VISUAL & PERFORMING ARTS | RESEARCH ARTICLE

Enhancing architectural engineering students’ acquisition of artistic technical competences and soft skills

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Abstract: In architectural engineering, artistic technical competences and soft skills have become particularly crucial for remaining competitive globally and for fighting against uniformized and/or disharmonized urbanized landscapes. The Design and Sculpture Studio taught at Wrocław University FA-WUST (Poland) illustrates the efforts made to teach these abilities. We investigated how students in architectural engineering develop artistic technical competences and soft-skills by means of the studio teaching method and to assess their role for the training of today’s architectural engineers. A survey using a 5-point Likert-scale was carried out among students who completed the Studio. Statistical analyses revealed that soft skills play a critical for the students’ training in architectural engineering. Furthermore, we found evidence validating the hypothesis that teaching design and sculpture by means of studios is fruitful for acquiring both soft skills and artistic technical competences. The findings of this study revealed that (i) creativity and innovative thinking, as well as knowing how an object should be integrated in the space and in the landscape as the most important for the training of today’s architectural engineers, (ii) the studio teaching method is particularly useful to increase the students’ acquisition of these abilities, and (iii) the recent awareness of the

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PUBLIC INTEREST STATEMENT

In architectural engineering, artistic technical competences and soft skills have become particularly crucial for remaining competitive globally and for fighting against uniformized and/or dis-harmonized urbanized landscapes. In this study, we investigated how students in architectural engineering develop artistic technical competences and soft-skills by means of the studio teaching method and to assess their role for the training of today’s architectural engineers. Our study revealed that soft skills play a critical for the students’ training in architectural engineering. In particular, creativity and innovative thinking, as well as knowing how an object should be integrated in the space and in the landscape as the most important for the training of today’s architectural engineers. At a more general level, the study brings into light the recent awareness of the importance of soft skills in architectural engineering education in the Central-European context.
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Subjects: Study of Higher Education; Teaching & Learning; Design; Visual Arts

Keywords: architectural engineering education; course assessment; studio teaching method; institutional culture; student-centered learning

1. Introduction
In the USA, engineers and scholars of engineering education became aware of the great importance of soft skills, such as creativity, innovation, critical thinking, people management, cognitive flexibility for remaining competitive globally very early (Charyton, Jagacinski, Merrill, Clifton & Dedios, 2011; Felder, 1987; Taurasi, 2007). In addition, the scientific community has raised the question of whether art, such as design and sculpture, has a place in engineering education (Carlson & Sullivan, 1999). This awareness has grown more and more in the last years and it targeted the identification of the new skills required to thrive in the Fourth Industrial Revolution (Gray, 2016; McGowan & Shipley, 2020; Reaves, 2019) as well as how to enhance students’ soft skills (Charyton & Merrill, 2009; Simpson et al., 2008) and how to develop their artistic competences, such as design and sculpture, among others (National Academy of Engineering, US, 2004). At the European level, it is worth mentioning Greece and the Technical University of Crete, where a restructuring of the curriculum took place in 2001 (Zampetakis et al., 2007). As put by Zampetakis et al. (2007), creativity development and searching for solution in a creative manner necessitate to be taken into account by education systems (Craft, 2003; Osborn, 1992). This is because there is a constantly growing need imposed on engineering graduates to become creative and innovative thinkers as creativity is a key skill for engineering, and especially for engineering design. In this context, the Technical University of Crete changed, in 2001, their curriculum of undergraduate studies in order to promote the development of creativity by setting two major priorities, namely: implementing tight links between education and industry and approaching problems with open-ended solutions.

In contrast, in other countries, such as Poland, for example, the awareness has occurred only recently and studies focused on developing new education methods preparing students to acquire not only technical competences, such as drawing (Zychowska, 2019) but also soft skills (Łątka & Michalek, 2021; Muszyńska, 2021). Despite this inceptive awareness, in the Polish context, the awareness about the importance of soft skills is not strong enough to result into major changes of curriculum and of the institutional culture, as it was the case in Greece (Zampetakis et al., 2007). On the contrary, design and sculpture classes have the tendency to lose ground in numerous Polish universities, as we show in Author (under review). The case study we present in this paper illustrates the efforts of some scholars to preserve the teaching of artistic (sculpture and design) technical competences to architectural engineering students and to develop their consciousness of the high importance that these skills for the work of present and future architectural engineers.

It should be emphasized that in the specific case of architectural engineers, developing soft skills and mastering artistic technical competences, that is competences related to design and sculpture, are essential for avoiding the main problem of architectural engineering, that is, the spreading of highly uniformized architectural realizations that are in disharmony with the landscapes (De Clercq, 2011). This issue can be certainly linked to the lack of spatial knowledge (i.e. how objects must integrate in the space) and of the awareness of the influence of visuality on the quality of the human environment. In Scruton’ words: “[architecture] takes up space: either it crushes out of existence what has gone before, or else it attempts to blend and harmonize” (Scruton, 1973: 332). The problem is not new. Already at the end of the 20th century in urbanized landscapes on all continents, bland chaotically enclosed “non-places” began to dominate, which were difficult to settle in a specific time or culture (Augé, 1995). For Augé, “non-places” do not have their owners or
their history, they do not arouse emotions, they do not build a community. They are “the same everywhere”—airports, supermarkets, gas stations, endless suburbs.

