ORIENTATING YOUNG NON-DESIGN STUDENTS IN THE DESIGN DISCIPLINE

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Abstract

After the recent COVID-19 crisis, which highlighted the need to ensure lasting and sustainable development for all European countries, the European Union implemented a new economic model to intervene in some damaged sectors, in particular education. Therefore, an aid plan must be implemented to encourage and guide students to transition to higher education. To help young students make a choice suited to their abilities and interests and cope with university dropouts in later years, the Politecnico di Milano organised experimental courses to involve high school students and bring them closer to the didactics of the School of Design. A team of teachers, applying a project-based approach, conducted a teaching experiment in which the design discipline was introduced to young non-designing students. Using specific design tools, students were guided in the realisation of quick project concepts. The paper aims to illustrate the organisation, conduction and results of experimental workshops organised to study new innovative teaching spaces in which the student is placed at the centre, defined by a strong relationship with an active learning approach and the valorisation of technologies.

Keywords: design education, design orientation, design tools, project-based learning, active learning.

1 INTRODUCTION

The COVID-19 pandemic and the resulting crisis affected several European countries already weak economically and socially, including Italy. This situation prompted the European Union to respond to the needs of many member countries through the construction of a broad program defined by investments and reforms: the Next Generation EU (https://next-generation-eu.europa.eu/index_en) [1]. It is a coordinated plan to promote and accelerate the recovery of the European economy under the banner of ecological transition, digitalisation, competitiveness, training and social inclusion [2]. The mission of education and research is a crucial focus for the Italian government as it works to support the education, training and employment of young people. According to the latest OECD report, "Education at Glance 2022" [3], in 2021, among 38 EU member countries, the share of Italians between the ages of 25 and 64 with a tertiary level of education (degree or similar) stops at 20%, a value half the average of OECD countries (41%). To address these issues, from the perspective of the PNRR, university and research institutions intend to upgrade school facilities, improving educational systems and digital skills. Among its earmarked investments, Politecnico di Milano has focused on an experiment for active guidance in high school-university transition to bridge the gap between the choice of university pathway and its completion. The School of Design of Politecnico di Milano believes that moving away from the conventional passive learning model and toward a more active learning experience will facilitate the transition from high school to university. Active learning can be defined as an instructional model that "involves students in doing things and thinking about the things they are doing" [4]. This approach aims to get students more involved, enhance their skills and lead them to explore their attitudes and values. In active learning, we see a radical change in the learning environment regarding the student and the teacher's role. According to Chi [5], active learning is commonly linked to the extensive range of social-constructivist methodologies that push educators to transition away from a conventional direct instruction paradigm in favour of more inquiry-based approaches; these techniques include problem-based learning, project-based learning, and authentic learning experiences. While the student becomes the protagonist of the educational experience and creates collaborative behaviour with each other, the teacher plays the role of facilitator and incites participation by creating true alliances among the students involved [6]. Because of such characteristics, active learning is considered a student-centred approach in which teachers facilitate, help and guide the learning experience [7]. By offering courses adopting the active learning approach, the School of Design wants to introduce young students to its approach based on the "epistemology of praxis" [8], [9]. The school proposes this educational model, which, since its foundation, is based on the interweaving of theory and praxis and aims to be an example of a plurality of approaches. A team of teachers from the School of Design applied a project-based approach to introduce the discipline of design to young students from a high school in the city of Milan (ITALY).

