Design for Future Skills

Three Case Studies on the Role of Design in Shaping the Narrative of Technology Education

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> If we could ask an AI to sketch the cover of a report on the future of education, it would probably be a classroom full of students in the process of learning "coding" or an apocalyptic world where there is no need for human workers, thanks to fully automated factories with robotics arms. This is what the AI could probably see if it would process all the pictures on the web and get across the last two industrial revolutions, two events that brought a rather positive narrative on the impact of digital technologies on human life: we will all become programmers or data scientists who use algorithms, machines, and data to make almost anything. Today, we could speculate that this positive narrative is driving the agenda on the digital transformation in education in every economy in the world: digital skills development is seen as a solution to the high demand for professionals who know "how to code." This narrative is rarely accompanied by reflections on how new technologies could reinforce social inequity or how their adoption can take place only if it is connected to a social change.
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From Art and Design Pedagogy to Technology Education for Creatives: An Introduction to the Opening of the Codes of Creation

In the late 1950s and early 1960s, Hungarian artist Victor Vasarely created *Planetary Folklore Participations*, a series of art pieces that people could buy as Do-It-Yourself (DIY) kits to be assembled. These works were made of colored plastic blocks that could be combined to create an infinite number of compositions and images. Each work was sold in a packaging similar to the one of board games, which contained the kit's components and the operating instructions, namely a manual explaining the rules of the visual alphabet designed by Vasarely. Vasarely invented *Planetary Folklore* to describe his work and his vision of a universal aesthetic for the masses. This vision was based on a teaching methodology patented by Vasarely himself in 1959: through the messages encoded by the artist, the viewer understands the principles and conceptual aspects related to the artist's perspective on art and architecture.[2] Influenced by the discoveries of Gestalt psychology, cybernetics, and astrophysics, Vasarely developed research that introduced concepts for the democratization of art: his *Plastic Alphabet* series consisted of a grid that established a modular relationship between shapes and colors.

Vasarely's research pointed to the creation of a visual programming language *ante litteram* that allowed the generation of infinite variations of shapes and colors to create unique works. During the same years, in Italy, the artist and designer Bruno Munari also contributed to the opening of creativity and design for all. With his laboratories called *Giocare con l'arte* (Playing with art) organized at the Pinacoteca di Brera in Milan in 1977, he presented a set of activities and materials to stimulate young children's development who would experience art through visual languages rather than with words. Munari's contribution as a designer to the domain of pedagogy expanded to books for children such as *Le Macchine di Munari* (Munari's Machines), in which fictional machines are combined with everyday life objects through the medium of fantasy: for example, a machine to tame the alarm clock.[3] Through the 1970s, he also worked on a series of products for the Italian design firm Danese called *Strutture* (Structures), a kit of sixty-five combination cards, sixty of which

2 Victor Vasarely, *Planetary Folklore Participations No. 1 (1960–1969)*, 1973, Sculpture, 20 × 20 in, 1973, Lions Gallery, https://www.artsy.net/artwork/victor-vasarely-planetary-folklore-participations-no-1.

3 Bruno Munari, *Le macchine di Munari*, Einaudi, Torino, 1942.

were printed on a transparent surface and could be laid one over the other to determine an image through superimposition. The idea was to stimulate the analysis of structures and components through a playful activity and support the development of children's combinatorial abilities. In another kit named *Labirinto trasformabile in mille altri giochi* (Labyrinth convertible in a thousand other games), he presented the same concepts of combinability with graphic modules: a board game consisting of a wooden base with grooves to insert cards that featured abstract patterns to allow children to transform the space according to their fantasy. Combinability, modularity, and experience were at the core of the learning experiences proposed by Munari.[4]