To prevent the propagation of uniformized or disharmonized architectural works, architectural engineers must develop specific technical competences, such as mastering practical methods and tools for creating and analyzing spatial forms, develop their presentation skills, such as the ability to visualize concepts in spatial, drawing, and painting forms, as well as develop their creativity and their cognitive flexibility. Design and sculpture studios may be seen as a solution to the lack of harmony and to “non-places” in modern architecture.

2. Background

2.1. The necessity of design and sculpture competences in architectural engineering education

The inclusion of art classes, such as design and sculpture, for architectural engineers was intended to humanize architectural engineering studies (Żychowska, 2019). This movement should gain more and more importance in contemporary education because the model favoring a narrow specialization and the improvement of professional abilities in one profession through many years of practice is no longer valid (Borucka et al., 2020).

Regarding competences in design, as pointed out by Daly et al. (2012: 187), even the very early accounts from professional engineering organizations included design as a key aspect in their definitions of engineering: “the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination …” (Engineers’ Council for Professional Development, 1947). In addition, the USA National Academy of Engineering also noted that “engineers in 2020, like engineers of yesterday and today, will possess strong analytical skills. At its core, engineering employs principles of science, mathematics, and domains of discovery and design to a particular challenge and for a practical purpose.” (National Academy of Engineering, US, 2004). In the more specific field of architectural engineering, design is also seen as a plan for the realization of an object (a building, a piece of craftwork or artwork, an architectural or engineering drawings, or a prototype), or as a process or activity, which provides such an object as its result (Anderson, 2011; Dorst & Cross, 2001). For the needs of this paper, we think of design as a process, which can be seen more broadly, as a discipline whose aim is to create high-quality works by joining a variety of technical competences with a large array of soft skills. Technical competences related to design, such as drawing, modelling, or mastering various factors related to geometry and space, are numerous and the necessity of their acquisition by architectural engineers is not called into question.

Technical competences related to sculpture are also highly relevant for engineers and architects when designing a building, bridge, mausoleum or other architectural works. The specific sculpture techniques, such as mastering different techniques of visualizing a piece of work, drawing and modeling competences, mastering the balance between the size and the weight of an object, as well as knowing how an object should be integrated in the space and the landscape, are helpful in designing harmonized building or other works as they enhance the aesthetic value of an architectural structure (George, 1974).

2.2. The necessity of soft skills in architectural engineering education

Nowadays, apart from artistic technical competences, architectural engineers must also have numerous soft skills, such as creativity and innovation (Blashki et al., 2007; Makowska, 2019; Zampetakis et al., 2007), the ability of understanding the users’ needs (Neuman, 2016), the ability to diagnose social problems, as well as understanding and creating the impact of construction investments on society and the environment (Gyurkovich, 2018; Muszyńska, 2021; Špaček et al., 2016). For example, Muszyńska’s (2021) study, which presents the course Workplace Design Studio: Factory of the Future taught at the Wrocław University of Science and Technology, illustrates very
well how architectural engineers acquire such critical soft skills. In this course, architectural engineering students are confronted to the shift of paradigm in industry, known as Industry 4.0, which completely changed the way in which the factories of the future, which are more sophisticated and multifaceted than traditional industrial buildings, must be designed. In this context, the course Workplace Design Studio: Factory of the Future gives students the opportunity to imagine the factory of the future by taking a multi-faceted and holistic perspective. By means of a survey, Muszyńska-Łanowy (2021) provides empirical evidence that the course Workplace Design Studio plays a crucial role for the development of the architectural engineering students’ soft skills, such as interdisciplinary, analytical and critical thinking, emotional intelligence in social issues, interpersonal communication, cooperation, and creativity. Among soft skills, creativity has certainly attracted the researchers’ highest interest and is the most studied skill. We discuss below some studies targeting its importance.

The engineering literature inquired whether creativity and other soft skills are currently being taught to engineering students since the regular curriculum still accentuates the importance of the basic sciences, such as physics, mathematics, and mechanics (Zampetakis et al., 2007). Engineering students’ curriculum. As put forward by Conole et al. (2008), the integration of creativity into the education of engineers still needs some consistent development. In a survey carried out by Zampetakis et al. (2007), current engineering students agreed that creativity was a skill that is necessary for their training (87%) and that they would like to take a course in creativity and creative problem solving (77%).

Thus, this need for developing creativity in engineering has led to searching for creativity support tools and methods useful for developing engineers’ and designers’ creativity (Shneiderman, 2007). Furthermore, studies also investigated what are the most appropriate methods of teaching creativity to engineering students (Simpson et al., 2008). Teaching creativity to engineering students is particularly challenging because engineering is tightly linked the notion of utility, of solving problems, preventing potential future problems (Charyton et al., 2008; Charyton & Merrill, 2009) and of fitting into the physical world (Perl, 2008). It is important to note that while aesthetic considerations may be less important for engineers to consider, they are particularly important for architectural engineers.

As for the importance and the acquisition of other soft skills, such as innovative, analytical, and critical thinking, and cognitive flexibility, the literature is scarcer than that regarding creativity. For this reason, we propose to focus on a wider range of soft skills including creativity, such as cognitive flexibility, innovative thinking, critical thinking and analytical thinking. We argue that design and sculpture classes for students of architectural engineering provide great creative freedom as they combine the creative process of artistic and sculptural spatial forms with architectural engineering knowledge and competences. All in all, sculpture and design classes, especially in the studio format, are a kind of testing ground not only in building a form but also in acquiring and strengthening various technical and soft skills.