According to Cocco [10], project-based learning (PBL) is an instructional method that prioritises student-centred learning and is grounded in three fundamental constructivist principles: the process of learning is contingent upon the unique context in which it occurs, learners have an active role in this process, learners engage in social interactions and exchange knowledge and understanding to attain their desired goals. It is student-centred and engages the students in an educational context in which they investigate authentic questions and problems in the context of real-world practices [11]. This approach aims to lead the student to construct a final product, something real, to show the knowledge acquired through different tools far from traditional teachings, such as videos, photographs, sketches, reports, models, and more [12]. The success of PBL depends on the teacher organising the activity and their ability to motivate and guide students at all stages, supporting them in their learning [13]. This paper recounts the pedagogical approach employed in teaching design to individuals without a background in design, using an PBL method and focusing on its ability to foster students' creative capacity. The overall aim of the experiment was to make them try out some typical design tools, make them reflect on a real, concrete design problem, and become aware of the designer's role in contemporary society. Non-designers need significant structure to feel comfortable and competent using design thinking [14]. Educators can mitigate the potential overload experienced by students during project work by implementing a structured approach supported by tools that systematically organise the design complexity of tasks at different stages of the design process. This approach ensures that students can handle the ambiguity and clutter inherent in project work. Due to their limited exposure to design tools, the initial implementation of these tools may cause discomfort for high school students. Exclusive reliance on classroom instruction must be improved, and practical engagement with authentic tasks is necessary to acquire skills [14]. According to Royalty [15], a design-based pedagogy aimed at non-designers possesses five primary characteristics:

- The target audience for this content is primarily people with no design background;
- The projects present open challenges that transcend the boundaries of the educational context;
- Teamwork is an essential aspect of the student's academic experience, and they engage in collaborative work;
- The way students engage in problem-solving is influenced by a process or set of tools commonly used by designers;
- One of the main objectives is to foster and increase students' creativity.

2 OBJECTIVES

In the "Education and Research" mission of the PNRR, Politecnico di Milano has joined the "Active Orientation in High School-University Transition" project, an investment aimed at facilitating and encouraging the transition from high school to university and addressing the university dropouts' issue in the following years. The program is facing all students in the third, fourth and fifth years of high school who are invited to participate in short courses organised by university professors in collaboration with high school teachers [2]. The goal of the program is to enable participants to understand the different educational pathways proposed, to verify and consolidate the knowledge possessed to reduce the gap with that required by the course of study of interest, to learn about job sectors, employment outlets and to have an overview of potential future sustainable and inclusive jobs (https://www.polimi.it/orientamento-pnrr). In response to this program, the School of Design has partnered with Einstein Scientific High School in Milan, where students are unfamiliar with design workshops and design courses since the design discipline is not included in the education program. The School of Design organised two courses: the first aimed at designing a space dedicated to innovative teaching (to be replicated throughout the school structure), and the second aimed at designing an innovative teaching space/prototype dedicated to future professions. For Einstein Scientific High School, these courses represented a real opportunity to:

- Investigate the actual needs of students;
- Learn about and understand possible future innovative systems useful for teaching;
- Identify what the professions of the future will be;
- Gather design proposals for these spaces to enact change in the school and classrooms.

For the School of Design, the courses aimed to bring the young students involved to form critical thinking about design, proposing a design activity on a space whose limits and potential they already know. The primary objective of the experimentation was to facilitate the development of design skills, albeit at a

'primordial' stage in these students. At the same time, the students also received educational guidance: all activities always had as a common thread the opportunity to make students more aware of what it means to study design within a university environment. A further goal was to rethink high school learning spaces as places that facilitate engagement, discussion and debate, making students more aware of the importance of the learning environment for collaboration and knowledge sharing. In recent years, research in the field of learning has shown that students increase their competencies more when they are involved in active, exploratory and social contexts; this stems from the fact that today's generation of students live in technological and digital environments in which they interact with an increasing amount of information and for which they need almost immediate answers [16]. The activities organised by the research team focused on introducing students to User Centred Design (UCD), an experimental design process driven by user-generated information that enables the ongoing design of engaging and intuitive products, interfaces or environments; a feature of UCD research is that its participants are the subjects of the study [17]. Adopting a user-centred design process also means valuing systems that enhance personal skills, designing personally satisfying workspaces, and adapting strategies to users' needs because they are actively involved in their design [18]. User Centred Design consists of four distinct phases:

- Understand the context of use;
- Identify user requirements;
- Design solutions;
- Evaluate the results against the context and initial conditions.

Each of these steps was associated with a design tool that was illustrated to the students, asking them to use it for the realisation of the design steps then discussed in plenary, supplementing the work with investigative and generative tools:

- Context analysis and brainstorming;
- Survey and interviews;
- Scenarios and user journey;
- Concepts definition.

