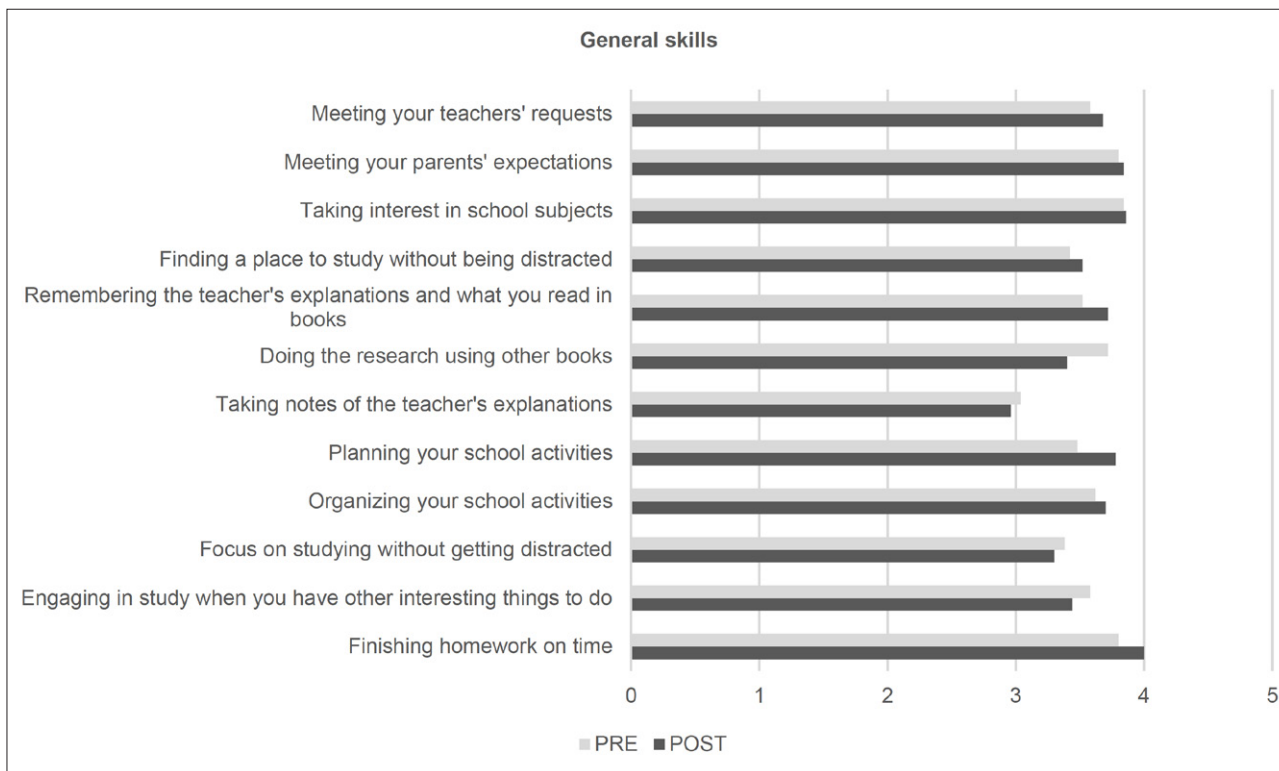


Fig. 7 Histogram showing pre–post data of Q2-General skills.

Conclusions

The results gathered in this first part of the project look promising. Data from the first pre–post comparison of questionnaires show that students have overall increased their levels of attitude and self-efficacy toward school subjects and 21st-century skills. The data also underline pupils' interest in engineering and technology and improvement in their organizational and interpersonal skills. Indeed, 21st-century skills are highly stressed by this kind of activity, and they achieved the highest increase in both Q1 and Q2. Math and science remain the areas to be worked on most, despite an initial improvement in prospects for study or work in these fields. In particular, an overall lower sense of self-efficacy emerged compared to the other subjects.