2.3. Teaching methods for developing students’ artistic competences and soft skills
The question that raises is how to teach soft skills to students and how to develop their artistic competences, such as design and sculpture. For example, Carlson and Sullivan (1992) present a learning environment, called the Integrated Teaching Program (ITT), implemented at the College of Engineering and Applied Science from the University of Colorado. In the ITT program, students from all four years of training can benefit from teaching activities which feature teaming, active learning and project-based design and problem-solving experiences. As listed by Carlson and Sullivan (1992: 20), the ITT program provides students with the following phases: during the first year, students benefit a learning frame in which the principles of design are introduced; during the middle two years, students have theoretical engineering science courses which are supplemented with hands-on, open-ended discovery activities; finally, during the fourth year, teams of senior students design, build and test real-world products. In terms of facilities, the ITT
Laboratory offers a large variety of teaching methods and activities: first-year design studios, an active learning center, a computer simulation laboratory, capstone design studios to put on display student projects, group work areas to support student teams, and interactive science-based kinetic sculpture galleries Carlson and Sullivan (1992: 20). In sum, the ITT program is a great example of changes in the engineering curriculum resulting in the enhancement of students’ artistic competences and soft skills.

Another example that is highly successful for progressing in creativity in engineering education is that of immersive learning (Blashki et al., 2007), which can be student-centered or learning from peers. In the student-centered approaches, the teacher does take the role of an expert but (he) guides and facilitates the learning process (Blashki et al., 2007; Conole et al., 2008). An alternative is combining traditional teaching with student-centered techniques (Conole et al., 2008). Among these, there is the studio teaching method. Studios are teaching techniques in which “students learn to experiment on their own, teach each other, and use all studio members as resources in the research” (Park, 2020: 524). Studio teaching is student-centered, where students are actively engaged in learning by experiencing. This method is opposed to teacher-centered teaching methods (such as ex-cathedra lectures and courses), where the focus is on the teacher’s lectures and on classroom presentations (Barrows, 1986; Neuman, 2016). For Schon, the studio teaching method, or as he called it, reflective practicum, is built on the premises of “learning-by-doing” and “reflection-in-action” principles (Schön, 1987). The studio is intrinsically reflective and facilitates the process of reciprocal dialogue, which is not restricted to that between the tutor and the student, but it is a social structure of collaborative learning (Iranmanesh & Onur, 2021). Indeed, such cooperative teaching methods allow for a mutual enrichment in gaining new abilities among students in architectural and civil engineering (Łątka & Michalek, 2021).

As noted by Park (2020), studios represent a unique pedagogical format widely adopted in the curricula from the field of design (Crowther, 2013; Forsyth et al., 1999; Long, 2012). Design studios tend to pursue collective and comprehensive projects and value design objects (e.g., landscapes, buildings, public/private spaces) to the shared benefit of others. In contrast, in other types of studios (such as sculpture or modelling) the students’ self-expression and their individuality are encouraged during the product-making process (Taylor & Ladkin, 2014). This method is key for both architectural engineering education due to its potential to empower to only rational and critical thinking (Cho & Cho, 2014; Wang, 2010) but also creative thinking (Salama & Wilkinson, 2007). Thus, in studio-based learning, students are expected to iteratively generate and refine concrete solutions, communicate effectively, and collaborate with others. In addition, the students’ evaluation may easily be carried out through peer-evaluation and/or auto-evaluation methods.

3. Current empirical research

In this paper, we present a case-study linked to one of the existing approaches to developing creativity and other soft skills, namely the approach combining traditional teaching with student-centered techniques. The main focus is on assessing the importance of various soft skills, including creativity, as well as artistic technical competences for the work of future architectural engineers. Indeed, they are expected be able to deliver harmonious architectural works, which perfectly integrate in a given landscape. Precisely, we present the studio teaching method in which students have access to design and sculpture contents. The studio is called the Design and Sculpture Studio, and it is being taught by the author of the paper to architectural engineering students from the Faculty of Architecture at Wroclaw University of Science and Technology (FA-WUST) in Poland. Architectural engineering students are enrolled in a four-year degree and follow the studio in their first and second year of study. Per year, there are approximately 12–15 students who follow the studio.

The studio includes three modules—one theoretical about the main principles of the professional presentation of artistic concepts and design visualizations, one on clay modeling, one on designing
and sculpting that focuses on practical design, modeling, and drawing skills, and a final applied project about how sculptural installation objects (single or multi-element) must be placed in different types of spaces. Then, we report on the results of a survey carried out among the students who have successfully completed the studio for the last three years. The purpose of studio was to answer the following research questions: (i) In the Polish context, are soft skills as important as design and sculpture technical competences are for the education of engineers and architects? (ii) What are the most important soft skills necessary for the training of today’s architectural engineers? (iii) How can students acquire these soft skills?

3.1. Case study: the design and sculpture studio for architectural engineers

The goals of the Design and Sculpture Studio are to teach architectural and urban design and sculpture techniques by taking into account significant factors of the creative process—from the human condition (e.g. ergonomics, psychology) up to the cultural and environmental contexts. As a result, students are able to understand the importance of non-technical aspects and effects of an engineer-architect’s design activity, including its impact on the cultural, visual, and natural environments. Students learn to take responsibility for architectural and urban values in the protection of the environment and for the visual impact of the architectural construction and its cultural heritage. The main practical part of the studio, which consists of design and sculpture workshops, is addressed at architectural engineering students who need to acquire a large palette of technical competences and of soft skills in order to avoid creating “non-places” or disharmonious realizations. These include, on the one hand, technical competences related to design and sculpture, such as acquiring modeling, drawing, and sculpting abilities, and mastering different visualization techniques, the balance between the size and the weight of an object, as well as the harmonious integration of an object in the space and the landscape (see Figures 1–7). On the other hand, the acquisition of various soft-skills—also required in a design process—such as creativity, cognitive flexibility, innovative, critical, and analytical thinking, is also expected during the studio.