Using these tools, students have always placed the user at the centre of all the research, design, evaluation and re-design, implementing a mix of methods and testing to ensure that the user's needs are always the focus [19]. By implementing this process in the courses, the research team wanted to introduce the students to different working and learning methodologies, experiencing them in the field through concrete design.

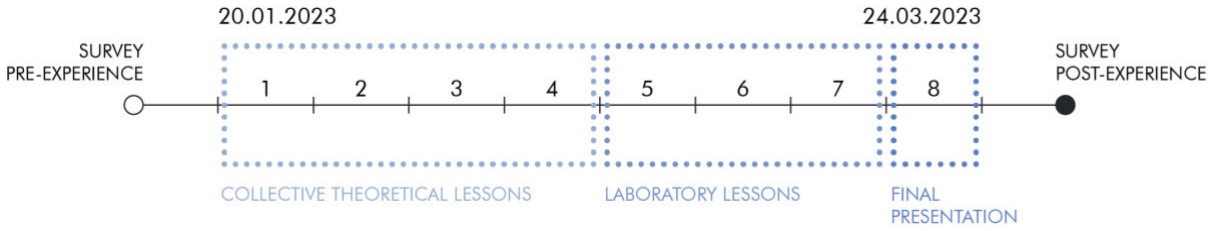
3 EXPERIMENT STRATEGY: TEACHING DESIGN TO YOUNG NON-DESIGN STUDENTS

The course featured students participating in more active, exploratory, and social procedures. It was designed to foster interactions and activities that could lead to an ongoing, reciprocal exchange of ideas and knowledge between educators and learners. Specific instruments were employed, such as questionnaires conducted before and after the project, to discover students' preconceptions before the course and to track how their perspectives on the field evolved due to their involvement. In addition, the surveys were valuable tools for teachers to study precise issues such as how the perception of the teaching space has changed after COVID-19, the use of technology in schools, and what students mean when it comes to teaching innovation. The post-project survey was designed to assess the effectiveness of the course taught and identify the key organisational components considering future course offerings.

3.1 Courses organisation

The course was delivered by two Professors from the School of Design of Politecnico di Milano, supported by an academic tutor. It involved 30 students enrolled in the third, fourth and fifth years of the Einstein Scientific High School in Milan. The course started on 20th January 2023 and lasted two months, with a weekly meeting every Friday afternoon in the high school classrooms. The course was organised into 8 afternoon meetings, 7 of which lasted 120 minutes each while the last one lasted 60 minutes, to present the final work to teachers and peers. The participants were divided into two groups, one for each course, according to the chosen project themes: one class of students decided to delve into the design of a space dedicated to innovative teaching to be replicated throughout the school

structure, while the other was focused on the creation of an innovative space-prototype devoted to the professions of the future. Within each course, the professors have divided the participants into three heterogeneous sub-groups with students from different classes and academic years to facilitate peer exchange, discussion and constructive debate among the members and help them to develop critical thinking towards potential future scenarios. By introducing different activities and levels of interaction, the students found themselves working together and indirectly learning new knowledge through diversified methodologies and tools. Even though students were divided into two parallel courses, each class was structured with theoretical and practical moments when students could share their research activities and results with all the participants. The first four meetings were characterised by theoretical lessons facing all thirty students to generate a continuous exchange and free debate between teachers and students. These were followed by three practical workshop activities, separated into two parallel classes. One professor guided each class better to follow the steps of data collection and processing, devising a concept per group and final design according to one of the school's existing classrooms.



3.2 Survey administration: a vision before the design experience

Since the courses were targeted at prospective design students not already immersed in the design discipline, an online survey was constructed and sent to all the participants one week before the start of the course, with twenty-two receiving responses. The goal of the survey was to investigate students' thoughts on the three main topics to be discussed during the following meetings:

- The personal view on design and the role of the designer;
- The meaning of educational innovation and innovative space and the role that technology plays in these fields;
- The changed perception of instructional spaces during the post-pandemic era.