These concepts were strongly connected to Jean Piaget's Constructivism theory and later became the ingredients of the Constructionism movement initiated by Seymour Papert. The latter was a pioneer of artificial intelligence and computer science education, and his work focused on the idea that intelligence is situated, connected, and sensitive to the variations of the environment. Actually, Papert draws our attention to the fact that "diving into" situations rather than looking at them from a distance is a powerful means of understanding.[5] With the Logo Programming Language and its integration in the Logo turtle, one of the first educational robots ever invented, Papert became the father of modern STEM (Science, Technology, Engineering, and Math) education as he highlighted how the development of tools like the Logo turtle should embed the idea of children mastering a technology instead of being passive users, and the integration of science and technology (and play) to simplify and overcome the fear of learning complex subjects in mathematics. In his influential book *Mindstorms*, Papert describes his contemporary times as a "culture that makes science and technology alien to the vast majority of people," where students grow up thinking that devices like robots belong to "the others."[6] This idea of transforming kids into active users rather than passive consumers of technology is at the core of the most diffused coding

4 Alberto Munari, "Bruno Munari The Surpriser," in *Giro Giro Tondo / Design for Children*, ed. by Silvana Annicchiarico (Milan: Mondadori Electa, 2017), 204–5.

5 Edith Ackermann, "Piaget's Constructivism, Papert's Constructionism: What's the Difference?," *Future of Learning Group Publication* 5, no. 3 (January 1, 2001), 438.

6 Seymour A. Papert, *Mindstorms: Children, Computers, And Powerful Ideas*, 2nd ed. (New York: Basic Books, 1993), 4.

initiative developed by Mitchel Resnik, the inventor of Scratch, the free visual programming language that introduces children to computer science.[7]

This idea of helping people to understand and use technology has been the most important lesson shared by the pioneers of computer science teaching. Those principles have been later adopted in design and art education. In the last two decades, computational artists and designers have developed original tools and methods for teaching technology to non-experts and new narratives around digital skills development in creative contexts. In 2001, Ben Fry and Casey Reas released the first version of *Processing*, the open-source sketch environment for generative graphics. Their idea was to combine the visual principles of design with ways of thinking about systems derived from computer science approaches.[8] *Processing*, together with its community of users, could be defined as one of the first user experience design contributions to the domain of computer science teaching as it provides a simplified interface and a set of resources and best practices that allow non-expert people to create artifacts with coding. *Processing* enabled the growth of a creative technology movement by empowering creatives to learn technology for creative purposes or with a critical mindset. As Casey Reas stated, coding is a way of thinking and a humanist activity, not a technical skill.[9] With this perspective, software literacy could reduce the separation between people and technology.

The same year, in a small village in the north of Italy, during an international interaction design program at the Interaction Design Institute of Ivrea IDII, the need to open the black box of embedded technologies and electronic devices determined the release of one of the most impactful platforms for learning technology with the Arduino board. The project started with the release of open hardware, a microprocessor that simplifies the programming of interactive behaviors through sensors and actuators.[10] Later, it became a larger ecosystem made out of software and hardware solutions and a global community that collaborates and develops interactive items,

7 Scratch, "Scratch – Imagine, Program, Share," accessed June 28, 2022, https://scratch.mit.edu.

8 Casey Reas and Ben Fry, "A Modern Prometheus," *Processing Foundation*, June 8, 2018, https://medium.com/processing-foundation/a-modern-prometheus-59aed94abe85.

9 Serena Cangiano, "Coding as a Way of Thinking — Interview with Casey Reas," *Progetto Grafico*, December 16, 2016, https://medium.com/progetto-grafico/coding-as-a-way-of-thinking-interview-with-casey-reas-cbb9ecdbb980.

10 Massimo Banzi and Michael Shiloh, *Make: Getting Started with Arduino*, 3rd ed. (Maker Media, Incorporated, 2008).

from educational tools to open manufacturing systems and art installations. The Arduino project board is a case study of bottom-up innovation and the results of a pedagogical design process addressing the future skills of designers in the domain of coding and electronics. This challenge was already tackled by products, kits, and toys in the early sixties if we take as an example the Raytheon Lectron, produced by the German company Egger with a design contribution by Dieter Rams.[11] In the early 2000s, technology education initiatives moved the focus from the educational product to a global movement to empower people by simplifying and opening technology. These two initiatives addressed innovation in education and technology skills development through new propositions that inspired global movements of change-makers in technology education.