The Design and Sculpture Studio is composed of three fundamental modules: Module 1: Theory—Technology—Material, Module 2: Clay Modeling, and Module 3: Design and Sculpture. The Design and Sculpture Studio ends with a final, applied, Project.

3.1.1. Module 1: Theory—Technology—Material

The first module consists of a series of informative seminars aiming to provide theoretical as well as material and technical knowledge related to methods employed in design and sculpture. This module provides students with general knowledge of the use of various artistic and sculptural materials, as well as modeling techniques in the design and the presentation of large-size spatial forms. This part of the studio gives the opportunity to acquire technical competences by learning the main principles of the professional presentation of artistic concepts and design visualizations, i.e. drawing, spatial sketches, creating models, and mockups.

3.1.2. Module 2: Clay modeling

The second module is the one in which the idea of learning while experiencing is adopted and it is implemented in a hands-on clay modeling workshop (e.g. Landart: clay modeling technique). It takes the form of exercises in clay, which develops the ability to communicate through the form and creativity, as illustrated in Figure 1.

This method of education is practical in the sense that it supports learning while acting, typical for studio format of teaching. A novelty in this method is that students are required to independently assess the impact of their projects upon the existing environment. The classes give students the opportunity to get acquainted with selected procedures of spatial description of projects on a scale—common conventions of presenting space and spatiality. The tasks carried out allow students to understand the essence of the phenomenon of space on various scales, which are
connected with architectural and urban design. The sessions consolidate the basic knowledge and skills related to professional communication with the use of spatial records.

The module starts with exercises in modeling materials and consists of simple sets of tasks in the clay modeling technique, such as Material strength and artistic effect, Material and geometry and Size and visual weight against physical value. The sessions are intended to explain the relationships between the shape of objects and their visual perception of size/weight balance as well as how they integrate in the space and the landscape. Thus, the student can better understand that the physical characteristics of objects, i.e. height, width, length, weight, are not the only elements determining their actual reception. The same height sphere and regular cube will visually differ in weight/size. The same situation will be when both objects are made of the same amount of material. The students’ task is to align visual values in the three different, simple geometric solids, as illustrated in Figure 2, which they previously modeled, as illustrated in Figure 3.
The module continues with a part on the reception and the evaluation of an object in motion, which allows students to learn about spatial vision and evaluate cubature objects. Students have the opportunity to comprehend that in order to correctly evaluate the space (visual size), some movement is needed to combine all views of an object. The same object, which is perceived as plane only from selected sides (view, projection, section), may distort the correct reading of the spatial value of the object (see Figures 4 and 5 for an illustration).

In this part of the module, the issues concerning the influence of the material used, the value of its filling (openwork), and textures (soft, hard) on the reception of objects and structures are also discussed. The exercises are aimed at sensitizing students to the specificity and complexity of the correct evaluation of spatial objects as well as to the problems and limitations, which are connected with the presentation of spatial forms (architecture, sculpture) on two-dimensional media (boards, visualizations). In addition, the exercises target the development of the students’ analytical and critical thinking, skills necessary to evaluate an object in motion, to evaluate the influence of the different materials used and of the textures, and to deal with the different problems and limitations of two-dimensionality.

3.1.3. Module 3: Design and sculpture workshops
The third module is carried out in the form of design and sculpture workshops. It begins with familiarizing students with the principles of collecting information and interpreting within the
framework of preparing a project concept. It specifies analytical methods for formulating and solving design tasks and creating one’s own spatial expression. During the classes, students acquire knowledge about the methodology, which enables the analysis of the existing spatial situations. They also learn how to define interaction between a specific design proposal and its surroundings. Design workshops focus on practical design and drawing skills, which are essential to be acquired for architectural engineering students. Sculpture workshops focus on different areas, e.g. promoting the individuality of designers by encouraging to develop unique concepts or by pushing them towards innovative thinking which goes beyond the already known boundaries. As such, these module components are also intended to develop students’ soft skills such as creativity, cognitive flexibility, analytical and innovative thinking.

The practical design tasks for architectural engineering students (e.g. Revitalization: spatial composition in a selected urban context) aim at developing their analytical thinking, including analyzing the spatial situation and teaching constructive solutions to design problems. It begins with the inventory and the evaluation of a selected situation form a natural or urban landscape—a method of assessment in various environments, both in open space and in a closed urban interior. Students are supposed to create an original spatial composition in natural environment. Then, they have to visualize the concept based on selected materials (mockup) and, on this basis, they prepare illustrative and technical boards using digital means, what trains them in different techniques of visualization of a piece of work. They start with determining the boundary of the selected area development, which should be close together with the last cubature elements visually influencing the working area. Next, attention is drawn to their typical features, which relate to the same categories that were covered in the first module of the studio, i.e. scale, proportion, density, articulation, material, texture. Two examples of their work result are provided in Figures 6 and 7.