During this initial discussion, students expressed their opinion on design, describing it as an artistic discipline combining aesthetics, creativity, and functionality. They described the designer as a figure capable of creating efficient spaces utilised in the most optimal way possible. Given that today's students are completely immersed in the digital world [16], it immediately became evident how important it is to understand how they relate to technology within the school context and what they mean by innovation in education and space.

"By educational innovation, I think we mean a new way of approaching lessons, including through the use of new technologies to deal with new topics and experiment with new learning methodologies."

"For me, it means renewing learning modes to enable students to learn in a more dynamic and participatory way."

From the survey responses, students also expressed the vital role of technology in improving classroom learning and introducing new study methodologies.

"Technologies in today's day and age are essential since everything is digital. Technologies have offered us an alternative, more inclusive and interesting education than the traditional one."

"They optimise time and make us develop new skills, important in future for the world of work."

Furthermore, the interviewed students believe that physical space is crucial for carrying out collaborative educational activities, but this should not forget the benefits brought by technology, which must still be an integral part of school education and classrooms, especially for interactive lessons and enabling students to work in more dynamic and participatory contexts.

"For group activities, I prefer a physical space since being all in the same place makes it easier to communicate, exchange ideas, or simply being in contact with other people, in reality, helps to make the experience more enjoyable."

Students' perceptions of educational space today are primarily linked to the role of technology introduced extensively during the COVID-19 lockdown period. According to the student's experience, these months of closure have emphasised the value of educational space, highlighting the importance of having a place that allows them to meet with peers and socialise. At the same time, distance learning and the use of technology have revealed specific weaknesses in the Italian school system, highlighting the need for more appropriate classrooms.

"I immediately noticed the difference between following in presence and digitally. I believe following in-presence is more functional, partly because we happened to be in a pandemic situation we had never experienced before. We had few digital tools at our disposal at the beginning."

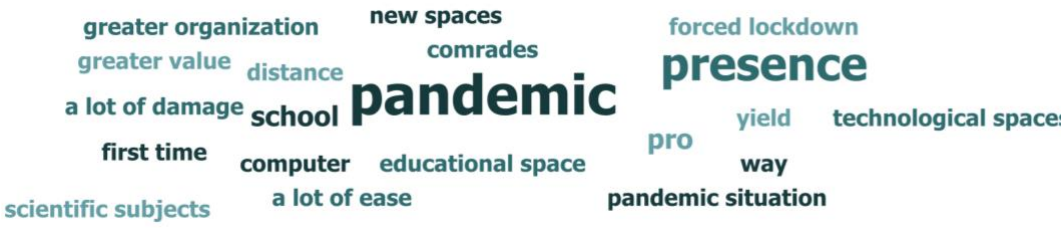


Figure 1. Keywords used by students to describe their experience with distance education.

3.3 Courses delivery

As previously mentioned, thirty students participated in a total of 8 sessions, divided into:

- 4 collective theoretical lessons;
- 3 workshops where students were divided into two courses;
- 1 final collective lesson for presenting the final project to the teaching staff.