The entry questionnaire also revealed interesting data, such as the prevalent use of traditional technological tools (computers, search engines, programs for creating texts or images) in schools and the students' awareness of building artifacts' usefulness for learning.

Maker activities authentically engage students in what Blackley and Howell (2019) refer to as *head–heart–hands* learning: head – cognitive demands and intellectual engagement; heart – enthusiastic engagement and development of interpersonal skills; hands – fine motor skills and spatial reasoning.

Part 2 aims to continue integrating activities into the curriculum to work on pupils' sense of self-efficacy. Another goal is to make teachers increasingly autonomous and expert and define guidelines to be shared to involve the rest of the teaching staff.

Future research directions concern analyzing data from the focus group with teachers, analyzing the students' log-books, implementing Part 2 (new tools, sample variations), comparing Part 1–Part 2 data to detect a long-term impact on students, and comparing data according to the gender variable.

References

- Andersen, C.U., Cox, G., & Papadopoulos, G. (2014). Postdigital research - Editorial. *A Peer-Reviewed Journal About*, 3(1). <https://doi.org/10.7146/aprja.v3i1.116067>
- Ausubel, D.P. (1968). *Educational psychology. A cognitive view*. New York: Holt, Rinehart and Winston, Inc.
- Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, 28, 117-148. https://doi.org/10.1207/s15326985ep2802_3
- Bayne, S., & Jandrić, P. (2017). From anthropocentric humanism to critical posthumanism in digital education. *Knowledge Cultures*, 5(2), 197–216.
- Blackley, S., & Howell, J. (2019). The Next Chapter in the STEM Education Narrative: Using Robotics to Support Programming and Coding. *Australian Journal of Teacher Education*, 44(4). <http://dx.doi.org/10.14221/ajte.2018v44n4.4>
- Bergmann, J., & Sams, A. (2012). *Flip Your Classroom. Reach Every Student in Every Class Every Day*. Washington DC: International Society for Technology in Education.
- Berry, D.M., & Dieter, M. (Eds.) (2015). *Postdigital aesthetics: Art, computation and design*. New York, NY: Palgrave Macmillan.
- Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (Vol. 1, pp. 17–66). Netherlands: Springer.
- Bishop, R., Gansing, K., Parikka, J., & Wilk, E. (Eds.) (2017). *Across & beyond: A transmediale reader on post-digital practices, concepts, and institutions*. Berlin: Sternberg Press.
- Bolter, D., & Grusin, R. (2000). *Remediation: understanding new media*. Cambridge: The MIT Press.
- Cascone, K. (2000). The aesthetics of failure: 'post-digital' tendencies in contemporary computer music. *Computer Music Journal*, 24(4), 12–18. <https://doi.org/10.1162/014892600559489>
- Coventry University. (2018). The centre for postdigital cultures (CPC). Retrieved from: <http://www.coventry.ac.uk/research/areas-of-research/postdigital-cultures/>
- Doppelt, Y. (2009). Assessing creative thinking in design-based learning. *International Journal of Technology and Design Education*, 19(1), 55–65. <https://doi.org/10.1007/s10798-006-9008-y>
- Dougherty, D. (2013). The Maker Mindset. In M. Honey, & D.E. Kanter (Eds.), *Design, Make, Play: Growing the Next Generation of STEM Innovators* (1st ed.). New York, NY: Routledge.
- Dougherty, D. (2016). *Free to make: how the maker movement is changing our schools, our jobs, and our minds*. Berkeley, CA: North Atlantic Books.
- Fishman, B., Penuel, W.R., Allen, A., & Cheng, B.H. (Eds.) (2013). Design-based implementation research: Theories, methods, and exemplars. *National Society for the Study of Education Yearbook*, 112(2). New York, NY: Teachers College Record.
- Friday Institute for Educational Innovation (2012). *Student Attitudes toward STEM SurveyUpper Elementary School Students*. Raleigh: Author.
- Giannandrea, L. (2021). Post umano, post digitale, terzo spazio. Riflessioni sulla didattica universitaria negli scenari che cambiano. In M. Stramaglia (Ed.), *Pedagogia, didattica e futuro. Studi in onore di Michele Corsi*. Lecce: Pensa MultiMedia.
- Gilbert, J. (2017). Educational makerspaces: disruptive, educative or neither. *New Zealand Journal of Teachers' Work*, 14(2), 80–98.