The first obstacle for any designer working in the public space is the surrounding architecture. Thus, the proposed design becomes sensitive or resistant to this environment. Of course, there are also situations when an object, situated several kilometers away (e.g., the chimney of a heat and power plant), still affects the situation of the selected place. Such situations are discussed with the group and solved individually. Students are asked to identify the scale of cubature objects, which build the character of the space within the boundaries of the area development. So, they are able to see the space (e.g. buildings, trees, landscaping, hills, embankments) and analyze the field composition what exercises their ability to harmoniously integrate a new object in the existing landscape.
Finally, other characteristic features of the terrain are analyzed, including the distinction between soft (i.e. the nature) and hard forms (i.e. the architecture), as well as the topography. During the analysis, the student also tries to determine those features of the area which create its specific character, e.g. dominants, transportation, water surface, and view axes. The inventory stage ends with the evaluation of its visual quality, the assessment of its cultural and natural values, and the indication of problem areas. Such a systematic analysis and discussion of the features of the object and of the space in which it would be integrated significantly develop students’ skills in analytical and critical thinking.
3.1.4. Final project
After completing the analysis stage, students start to develop three proposals for one selected location, which consists in proposing design concepts of a sculptural installation object (single or multi-element) to be placed in a selected space. In the last stage, after the discussion, one project is selected and refined in detail. The proposed concepts of sculptural installations should not be created only as decorations because they are created to interact with them and to experience them. As such, they are very closely connected with architecture in the sense that the spaces in which we live are read through the process of walking through them and the process of their settlement.

The evaluation of the area, which completed the inventory stage, is of great importance, as it allows us to determine the place and scale of the assumption adopted by the designer—it is able to formulate recommendations quite precisely by referring to the protection or improvement of the landscape. It is important to consider the context, whether in terms of individual space, local geography, culture, or what a student wants to express. It is also significant that the effect is one that does not look cluttered or mismatched and which goes towards the strengthening rather than distracting from the surroundings. Here, not only technical competences are of help for student’s task but also the array of soft skills they gained during the three preceding modules of the studio: cognitive flexibility, creativity, innovative thinking, critical and analytical thinking.

The evaluation of three design proposals, which are developed for the same area, volume and place, makes it possible to determine the way the proposed forms of spatial installations change and modify the existing situation. By evaluating the aesthetics, strength and nature of the impact of each of the three variants, the self-assessment method, characteristic of studio teaching format, turned out to be crucial for achieving learning outcomes.

In some cases, students admit that the project which seemed to be the most attractive, probably due to poorly selected measures, may lead to a deterioration in the overall quality of the existing site, and that the acceptance of the proposed installation itself will not be in accordance with the initial assumption. On the other hand, a complete integration and a perfect unity with the visual features of the existing site may equally result in an unsatisfactory final result. Moreover, the self-assessment task helps young architectural engineers to be self-critical and accountable for their designs.

In sum, by using the tools presented above, students have the opportunity to evaluate the impact of their intervention. Moreover, this sequence in the creative process motivates architectural engineers to recognize the landscape as common good, which is more important than personal tastes and ambitions. Finally, thanks to self-assessment, the studio teaches students responsibility and critical thinking. These skills are especially valuable within the current priorities in architectural engineering education which for young architectural engineers includes the challenge to create functional sustainable architecture which harmoniously fits its context.
3.2. Survey: the evaluation of the design and sculpture studio

3.2.1. Methodology
To assess the students' evaluation of the importance of the Design and Sculpture Studio to acquire artistic (design and sculpture) technical competences and soft skills necessary for their training as architectural engineers, we carried out a large-scale voluntary and anonymous survey among the students who participated in the studio. The survey was distributed among all students who successfully completed the Design and Sculpture Studio during the last three years. Since the participation was voluntary, a total of 69 students (9 females, 60 males), being between 20 and 27 years old, participated in the survey and fully completed it. The survey was digital, and it was prepared and distributed by means of the Qualtrics® platform. Participants read all the questions, which appeared in a random manner to avoid having an order effect in the results.

The survey was designed to answer the following research questions:

1. Are design and sculpture technical competences, i.e. mastering different techniques of visualizing a piece of work, drawing competences, modeling competences, mastering the balance between the size and the weight of an object, and knowing how an object should be integrated in the space and the landscape, perceived by students as necessary for their training of architectural engineers?

2. Are soft skills, i.e. cognitive flexibility, creativity, innovative thinking, critical thinking and analytical thinking, perceived by students as necessary for their training of architectural engineers?

3. Did the Design and Sculpture Studio allow students to acquire the above-mentioned design and sculpture technical competences and soft skills?

4. Did the specific features of the studio teaching, i.e. student-centered, students being actively engaged in learning, and learning by doing, allow students to acquire the above-mentioned competences and soft skills?

The survey consisted of 23 questions, among which 10 targeted the assessment of the above-mentioned specific technical competences, 10 the assessment of the above-mentioned specific soft skills and 3 the assessment of the importance of above-mentioned features of the studio teaching method for acquiring artistic technical competences and soft skills. The questions were formulated as follows:

(i) How much important is [a specific TECHNICAL COMPETENCE] for your training as engineer-architect?

(ii) How much important is [a specific SOFT SKILL] for your training as engineer-architect?

(iii) How much important was this studio to acquire [a specific TECHNICAL COMPETENCE]?

(iv) How much important was this studio to acquire [a specific SOFT SKILL]?

(v) How much important was the [FEATURE OF STUDIO METHOD] to acquire design and sculpture technical competences and soft skills?

Participants had to answer on a 5-point Likert scale, with values between 1 and 5, where 1 means not important at all and 5 means very important.

