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# Adapting to Change: Emphasizing Holistic Architectural Design in Online Structure Courses through a Term-Long Assignment

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## ABSTRACT
There is a dissociation of students towards structure courses which causes challenges in teaching these courses. Different teaching methods were proposed to highlight the holistic approach of architectural design and that structure was part of this process. But this challenging situation became a problem due to the global pandemic situation forcing schools and universities to leave traditional learning environment for an online-learning one. Structure courses which relied on a hands-on teaching method had to adapt to this new environment. This article proposes a term-long assignment given within the context of an online structure course that emphasizes the holistic approach of architectural design. The course content and details of the assignment are presented alongside students' final works followed by an evaluation of the assignment with the results of an anonymous survey conducted with volunteering students. Finally, the outcome and further possible work are discussed allowing a view of the assignment that can be developed to further solidify the understanding of holistic architectural design within the context of a structure course.
**Keywords:** Structure Course, Architectural Education, Online-learning environment, Online Architectural Education.

## INTRODUCTION
Architectural design is a holistic process that requires a transposition, interaction and affinity between space, materials, structure, and services. However, architecture students have a tendency to separate these elements and work with an *add-on* attitude instead of having an integrated approach to the given design problem. Therefore, structure courses affect the understanding of the holistic approach within the architectural design process as much as the studio courses. But students are biased toward structure courses due to its mathematical nature making the course challenging thus compelling lecturers/architects to find different ways to teach structure. This challenging situation changed to a difficult one due to the COVID-19 pandemic forcing schools/universities to change their teaching medium to an online learning/teaching environment. So, this paper presents a term assignment given in an online structure course that tries to convey the holistic design approach by breaking the barrier between the structure courses and architecture students.

## STRUCTURE COURSES AND TEACHING/LEARNING ENVIRONMENTS
Structure courses which are also referred as *technology courses* (Guerguis and Pitts, 2021) are taught in diverse ways within the architectural curricula. In the first approach, subjects are taught in classes with a lecture-based method like generic theoretical courses. Another approach is a studio-based method where experimental learning methods such as learning-by-doing or project- and problem-based learning methods are used together with lectures (Frances, 2009; Vrontissi, 2015; Wetzel, 2012; Emami and von Buelow (2016); Guerguis and Pitts,2021). Even though there are different teaching methods there is one widespread problem teaching structure to architecture students. There is a dissociation toward

structure courses that can be observed in students based on the mathematical nature of the courses, or on the curricular separation of structure and design courses which is reinforced by the teaching methods (Chiuini, 2006; Maor and Verner, 2007; Frances, 2009; Ilkovič et all., 2014; Guerguis and Pitts,2021). This dissociated standpoint of the students, surfaces as an attitude where the structure is treated as an *add-on object* rather than part of the design process.

Over the years many researchers presented that one of the best ways of teaching structure, within the structural course content, is to associate structure with a design problem and use experiential learning teaching model, like model making, to reinforce the learning of structural principles and to emphasize the holistic process of design (Frances, 2009; Wetzel, 2012; Vrontissi, 2015; Vrontissi et all., 2018; Castellón González, 2022). At the same time Salvadori (1958) and many other like Severud (1961), Chiuini (2006), Ilkovič et all. (2014), Emami and von Buelow (2016), and Brito and Povoas (2022) believe that architecture students, unless enrolled within a specific architecture/engineering program, are not required to have a deep understanding of how a structure works but have to develop an *intuitive understanding of the behaviour of the structure* or have a *feeling for the structure*. All these views pointed to a studio-based structure course where lectures are supported by hands-on exercises, like scaled physical structure models, where structural principles are demonstrated and experimented by students.

But at the end of 2019 and beginning of 2020 with the COVID-19 pandemic the architectural education like all types and grades of education had to abruptly change their teaching methods from a traditional face-to-face setting to an *online-learning environment*. This change was challenging to architectural education which requires a more active hands-on learning method. Different online teaching methods (Vandana and Thurman, 2019) were adapted by schools and universities based on their infrastructure. Some used *asynchronous* online teaching method where source materials are uploaded, sometimes accompanied by a video-lecture, to a system where discussion boards allow students to communicate with the lecturer on their own time. The other was the *synchronous* online teaching method which allowed a real time interaction between students and lecturer via videoconferencing applications. Asynchronous method is a difficult method to use in architectural education where the applied courses require an interaction between student and lecturer so if the infrastructure allowed it architecture schools/universities used the synchronous methods.