Three Case Studies

With the above brief excursus, it is possible to draw a line that connects the design disciplines with transformations in technology education, from the history of computer science education to contemporary days. This line shows that the role of the design agency has always been somehow to critically investigate technology impact as well as empower people by creating inclusive interfaces to relate to technological innovation. By following this line, this section presents three case studies of applied research projects aimed to question and define the role of design and its impact in digital transformation in education.[12] The first case study, the Ethafa Steammians Kit, tackles the issue of the gender gap in technology education. The second case study, project TAC Technology Ambient and Competences, proposes hands-on journeys in data literacy for primary school teachers and students. The last one, titled Untouched, introduces experiments and the implications of teaching machine learning to designers faced with the global challenges derived from Covid-19. These three projects present a different perspective on technology education and help in interpreting the role of design in reshaping the narrative around future skills development.

11 The Universe of the Lectron System, "What is the Lectron System,"accessed June 28, 2022, https://lectron.info.

12 The projects were carried out from 2017 to 2020 by the research team of the Interaction Design Research unit of the Design Institute at SUPSI University in Switzerland.

The Ethafa Steammians Kit

The miniaturization of sensors and actuators and the growth of computing power allow the development of ludic devices that teach science and technology to children through tangible interfaces, connected applications, robots, mobile apps, AI, and cognitive toys. Global movements like the Maker Movement are advocating the application of methods and tools that consider STEM education a pivotal approach to teaching almost anything. Start-up companies are also working to deliver this promise by introducing into the toy market new educational kits that address, in particular, the playful learning of coding and robotics through the application of ideas and principles, very close to Seymour Papert's research. From initiatives that introduce young kids to robot programming through a simple robot with wheels to physical toys to teaching computational thinking to preschool kids, many platforms have been made available to empower a new generation of digital makers.[13] A *maker education* ecosystem started growing promoting hands-on approaches to learning almost everything. The maker education has been generated by a political context: back in 2014, US president Barack Obama launched the initiative "A Nation of Makers," aiming to provide many more students, entrepreneurs, and citizens access to a new class of technologies to design, build, and manufacture just about anything, as well as increased access to mentors, spaces, and resources to support them in the making.[14] It was a moment of great enthusiasm for new production technologies, particularly 3D printing and its promise of sustainable and distributed manufacturing.[15] It was a decade where we have probably witnessed the most prolific collaboration between bottom-up movements, design and entrepreneurship actors, and innovative policymakers on the challenge of digital skills development. Nevertheless, some key issues remained unsolved and underestimated. One of these is the gender gap in STEM education.

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13 Sue Sentance, Jane Waite, Steve Hodges, and Emily MacLeod, and Lucy Yeomans, "'Creating Cool Stuff': Pupils' Experience of the BBC Micro:Bit," in *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*, SIGCSE '17, (New York, NY: Association for Computing Machinery, 2017), 531–36, https://doi.org/10.1145/3017680.3017749.

14 The White House, "The First White House Maker Faire," accessed June 28, 2022, https://obamawhitehouse.archives.gov/node/316486.

15 The Economist, "The Third Industrial Revolution,"April 21, 2012, https://www.economist.com/leaders/2012/04/21/the-third-industrial-revolution.

Even if trends show that women employment in science and engineering in Europe is growing, the percentage of women in Information and Communication Technology (ICT) careers still remains below 2 percent of women's total share in the European labor market.[16] According to recent research, the reasons can be found in the overall academic environment and in the educational resources offered. In fact, many female students are not interested in the educational material provided but still have to work with it.[17]

From primary schools to universities, tools play a key role in how the learning experience is usually distributed. In general, they are designed to be genderless, but the learning environments combined with the overall technology culture still discourage girls from engaging with it, limiting the opportunities in their development. Starting from this issue, some questions arise. How do we design STEM learning experiences that could help create girl-friendly environments? How do we reduce the gender gap and engage more girls as early as in primary school in order to stimulate their positive attitude towards STEM careers? And finally, how do we create educational resources that support these more inclusive experiences?