3.2.2. Statistical analysis
Data about importance of technical competences and of soft skills were analyzed by means of a Friedman Two-Way ANOVA by Ranks using the SPSS software. ANOVA (from Analysis of Variance) is useful to find out whether the differences between the groups of data tested are statistically significant. This type of ANOVA is used to compare the distributions of scores of two or more quantitative variables (which are either ordinal or nonnormally distributed) obtained from dependent
samples (repeated measures or matched groups). This statistical analysis is used to compare two or more quantitative variables in a set of data containing dependent samples in which the measurement scale is ordinal. The null hypothesis of the statistical analysis is that the distributions of the scores given by participants for two or more questions are the same. The ANOVA analysis is suitable for this study as we compare groups of observations produced by the same participants (dependent samples) and the measurement of the participants’ answers is made by means of a Likert scale.

### 3.2.3. Results

First, we analyzed the scores given by students to the questions, which assessed the importance of specific technical competences related to architectural sculpture, on the one hand, and of specific soft skills, on the other hand, for their training as architectural engineers. The students’ scores to these two groups of questions, a mean of 4.21 to the former and of 4.48 to the latter, reveal that they perceived design and sculpture-specific technical competences, as well as soft skills, as highly important for their training as architectural engineers. Second, the students’ scores to assess the importance of studio-specific features were also high, mean of 3.84, indicating that they appreciated this teaching method and found it useful to acquire specific technical and soft skills. Third, the students’ scores to assess whether following the Design and Sculpture Studio allowed them to acquire the specific technical competences and soft skills were rather high, mean of 2.87 for technical competences and 2.93 for soft skills, indicating that they perceived this specific studio attained its objectives regarding the acquisition of specific technical and soft skills. All mean scores are much higher than 2, which suggests that students gave, in general, a positive evaluation of the Design and Sculpture Studio.

To answer the first two research questions, we carried out by means of ANOVA the following analyses:

1. The mean scores given to questions about how much all sorts of design and sculpture technical competences were important for studies in architectural engineering were compared with the mean scores given to questions about all sorts of specific soft skills.
2. The scores given to questions about how much each of the five sorts of technical competences were important for studies in architectural engineering were compared among themselves.
3. The scores given to questions about how much each of the five sorts of soft skills were important for studies in architectural engineering were compared among themselves.

The first ANOVA revealed that students gave higher scores to questions about the importance of soft skills for their training as architectural engineers (mean = 4.48, SD = .502) than to questions about the importance of technical competences (mean = 4.21, SD = .502), $\chi^2(1) = 6.56, p = .010$, as shown in Figure 8.

The second ANOVA revealed that students assessed differently the importance of the five sorts of technical competences for their training in architectural engineering, $\chi^2(4) = 67.89, p = .000$. Specifically, they rated knowing how an object should be integrated in the space and the landscape (mean = 4.64) as the most important technical competence, thus more important than mastering different techniques of visualizing a piece of work (mean = 4.17), drawing skills (mean = 3.74) and mastering the balance between the size and the weight of an object (mean = 4.01) but as equally as important as modeling skills (mean = 4.52), as shown in Figure 9.

The third ANOVA showed that students assessed differently the importance of the five sorts of soft skills for their training in architectural engineering, $\chi^2(4) = 36.72, p = .000$. Specifically, they rated creativity (mean = 4.71) as the most important soft skill, thus more important than cognitive flexibility (mean = 4.51), analytical thinking (mean = 4.14) and critical thinking (mean = 4.39) but as equally important as innovative thinking (mean = 4.65), as shown in Figure 10.
To answer the third research question, we carried out by means of ANOVA the following analyses:

(i) the mean scores given to questions about how useful was the Design and Sculpture Studio to acquire all sorts specific technical competences were compared with the mean scores given to questions about the acquisition of all sorts of specific soft skills.

(ii) the scores given to questions about how useful was the Design and Sculpture Studio to acquire each of the five sorts of technical competences were compared among themselves.

(iii) the scores given to questions about how useful was the Design and Sculpture Studio to acquire each of the five sorts of soft skills were compared among themselves.

The fourth ANOVA indicated that students perceived the Design and Sculpture Studio as being equally useful to acquire specific technical competence (mean = 2.87) and specific soft skills (mean = 2.93), $\chi^2(1) = 0.02, p = .889$, as shown in Figure 11.

The fifth ANOVA revealed that students perceived the Design and Sculpture Studio as being equally useful to acquire each of the five technical competences investigated: mastering different techniques of visualizing a piece of work (mean = 2.86), drawing skills (mean = 2.9), modeling skills...
Figure 11. Mean scores of technical competences and soft skills: the role of the studio for their acquisition.

(mean = 2.93), mastering the balance between the size and the weight of an object (mean = 2.97), and knowing how an object should be integrated in the space and the landscape (mean = 2.74), $\chi^2 (4) = 1.909, p = .753$, as in Figure 12.

The sixth ANOVA revealed that students perceived the Design and Sculpture Studio as being more useful to acquire certain soft skills than others, $\chi^2 (4) = 32.508, p = .000$. Precisely, we found that following the Design and Sculpture Studio was perceived as more useful to acquire cognitive flexibility (mean = 3.09), creativity (mean = 3.19), innovative thinking (mean = 2.99) and critical thinking (mean = 3) than analytical thinking (mean = 2.42), as in Figure 13.

To answer the fourth research question, we carried out by means of ANOVA the following analysis:

(i) the scores to one question about the specific features of the studio teaching method were compared to the other two.