- Gratani, F., & Giannandrea, L. (2021). Learning through practice: integrating the maker approach into primary school curriculum. *EDULEARN21 Proceedings*, 11378 - 11386. <https://doi.org/10.21125/edulearn.2021.2372>
- Hall, G. (2013). Towards a post-digital humanities: Cultural analytics and the computational turn to data-driven scholarship. *American Literature*, 85(4), 781–809. <http://dx.doi.org/10.1215/00029831-2367337>
- Halverson, E., & Sheridan, K. (2014). The Maker Movement in Education. *Harvard Educational Review*, 84(4), 495-504. <http://dx.doi.org/10.17763/haer.84.4.34j1g68140382063>
- Martin, L. (2015). The Promise of the Maker Movement for Education. *Journal of Pre-College Engineering Education Research (J-PEER)*, 5(1), Article 4, 30-39. <https://doi.org/10.7771/2157-9288.1099>
- Martinez, S.L., & Stager, G. (2013). *Invent to learn: Making tinkering and engineering in the classroom*. Torrance, CA: Constructing Modern Knowledge Press.
- MIUR (2020). Valutazione periodica e finale degli apprendimenti delle alunne e degli alunni delle classi della scuola primaria. Retrieved from: https://www.istruzione.it/valutazione-scuola-primaria/allegati/ordinanza-172_4-12-2020.pdf
- Monoskop. (2018). Post-digital aesthetics. Retrieved from: https://monoskop.org/Post-digital_aesthetics
- UN (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Retrieved from: <https://sdgs.un.org/2030agenda>
- Pastorelli, C., & Picconi, L. (2001). Scala di Autoefficacia Scolastica Percepita. In G.V. Caprara (Ed.), *La valutazione dell'autoefficacia* (pp. 89-92). Trento: Erickson.
- Rossi, P.G. (2019). L'ambiente digitale come terzo spazio nella didattica universitaria. In P. Federighi, M. Ranieri & G. Bandini (Eds.), *Digital scholarship tra ricerca e didattica. Studi, ricerche, esperienze* (pp. 40-52). Milano: FrancoAngeli.
- Rossi, P.G., Giannandrea, L., Gratani, F., Laici, C., Tarantino, A., & Paviotti, G. (2021). Assessment as learning: transforming practices with secondary school teachers. In L. Gómez Chova, A. López Martínez, I. Candel Torres (Eds.), *ICERI2021 Proceedings* (pp. 6543 – 6551). Valencia: IATED Academy. <http://dx.doi.org/10.21125/iceri.2021.1483>
- Screpanti, L. (2020). *Study, assessment and identification of Educational Robotics experiences at school*. PhD Dissertation, Ancona, AN: Università Politecnica delle Marche.
- Spiller, N. (2009). Plectic architecture: Towards a theory of the post-digital in architecture. *Technoetic Arts: A Journal of Speculative Research*, 7(2), 95–104. <http://dx.doi.org/10.1386/tear.7.2.95/1>
- Taffel, S. (2016). Perspectives on the postdigital: Beyond rhetorics of progress and novelty. *Convergence: The International Journal of Research into New Media Technologies*, 22(3), 324–338. <https://doi.org/10.1177/1354856514567827>
- Vinatier, I. (2013). *Le travail de l'enseignant. Une approche par la didactique professionnelle*. Bruxelles: DeBoeck.