The Ethafa Steammians Kit started as a graduate project that explored how interaction design could contribute to filling the gender gap in technology education. Initiated as a thesis at the Master's Degree program in Interaction Design at the SUPSI University in Switzerland, it has been developed as an entrepreneurial project that promotes a design-driven approach to electronics and science learning.

The kit design simplifies the interaction with the Arduino board for kids from nine to twelve years. It uses a physical interface consisting of a printed circuit board with embedded sensors that allow it to capture data from the environment (light, colors, sounds) and triggers some digital contents accessible via a tablet application in real-time. This application supports the experience with science resources and stories. The kit embodies, moreover,

16 Zacharias C. Zacharia, Tasos Hovardas, Nikoletta Xenofontos, Ivoni Pavlou, and Maria Irakleous, "Education and Employment of Women in Science, Technology and the Digital Economy, Including AI and Its Influence on Gender Equality," European Parliament, April 15, 2020, https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2020)651042.

17 Shao-Na Zhou, Hui Zeng, Shao-Rui Xu, Luc-Chang Chen, and Hua Xiao, "Exploring Changes In Primary Students' Attitudes Towards Science, Technology, Engineering And Mathematics (STEM) Across Genders And Grade Levels," *Journal of Baltic Science Education* 18, no. 3 (2019), 466–80, https://doi.org/10.33225/jbse/19.18.466.

a cute alien who guides kids into STEAM subjects (Science, Technology, Engineering, Art, and Math). Eolim, a biologist, invites the users to join him in his adventures and learn about nature on Planet Earth. To learn and later advance in the story, children have to create a circuit and use it to measure, for example, environmental data in their surroundings.

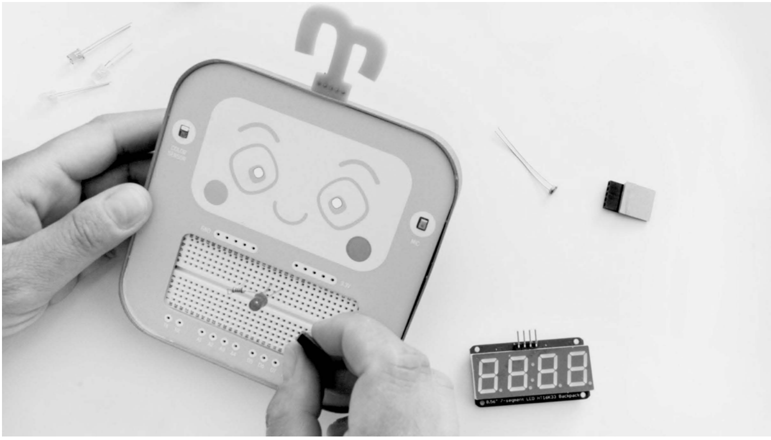
Beyond the specific features of the physical kit, the Ethafa Steammians Kit proposed product development based on the participation of practitioners and educators in co-design sessions with the goal of creating additional didactic activities with a specific focus on:

- How children can learn about technology through exploratory activities that do not require the use of a keyboard and a mouse;
- How children can learn technology and science subjects through activities that are based on stories. In fact, the story-led approach was chosen as it is proven that students usually learn more, remember concepts in the long term, and overcome intimidation or anxiety when they face complex and new subjects through stories;[18]
- How the story-led didactic activities can transfer basic notions on electronics and circuit making when they are built both on references to the children's specific context and culture.

Tested in several workshops held in Maker and Fablab-related events, the Ethafa Steammians Kit is a framework used to design the didactic activities proposed as an ecological approach to technology education in which the learning experience triggers the development of multiple skills, from problem-solving to collaboration. This approach promoted a different discourse around technology through the use of materials that, by design, allowed teachers and children to experience technology as less intimidating and as a medium to understand various phenomena in their physical environments. It also helped to solve problems close to their everyday life and local culture. This perspective focuses on how children's development with technology materials could (or should) lead them to become active digital citizens with critical thinking skills rather than just the future workforce of the technology industry. Bringing these aspects as early as in primary school programs helps to create learning

18 New York University, "The Purpose of Stories," accessed June 28, 2022, https://www.nyu.edu/content/nyu/en/faculty/teaching-and-learning-resources/strategies-for-teaching-with-tech/storytelling-teching-and-learning/the-purpose-of-stories.

experiences that are less intimidating for girls, and it also helps all genders to develop other crucial twenty-first-century skills such as emotional intelligence and collaboration skills, to name a few, that are rarely put at the center of STEM educational tool use.