The first session was structured by university professors as an introductory lecture on the project themes of the two courses, outlining what to design and where and the objectives to be achieved for each of them. The students were given a sheet with all the parameters (size of the classroom, colour of the walls and floor, natural and artificial lighting, etc.) to help them carry out a spatial analysis to guide them during the quantitative space search after receiving an introduction to the identified spaces within the school where they would go to design their projects. Quantitative research is an empirical investigation that employs numerical and measurable data, which can be independently measured and verified. It leads to objective, systematic observations and statistics [17]. The second session was the only one organised at the Design Campus of the Politecnico di Milano. During the lesson, students were shown case studies illustrating the theme of innovation in educational spaces. The purpose of this session was to allow students to attend a lecture in the innovative didactics room designed by a research team at the Politecnico di Milano and used by the School of Design [20]. On this occasion, the students had the opportunity to experience an environment involving various innovative technologies directly. They were also able to experience a variety of adaptable furniture components and systems, which facilitate the achievement of educational objectives by adapting to the users' needs. On that day, the students had the opportunity to study and work in an academic environment that prioritises learners' needs and integrates innovative and inclusive technological solutions, all while touching upon a design solution related to the core topic of the course. During the third session, students were introduced to a different research methodology, namely qualitative research. Qualitative research is employed when there is limited information about the subject of interest, unknown variables, or inadequate or missing relevant theoretical foundations. Qualitative research examines impressions, opinions, and perspectives from various sources to construct a rich and meaningful understanding of a complex and multifaceted situation [17]. Based on this, the thirty students developed a list of questions to pose to their school's teachers and peers to record views, traits, attitudes, and experiences related to the project's topic. This activity was done during a brainstorming session where all group members contributed ideas spontaneously [21]. As a result, they created an online survey by choosing the most relevant questions. Simultaneously, the students participating in the course focusing on designing the classroom for the "professions of the future" were asked to integrate their survey with further questions, this time aimed to delve deeper into the topic, seeking to understand the relevant disciplines, potential tools, and services.

During the fourth collective session, students presented the results of their online surveys to their peers and teachers in structured and systematic order. This activity allowed for a comprehensive view of user

needs. At this point of the work, the teachers guided the students in interpreting the information gathered from previous sessions to identify general and exciting requirements for each working group. Many people questioned stated that they would prefer to learn in more adaptable, inclusive, participatory, and immersive environments. The groups that focused on the class for the "professions of the future" focused instead on understanding what these' professions of the future' are. This activity revealed how everyone favours studying digital and technological tools in schools, along with robotics, medicine and environmental studies. Each group used this information to create a project idea, i.e. an initial proposal outlining the main components and serving as the basis for project execution.

Students were divided into two classes according to the project theme from the fifth to the seventh session. For each class, three sub-groups conducted small brainstorming activities to collect the survey data, reworking the information and finding solutions for the identified needs. Students worked in small groups to develop their idea of space and services. The professors and tutor consistently assisted the students in setting up individual and group reviews to foster conversation opportunities with other group members and define a more dynamic and collaborative work environment. Starting with the measurement, the students moved to the classroom designated as the project space. The teacher's lecture, which explained each tool used by the designer, allowed the students to work independently. However, they were asked to measure the room using their body as a unit, thus introducing them to the relationship between humans and space and teaching them the fundamentals of proxemics. As a drawing tool, the students mainly used the AutoCAD software, already taught at Einstein Scientific High School, to organise their proposed work using technical drawings. The required output was created by combining and exchanging the competencies of all group members, urging students to emphasise each other's skills. Students could choose the tools and modes of communication and representation most familiar to them, even exploring new ones. Each group developed its design idea, including the layout of spaces and the selection of furniture, materials and colours.

The final meeting, in which the six projects developed by the individual sub-groups were presented, occurred in the high school conference room. Each group was asked to compile their work into a ten-minute presentation to their peers, university teachers and the school's course coordinator. The groups presented the various stages of their design methodology and activity in several slides, together with the results of their investigation and the completed proposal. The working groups on innovative learning spaces formed the first part of the session. According to the definitions provided by the three working sub-groups, an immersive, inclusive and interactive learning environment is necessary to foster sociability and contact between students and teachers. From this point on, the students decided to work on three projects combining traditional teaching strategies with immersive learning techniques to increase student engagement in the classroom. For this reason, the spatial design of each subgroup has specific characteristics.

The main requirement is to have a classroom that can be reconfigured hourly, providing students with private, shared and informal areas that can also extend outside the classroom walls and into the school corridors. Figure 2 shows a flexible space that can be modified according to the activities and needs of the three projects presented.