The seventh ANOVA revealed that students assessed differently the importance of three features specific to the studio teaching method for acquiring competences in architectural-sculpture and design, $\chi^2 (4) = 12.64, p = .002$. Specifically, the fact that the studio teaching method is student-centered was assessed as being more important (mean = 4.09) than the fact that students are actively engaged in learning (mean = 3.64) and that students learn by doing (mean = 3.8), as in Figure 14.

4. Discussion
The research questions and the findings of the current empirical study reinforced previous proposals that art courses have their place in the architectural engineering education (Carlson & Sullivan, 1999; De Clercq, 2011; National Academy of Engineering, US, 2004; Żychowska, 2019). The results of the survey carried out among students who followed the Design and Sculpture Studio
revealed several facts about the importance of art courses, such as design and sculpture classes, for the current and future training of architectural engineers in the Polish context.

We first addressed the question of whether students perceived artistic technical competences, that is, competences related to design and sculpture, as being more important than soft skills, such as cognitive flexibility, creativity, innovative thinking, critical thinking, and analytical thinking, for their training as architectural engineers. The results of the survey revealed that students rated soft skills higher than design and sculpture technical competences. This finding recalls Zampetakis et al.'s (2007) pioneering observation that the regular curriculum in engineering studies still accentuates the importance of the technical competences resulting from basic sciences such as physics, mathematics, and mechanics, while creativity and other soft skills are being less taught to students. Among the soft skills tested in our survey, creativity and innovative thinking were perceived as most important for the students' training in architectural engineering. This result is in line with the those found by Zampetakis et al.'s (2007) and by Muszyńska (2021). Indeed, in the survey carried out by Zampetakis et al. (2007), engineering students agreed that creativity was a skill that is necessary for their training (87%) and that they would like to take a course in creativity and creative problem solving (77%). The crucial place of creativity around the year 2002 had also been predicted by Gray (2016), when speaking about the ten skills society will need to thrive in the Fourth Industrial Revolution. What is new however, is the fact that creativity is not the only soft skill rated the highest. Indeed, innovative thinking was rated as being as important as creativity. This finding demonstrates the necessity of taking into consideration other soft skills in the curricula of architectural engineering education. In contrast, the more cognitive oriented soft skills (analytical thinking, critical thinking, and cognitive flexibility) were evaluated by students as less important for their training. This result is rather surprising because cognitive related abilities are expected to count as much as the more artistic related soft skills (creativity and innovative thinking). Further research should investigate the reasons of this discrepancy.

Second, we questioned whether design and sculpture technical competences, i.e., mastering different techniques of visualizing a piece of work, drawing skills, modeling skills, mastering the balance between the size and the weight of an object, and knowing how an object should be integrated in the space and the landscape, were perceived by students as necessary for their training of architectural engineers. The students who participated in the survey found that all the technical competences ensuing from following the Design and Sculpture Studio are highly important for their training in architectural engineering. Among them, they gave the highest scores to the following competences—knowing how an object should be integrated in the space and the landscape and modeling skills. Indeed, knowing how an object should be integrated in the space and the landscape is an essential competence allowing future architectural engineers to fight against...
the spreading of uniformized or disharmonized architectural works (De Clercq, 2011; Scruton, 1973).

Our third research question concerned the use of Design and Sculpture Studio to allow students to acquire the above-mentioned specific technical competences and soft skills. In the students’ view, following the Design and Sculpture Studio allowed them to acquire to a considerable extent design and sculpture technical competences and specific soft skills, which are highly important for their training. We believe that the source of acquiring these technical competences and soft skills are both the content and the teaching method implemented in the Design and Sculpture Studio. Regarding the content, the three modules (a theoretical one and two applied ones targeting modeling, as well as, design and sculpture) and the final project are planned in a way to allow students to learn and to acquire a large array of competences, such as communicating through the form, explaining the relationships between the shape of objects and their visual perception of size/weight balance, underestating the essence of the phenomenon of space on various scales which are connected with architectural and urban design, to formulate and solve design tasks, and preparing illustrative and technical boards using digital means, among others. Regarding the teaching method, the Design and Sculpture Studio is planned to be student-centered, in which students are actively engaged in learning and that they learn by doing or by experiencing (Iranmanesh & Onur, 2021; Schön, 1987). So, we raised the fourth research question of whether these specific features of the studio teaching allow students to acquire competences in architectural sculpture. Our study confirmed in particular the usefulness of the student-centered format but also, albeit to a lesser degree, of its active engagement in learning and learning by doing principles. As such, these specific features of the studio teaching method are known to enable creativity and rationality, and the results of our survey confirmed this as well.

At a general level, the findings strongly support our proposal that design and sculpture classes have a role to play in the academic curriculum of architectural engineers. This is because following such classes allow students to acquire artistic technical competences and soft skills necessary for finding solutions to the lack of harmony and the issue of “non-places” in modern architecture. Indeed, architectural engineers, when developing artistically, gain experience and develop creativity in order to know exactly how and where to combine art and architecture in the way, which transforms the synthesis of both into something more than the sum of their parts. Thus, architectural engineers become highly capable of conceiving well-thought works, and second, conceiving a well integration of works of architecture in the landscape. Places and spaces can be both highly functional (e.g. commercially successful in the case of a supermarket) and aesthetically pleasing, but they require good planning. Architectural engineers should have knowledge and competences to fulfil these two aspects, and thus sculpture and design classes should remain a constitutive part of the training of future architectural engineers.