Ethafa Steammians Kit.[19]

Project TAC Technology Ambient Competences: Data Literacy for the Active Citizenship Development

In the education field, digitalization is usually portrayed as a classroom of the future: a space equipped with advanced tools such as virtual reality sets, smart boards, and smart tables. In parallel, the need for more professionals in ICT and innovation promotes another image in which schools become factories where to train the next generation of tech-savvy workers thanks to the introduction of computer science classes. Even if there is an increasing demand for adapting the competencies to future jobs in the technological fields such as data analysis, AI, or robotics, primary or secondary school programs in developed countries still struggle to bring computers and coding classes into their curricula. In this polarized landscape where tech companies sell

19 Ethafa, Photograph of the Ethafa Steammians Kit, 2021.

hardware and services to educational organizations and governments and, on the other side, school teachers require the right pace to update their skills, civic tech initiatives provide a critical dialogue on the need for ecological and more social-driven perspectives to propel digital transformation in education. From citizen science to smart citizens' actions, global bottom-up innovation movements are proposing alternative approaches to the use of technology in education. New learning models are emerging, and trying to reconnect students with their societal context and personal development as citizens. Connected learning, for example, proposes a learning model in which students pursue a personal interest or a passion, a link to what they are learning and their interests to academic achievement, career success, or civic engagement.[20]

A relevant field of application for these fresh approaches is environmental monitoring: low-cost sensors and web platforms that allow non-experts to collect and interpret the environment's data so that they can learn more about it. Better environmental education through the use of data and technologies encourages more attentive and sustainable behaviors. Within civic environmental monitoring initiatives, for example, young people usually get in contact with sensing technologies as active users, and they learn how electronics and sensors work, how to build devices, and about participating as citizen scientists in environmental monitoring campaigns. As the paradigm of IoT and connected devices is becoming increasingly pervasive in our daily environment, this approach prevents young students from experiencing these technology trends passively. However, to be effectively implemented, it requires innovative teaching approaches and tools that overcome technological complexity and create learning experiences that help make sense of the collected data through hands-on, inclusive, playful, and collaborative sessions.

The project TAC introduced primary school children to environmental data sensing related to their urban environment through a learning experience based on the use of context-based tools. In general, the goal was to introduce the concepts of IoT and data literacy as early as the primary school level to experiment with formats that focus on digital citizenship skills rather than scientific data collection techniques. The project involved five elementary schools (pupils in fourth grade) and six teachers in pilot sessions to facilitate the integration of new civic tech formats and tools in

20 Connected Learning Alliance, "About Connected Learning," accessed June 28, 2022, https://clalliance.org/about-connected-learning.

the official school curriculum. It was a multi-stakeholder project that involved one municipality (the City of Lugano, Switzerland), five elementary schools, two private companies (Arduino.cc and Swisscom), and a research laboratory. The challenge was to design a process to validate the design of the educational activities and the hardware and software tools to be used.

The municipality had a vision to create a collaborative ecosystem of tools and a set of methods to connect with the civic society and engage it through sensing technologies. This required careful consideration about the needs of various stakeholders, including the school system, teachers, and students. For the school system, the design process had to consider the official curriculum guidelines, which required introducing technologies in the classroom only as a medium to learn something and not as a subject itself. To ensure the success of this approach, the teachers' technology skills and expertise had to be taken into account to define a professional development program on IoT and sensing technologies, and a co-design technique had to be implemented to collaboratively define the didactic activities. Additionally, the students' age and cognitive skills development during the fourth grade had to be considered to ensure the activities were age-appropriate and suitable for the students' level of understanding.