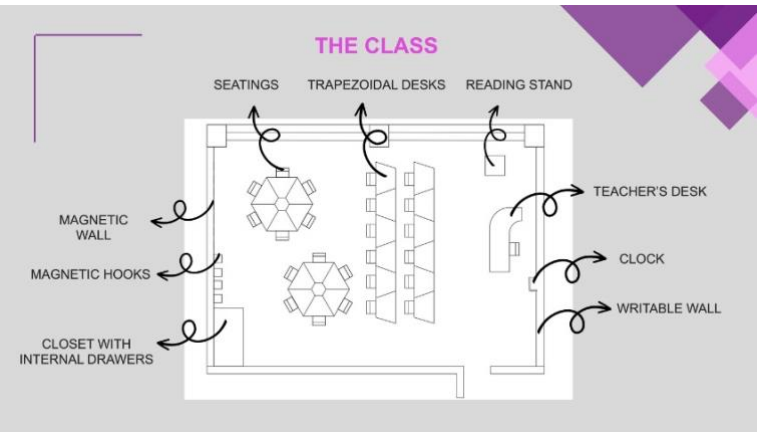


Figure 2. Design solution by sub-group A.

The exact solutions were found for each sub-group: writing walls, storage for students to place their things, and moveable desks in the shape of a trapezoid that may be arranged in numerous ways (Figure

3). Despite these similarities, a sub-group investigated the necessity for students to have greater access to technology for academic purposes and proposed offering portable chargers in the area.

Figure 3. Design solution by sub-group B.

Another subgroup focused on the issue of school laboratories and the fact that classrooms and teachers no longer use them. In response to this problem, the students designed a small laboratory area to conduct experiments and study in their assigned space. In this way, whole classes can spend more time in the classroom doing experiments and practical tests, as they do not have to move from one part of the school to another (Figure 4).

Figure 4. Design solution by sub-group C.

Participants in the second course, which focused on the design of an innovative classroom for the 'professions of the future', presented their conception of what is meant by the profession of the future, describing activities characterised by the use of robots, communication technologies, digital contexts, sustainable and environmentally friendly. One subgroup did not complete the assignment and did not hand in any work; two other subgroups created an area where students could pursue their interests in podcast recording, photography, video and sound design. The space analysis identified the need to divide the classroom into two distinct areas, taking advantage of its current state (Figure 5).

Figure 5. The current status of the classroom that was identified as a design area and

Both sub-groups set up the space, which is naturally dark at the entrance and has no windows, to provide space for additional workstations and technological activities that do not require natural light. In addition, the space area furthest from the door was designed to support group work and to accommodate more extensive manual activities. It features large windows on both sides and thus more natural light. The two subgroups that emphasised the need for this configuration responded by introducing comparable design alternatives.

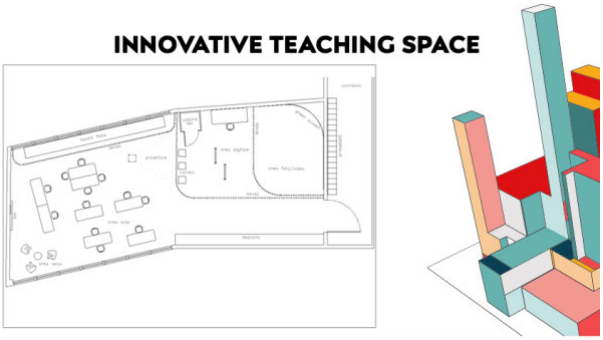


Figure 6. Design solution by sub-group D.

Sliding panels and curtains make separating the area better, providing a layout that can be configured as required (Figure 6). To make the space more adaptable to different applications, the two student subgroups organised the naturally lit classroom area using movable components, including tables, writable panels and blackboards (Figure 7).

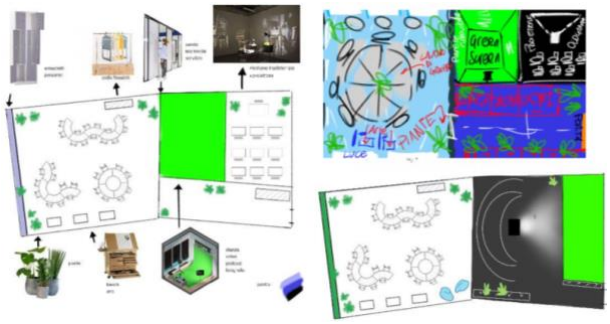


Figure 7. Design solution by sub-group E.