From a methodological point of view, the current study is innovative by using a digital survey distributed among students who followed and completed the studio in the last three years. Since the participation was voluntary and anonymous, we expect that students were objective and sincere when they answered the questions. At the same time, there is the risk that only the
students who actually enjoyed and appreciated the studio participated in the survey. The associated drawback of the survey is thus that we might have missed the evaluation of students who either were not successful during the studio or who did not enjoy it. In future research and in order to have access to the evaluation of all students (successful or not in the studio), the survey should be carried out on an obligatory basis at the end of the academic year. Crucially, it must remain anonymous.

5. Conclusions and implications
In architectural engineering, artistic technical competences and soft skills have become particularly crucial for remaining competitive globally and for fighting against uniformized and/or dis-harmonized urbanized landscapes. This has been acknowledged for the last twenty years in the USA but has only recently become of interest in Central European countries, such as Poland. In this study, we present a case study illustrating this recent awareness of the importance of artistic competences and of soft skills in the Polish context. Specifically, we first described the Design and Sculpture Studio taught to architectural engineers studying at the Faculty of Architecture at Wroclaw University of Science and Technology (FA-WUST), and second, we reported on the results of a survey carried out among the students who followed the studio. In the survey, our first purpose was to test whether soft skills are perceived by architectural engineering students as being as much important as artistic technical competences are. Second, we wanted to assess what are the most important soft skills—besides creativity—and artistic technical competences for the training of today’s architectural engineers. Third, we hypothesized that teaching design and sculpture by means of studios is useful to acquire soft skills and artistic technical competences that are critical for the training of architectural engineers. Certainly, apart from pure aesthetics, architectural engineering must face certain functional obligations. However, new technologies and engineering have arguably relieved the discipline of much of its conceptual limitations. The development of modern construction technology also causes the development of spatial sculpture. It can be said that many sculptors of the 20th century treated their works architecturally—they learned to relate to the existing surrounding space. Undeniably, relating and arranging sculptures in the surrounding environment is an artistic technical competence, which strongly draws on and enhances architects’ creativity.

The Design and Sculpture Studio is taught to students in their first and second year of their training in Architectural Engineering. This plays an essential role for the development of soft and artistic technical skills at an early stage of their training. Indeed, following the studio allows students to become open-minded with respect the space of architecture and of sculptural installations. They also had the opportunity to deal with questions about limits—limits of space, limits of self and human interactions. Our study confirmed that, by participating in the studio, students acquired a series of artistic technical competences, which gave them the ability to map space on a scale using various tools and to propose an individual way of shaping it as well as the ability to prepare proposals and projects in which space (both real and virtual) will be used in a unique and creative way. The studio also allowed students to organize knowledge in the field of basic elements of spatial composition, primarily architectural and urban planning, including problems of the scale, structure and material.

In summary, the findings of this study increase our knowledge about (i) the recent awareness of the importance of soft skills in architectural engineering education in the Central-European context, nevertheless without reaching the threshold allowing concrete changes in the institutional culture (ii) what soft skills, besides creativity, and what artistic technical competences are necessary for the training of today’s architectural engineers, and (iii) what teaching methods are particularly useful to increase the students’ acquisition of soft skills, such as creativity, cognitive flexibility and innovative thinking. In particular, our study demonstrated that other soft skills, besides creativity, should receive a more systematic attention in education of future architectural engineers. Thus, the study indicates that interventions on the interface of architectural engineering and art should be treated as a tool, which helps to avoid homogeneity of architectural works by
combining artistic technical competences and a large variety of soft skills. Such interventions change the perception of space and constitute an important step towards creating a place, a harmonious comprehensive entity, instead of a “non-place”.

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1. Qualtrics XM // The Leading Experience Management Software.

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Appendix: Survey questions

Questions about the importance and the acquisition of technical competences

(1) How much important is mastering different techniques of visualizing a piece of work for your training as engineer-architect?

(2) How much important are drawing skills for your training as engineer-architect?

(3) How much important are modelling skills for your training as engineer-architect?

(4) How much important is mastering the balance between the size and the weight of an object for your training as engineer-architect?

(5) How much important is knowing how an object should be integrated in the space and the landscape for your training as engineer-architect?

(6) How much important was this studio to acquire different techniques of visualizing a piece of work?

(7) How much important was this studio to acquire drawing skills?

(8) How much important was this studio to acquire modelling skills?

(9) How much important was this studio to acquire knowledge about balancing the size and the weight of an object?

(10) How much important was this studio to acquire knowledge about how an object should be integrated in the space and the landscape?

Questions about the important and the acquisition of soft skills

(1) How much important is cognitive flexibility for your training as engineer-architect?

(2) How much important is creativity for your training as engineer-architect?

(3) How much important is innovative thinking for your training as engineer-architect?

(4) How much important is critical thinking for your training as engineer-architect?

(5) How much important is analytical thinking for your training as engineer-architect?

(6) How much important was this studio to acquire and to develop cognitive flexibility?

(7) How much important was this studio to acquire and to develop your creativity?

(8) How much important was this studio to acquire and to develop your innovative thinking?

(9) How much important was this studio to acquire and critical thinking?

(10) How much important was this studio to acquire and analytical thinking?
Questions about the teaching method

(1) The class was intended to be student-centered rather than teacher-centered. How much important was this to acquire design and sculpture technical competences and soft skills?

(2) The class was intended to have students actively engaged in learning. How much important was this to acquire design and sculpture technical competences and soft skills?

(3) The class was intended to practice the learning by doing method. How much important was this to acquire design and sculpture technical competences and soft skills?