The requirements to design the project's pedagogical framework were defined in collaboration with the school directors and the learning researchers in order to make it compatible with the official curriculum guidelines. In an attempt to avoid a technological focus and to put the students at the center, the framework focused on developing key competencies such as exploring specific realities and collecting information, as well as transferring the fundamental concepts and processes of the scientific method. A major emphasis was also placed on the development of skills in the use of new technologies, particularly sensors connected to an IoT network. This experience allowed students to understand technology beyond the classic images of smartphones, video games, and the web. Additionally, the framework highlighted the need to foster the development of environmental awareness in relation to citizens' behaviors and the urban context, which is crucial for understanding and improving our environment.

TAC student kit, prototype version 0.1. The student kit supports outdoor activities where, for example, children measure and confront the data of sunny and shady areas in the school garden.[21]

Following the mapping of needs, the development of the project was focused on analyzing the technical requirements to support a smooth user experience. In order to gather and analyze data about the environment, this project utilizes three key components: the TAC Node, the Kit, and the Web App. The TAC Node is a localized device that features a GPS module, a sound meter (microphone), a PM10 sensor, a humidity and temperature sensor, and a

21 Claudia Cossu Fomiatti and SUPSI, Photograph of TAC Technology Ambient Competences student kit, 2021.

light sensor. This device is used to gather real-time and continuous data from a specific location, enabling comparisons among different locations. The Kit is a portable device with the shape of a green figure, it includes a humidity sensor, a temperature sensor, and a light sensor, which can be used to gather data in various locations. The Web App, a web-based application for tablets, features an interactive map and the data captured by the Nodes and the Kits. The data is then visualized through interactive graphs, making it easy to understand and interpret the data. Together, these components provide a comprehensive and effective way to gather and analyze environmental data.

Through the use of design thinking templates, the teachers co-created an open syllabus, namely an open collection of ideas on educational activities that had been implemented and tested in the classroom. Over a period of three months, the tools and the activities were tested and the co-design process allowed the identification of overall barriers and opportunities. In particular, it emerged that more diversified, hackable, and expandable devices helped the teachers with varied technology skills, or no technology skills at all, to carry out such kinds of activities. To conclude, the project TAC highlighted how educational initiatives based on the collaboration of multiple stakeholders, from schools to companies, could help create the conditions for the long-term development of an educational tool that evolves according to the new needs of the ecosystem actors and can be openly maintained without the risk of the technology obsolescence or a possible discontinued production.

Untouched ML-based spaces to enable citizens' interactions in the post-pandemic

Artificial intelligence and, more specifically, machine learning technologies strongly shape how people interact with today's online services. New types of intelligent artifacts are already embedded in our mobile devices and are unlocking interaction approaches that were unthinkable just a few years ago. Beyond the design of digital assistants and bots, AI and ML technologies are pushing for a paradigmatic change where the interaction patterns based on the logic of "If-this-then-that" are replaced by user experiences based on models for "training-supervising-classifying" that allow a highly personalized control over a technological product. In this context, designers can be the protagonists of such a digital transformation in which their role is to make algorithms more transparent or even programmable by the end-user.

Screenshot from the web-based prototype "Untouched" by Tim Pulver and Oliver Brückner accessible at untouched.timpulver.com. Using Tensorflow.js Handpose5 it detects key points of the hand and its horizontal position. Once detected, the user can form a fist to "grab" the slider and then move it along the axis to adjust the temperature. Ambient lighting behind the sink indicates the current temperature and slider range.[22]

In February 2021, within the project "Untouched ML-based spaces to enable citizens' interactions in the post-pandemic," a series of creative technology sessions were carried out to experiment with designing interactive experiences that dealt with the redesign of touch interfaces in public spaces. One core goal of the project was the definition of an experimental online setup for supporting young students, designers, and researchers to ideate and prototype original interfaces using recent tools for programming applications based on machine learning algorithms. The sessions involved participants with different backgrounds, including design students, interaction design practitioners, developers, and researchers who engaged in long-distance ideation and a prototyping workshop that ran over a Discord server. After an introduction to the fundamental concepts of machine learning through case studies and simplified infographics that represented how neural networks

22 Tim Pulver and Oliver Brückner and SUPSI, image of web-based prototype, 2023.

work, the participants were introduced to the use of open-source tools that enabled designers and artists to develop applications with intelligent algorithms such as ml5.js.