3.4 Survey administration: a vision after the design experience

At the end of the two-month program, the students were asked to complete the initial survey again to investigate and understand how their perception of the design discipline had changed through these experimental courses. Out of the thirty enrolled students, six completed the survey. It was structured by presenting them with the same questions as the initial one, a total of eight questions, to compare the responses obtained at the program's beginning and end. Despite the low number of participants (which indicates the need for further engagement strategies for post-course activities), their responses revealed that when students are engaged in active, exploratory, and social contexts, they can develop critical thinking about the activities carried out and improve their perception of a specific topic to which they were previously unfamiliar but were introduced through a praxis-based approach.

4 DISCUSSION

At the end of the experimental process in the two courses held at Einstein Scientific High School in Milan, we positively assessed the involvement of the students, who showed interest in the project theme and actively engaged in the proposed activities that deviated from the current passive model still prevalent in Italian high schools. By using a different teaching approach that emphasises collaboration and exploration, the students demonstrated that using an active teaching approach based on finding a solution to a real design problem made them more aware of and disposed towards the design discipline. At the same time, they acquired and developed new and different skills, interacted constructively with peers and teachers, and were more inclined to engage in dialogue and teamwork for their own academic

and personal growth. From the first meeting, however, it was evident that this didactic approach generated interest in the students because it exposed them to alternative and new learning methods. Furthermore, it became clear that the courses, with their participative activities, introduced young high school students to the discipline of design and how it is taught in a higher education institution. The results of the final projects identified positive and negative aspects arising from the approach taken in both courses. The positive outcomes are:

- Students' attention to the proposed topic;
- Accurate analysis of the existing space based on quantitative and qualitative criteria;
- Active participation of students in imagining the designed space in different ways;
- Unexpected quality of some final concepts.

The negative outcomes are:

- Tight course time;
- One group did not complete the course and did not present the project at the final meeting;
- Twenty-five out of thirty students completed the course;
- Low engagement in the activity after the conclusion of the experiment.

5 CONCLUSIONS

Through these active, participatory and laboratory teaching experiences, the School of Design and its research team aim to guide more and more young people towards an informed choice of future academic path besides the conventional structured orientation activities, through the active participation of students in these courses, where they were guided in realising a design concept. By consistently applying a project-based method, students were not only asked to design, develop and construct practical solutions to a real problem but they were led to build their creative skills to enable them, in the future, to solve other and more complex problems through teamwork.

Considering the students' overall positive feedback and active involvement, it has been decided to propose these experimental courses again in the future, but with some changes. The goal remains to continue delivering these activities, always offering short design courses structured in such a way as:

- To bring students closer to the didactics provided by the School of Design and the design discipline in general;
- To encourage the transition from high school to university;
- To make students more aware of the importance of the educational environment both as a place where collaboration (between students and between students and teacher) takes place and as a place where knowledge is shared;
- To increase the skills possessed by the individual student through the active participation of students;
- Reduce the gap between the skills possessed and those required by the course of study of interest.

Future courses will allow new students to work through an interdisciplinary methodology, using new tools and technologies to make project communication and realisation more efficient. The challenge for university professors and academic tutors will be to propose simple, agile and fast design requests to participants so that they can focus more on creating project relationships between the submitted content and the practice of its realisation. One of the novelties of the future courses will be the location where they will be organised. To further involve students in the university context, the School of Design intends to bring students to its campus in Milan instead of holding the courses at their high school. This choice is motivated by the intention to support high school students with additional orientation tools outside traditional contexts, such as the annual university open days, to acquaint them with the university and its educational offerings. The aim is to immerse high school students in the design reality of the university, turning them into real design students, even if only for a limited period. They will get to know the services available to university students and the spaces on campus, such as classrooms and laboratories, which they rarely encounter during open days and which they only begin to use after becoming first-year university students.

REFERENCES

[1] A. D'Alfonso, *Next Generation EU. A European instrument to counter the impact of the coronavirus pandemic*, European Parliament, 2020. Retrieved from https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/652000/EPRS_BRI(2020)652000_EN.pdf

[2] Presidenza del Consiglio dei Ministri del Governo Italiano, *Piano Nazionale di Ripresa e Resilienza, #NextGenerationItalia*, Italia domani, 2021. Retrieved from https://www.governo.it/sites/governo.it/files/PNRR.pdf

[3] OECD, *Education at a Glance 2022: OECD Indicators*, OECD Publishing, Paris, 2022.

[4] C. C. Bonwell and J. Eison, "Active Learning: Creating Excitement in the Classroom," *ASHE-ERIC Higher Education Reports*, vol. 1, Jan. 1991.

[5] M. T. H. Chi, "Active-Constructive-Interactive: a conceptual framework for differentiating learning activities," *Topics in Cognitive Science*, vol. 1, no. 1, pp. 73–105, Jan. 2009.

[6] P. Baepler and J. D. Walker, "Active Learning Classrooms and Educational Alliances: Changing relationships to improve learning," *New Directions for Teaching and Learning*, vol. 2014, no. 137, pp. 27–40, Mar. 2014.

[7] C.C. Christersson and P. Staaf, *Promoting active learning in universities thematic peer group report*, European University Association, 2019. Retrieved from https://eua.eu/downloads/publications/eua%20tpg%20report%205-%20promoting%20active%20learning%20in%20universities.pdf

[8] D. A. Schön, *Educating the Reflective Practitioner: Toward a new design for teaching and learning in the professions*. 1987. Retrieved from: http://psycnet.apa.org/record/1987-97655-000

[9] L. Collina, "Scuola del Design, Politecnico di Milano," *Domus,* 1010, February, pp. 12-17, 2017.

[10] S. Cocco S. *Student leadership development: The contribution of project-based learning* (Unpublished Master's thesis). Royal Roads University, Victoria, BC, Canada, 2006.

[11] S. M. Al-Balushi and S. S. Al-Aamri, "The effect of environmental science projects on students' environmental knowledge and science attitudes," *International Research in Geographical and Environmental Education*, vol. 23, no. 3, pp. 213–227, Jun. 2014.

[12] R. Holubová, "Effective Teaching Methods--Project-based Learning in Physics.," *US-China Education Review*, vol. 5, no. 12, pp. 27–36, Dec. 2008.

[13] D. Kokotsaki, V. Menzies, and A. Wiggins, "Project-based learning: A review of the literature," *Improving Schools*, vol. 19, no. 3, pp. 267–277, Jul. 2016.

[14] J. Liedtka, R. Salzman and D Azer, "Democratising Innovation in Organisations: Teaching Design Thinking to Non-Designers", in *Design Management Review*, 28(3), pp. 49–55, 2017

[15] A. Royalty, "Design-based Pedagogy: Investigating an emerging approach to teaching design to non-designers," *Mechanism and Machine Theory*, vol. 125, pp. 137–145, Jul. 2018.

[16] D. Oblinger, "Leading the transition from classrooms to learning spaces," *Educ. Q.*, vol. 28, no. 1, pp. 14–18, 2005.

[17] G. Muratovski, *Research for Designers. A guide to methods and practice*. SAGE, 2016.

[18] R. Kling, "The organizational context of User-Centered Software Designs," *Management Information Systems Quarterly*, vol. 1, no. 4, p. 41, Dec. 1977.

[19] H. Shawn Lawton, *Just Ask: Integrating Accessibility Throughout Design.* Lulu.com*,* 2007

[20] G Gerosa and A. Manciaracina, "L: Space and technology as facilitators of new hybrid learning experiences: the Politecnico di Milano's Innovative Classroom Project," in *Multiple-scalarities* (G. Gerosa and A. Manciaracina, eds.), pp. 73-101, Franco Angeli, 2023.

[21] H. Osborn, "The Journey of Brainstorming" in *Journal of Transformative Innovation*, vol. 2, n°1, Regent University, 2016. Retrieved from https://www.regent.edu/journal/journal-of-transformative-innovation/the-history-of-brainstorming-alex-osborn/