The ideation phase was guided by the following design brief: How to let people interact in physical spaces without touching surfaces? How to design gesture-based interfaces by taking into account cultural specificities and biases?

The results of the program were concepts and prototypes of services and installations in public spaces that mostly used face and gesture recognition, for instance, a system for accessing a shared mailbox through a custom password made with hand gestures. Another key outcome was the release of a library that taught the algorithm how to recognize hand gestures that run in the browser.[23] During the project development, many considerations were documented and, in particular, many design opportunities were envisioned considering interaction scenarios in which the users can personalize the way they interact with a device (i.e., custom gestures for opening a mailbox) according to their abilities, as well as their culture (i.e., the use of face masks).

In this project, design approaches and creative technology practices highlighted how unusual challenges such as Covid-19 required a reflection on how to use AI technologies to improve the users' skills in the interactive experience. The possibility of understanding how the system works is, in fact, the fundamental aspect of the interaction since the users have to design their own language of interaction with the machine. This represents a change of perspective for the designers since they have to apply new methods to evaluate the experience and, more in detail, the level of adoption of a solution in different cultural contexts.

Design should focus on changing the narrative around technology, but how?

As Jennifer Gabry points out in her book *Citizen of Worlds* "while citizen-oriented technologies might promise a straightforward realization of positive political change, they rarely yield such effortless or liberatory outcomes when

23 Tim Pulver and Olivier Brückner, "Untouched: Faucet," accessed June 28, 2022, https://untouched.timpulver.com.

put into practice."[24] This sentence helps to realistically think about the role of the design agency in the domain of technology education. Should it focus on the release of new toolkits to inform a new narrative? Or should it work as a mediator of collaborative bottom-up innovation processes?

From new tools for data literacy development and inclusive technology education, to the use of machine learning algorithms to create interactive experiences that empower the users, the three case studies helped us to identify how design can really have an impact on future skills development. In the first place, a critical reflection emerges and it is required to move the focus from the release of new tools to the co-creation of inclusive learning environments, especially the ones addressing the early development of children. Those environments should be more inclusive to engage more women in STEM careers and, as a consequence, to not exclude female students from becoming citizens that can take active participation in a future digital society. Moreover, innovative approaches in design for STEM education should put teachers at the center to be the protagonists of innovation in schools rather than passive distributors of companies' visions of the future.

A second reflection concerns the need for digital transformation projects in which different stakeholders can collaborate and align their visions, including: governments, companies, nonprofit organizations, civil society, the educators' community, and designers who can all participate in defining and constantly re-defining the map of relevant future skills. This can allow us to fight the "narration" of a necessary innovation, that leads only to investments in new hardware and software rather than in a human-paced lifelong education. Finally, the presented case studies showed that design can humanize technology with approaches that include more skills, beyond coding, such as critical thinking and emotional intelligence.

To conclude, as Victor Vasarely and Bruno Munari proposed in their pioneering works, design can help open up the codes of digital transformation by making the resources and the tools more accessible and easier to use. It can empower future citizens to have more control over digital processes

24 Jennifer Gabry, *Citizens of Worlds. Open-air Toolkits for Environmental Struggle*, University of Minnesota Press, accessed January 1, 2023, https://manifold.umn.edu/projects/citizens-of-worlds.

and products, which probably represents the most important requirement to enable the participation in the development of a digital society.[25]

25 SUPSI University of Applied Sciences and Arts of Southern Switzerland — Design Institute and FabLab: The team members are Dr. Serena Cangiano (researcher and project leader), Leyla Tawfik (co-founder at Ethafa.com), Dr. Iolanda Pensa (senior researcher and project leader, project TAC), Marco Lurati (engineer and interaction designer, project TAC), Daniele Murgia (assistant researcher and designer, project TAC), and Matteo Loglio (lecturer at MA in Interaction Design, co-founder at Oio.com, researcher at SUPSI project "Untouched").