**RESEARCH QUESTIONS**

There is a general challenge in teaching structure to architecture students due to their blockage towards these courses either because of their mathematic context or of the *add-on* attitude toward the structure because of the dissociation between design and structure courses. These challenges became problems with the pandemic conditions which removed face-to-face teaching. The new teaching environments were defined by schools' and/or universities' boards according to the availability of their infrastructure.

This paper presents an assignment that was given to fourth-year architecture students in Istanbul Beykent University Architecture department within the 'Contemporary Structural System' course in 2021-2022 fall semester during the COVID-19 pandemic. Contemporary Structural System course's online-learning teaching environment was defined by the university's infrastructure providing both synchronous and asynchronous methods which could be used simultaneously. Lectures were conducted synchronously and recorded to allow absent students to watch them on their own time. Based on these problems arising from the course's nature and the new learning environment, the following questions were asked during the alterations of the course's teaching methods:

- What kind of assignment can be created that emphasizes the holistic approach of architectural design within the context of an online structure course?

- Is it possible to implement the role of mathematics in a structure within this assignment so that students can overcome their dissociation towards these courses?
- Is it possible to create an assignment that will demonstrate the relation(s) between structure and form through geometry?

## CONTEMPORARY STRUCTURAL SYSTEM

The structure course, Contemporary Structural Systems, was initially prepared as a theoretical elective course for fourth year architectural students within the traditional setting but the course's contents had to be reassessed because of the pandemic. The course's aim is to provide students with knowledge to define and analyse different types of structural systems, and finally to be able to interpret and apply it to their own design. To achieve this, students were given lectures on different types of structures with complex geometries, in the traditional settings they would have been required to create models to understand their structural principles, but these hands-on methods were no longer possible to apply thus a term-long assignment was planned that would be conducted in groups. The term assignment would address the dissociation students have toward structure by conveying the role of geometry within the design of a building both in form and structure through geometrical and structural analysis.

The fourteen-week long course started with the presentation of the course's content along the aims and subjects that will be discussed. The assignment was presented in detail during the second week along with an assignment sheet. The assignment was designed as a three-step case study that included structural and geometrical analysis of the building. During the third week of the course a large variety of projects that ranged from concrete thin structures to steel frame structures was presented to be selected as case studies by the student groups. Lectures on different types of structural systems were conducted for ten weeks along with discussion sessions starting the third week with the introduction of the assignment. Each week a different type of load-bearing system was explained with their elements, connections, and performance under stress. Discussion sessions were added to create an environment that facilitates group works and provide a learning environment where active participation was strongly encouraged. The last three weeks of the course student groups were asked to present their assignment and discuss their findings. The synchronous courses were supported with an asynchronous access to lectures and discussion sessions but also forums allowing students to ask questions about the lecture or their assignment.

At the end of the course a general discussion was carried out with students about the content of the course and the given assignment to assess the course. Also, a 10 questions online survey was conducted with voluntary participant students to determine if the assignment was successful in achieving its goals.

## TERM ASSIGNMENT "STRUCTURE-*GEOMETRY*-FORM"

The term assignment addresses the problem between architectural students and structure courses by a case study method allowing them to understand the interaction between the structure and the form of the building through analysis. With an underlaying purpose for the students to determine the role of geometry in the creation of spatial and physical qualities of a building in hope to bridge the dissociation of the students towards structure courses.

The assignment is a three-step process: first a geometrical analysis of the form, second a structural analysis of the building's structural system and finally a conclusion on the relationship of the structure with the form by superimposing both analyses.

### Geometrical Analysis

The assignment starts with the geometrical form analysis of their selected project that should be presented as a *form-generation process* also described as a visual algorithm.

Students were asked to analyse the geometry of their building by deconstructing the form to its simplest geometrical shapes and then to reconstruct the form using these shapes with transformation principles like translation, rotation and/or reflection.

This step was strongly influenced by the work of Ostrowska-Wawryniuk, Strzała, and Słyk (2021) about "algorithmic form-finding". Even though the name *'form-generation process'* is similar to *'algorithmic form-finding'* the difference between these two exercises is that this course's purpose is not to "to teach students how to develop unique form-generating algorithms" (Ostrowska-Wawryniuk et all., 2021) but to teach them to analyse a form and understand the geometry behind it. The aim was to introduce a different way of approaching geometry by deconstructing it to its simplest form and to be able to reconstruct it by following a visual "infographic" (Ostrowska-Wawryniuk et all., 2021) set of rules: an algorithm. Groups had four weeks to do a geometrical analysis then they were asked to prepare a poster to present their work in a geometrical construction order. The visual set of rules should present a logical step-by-step construction of the form but not necessarily a data that can be used as a parametric input.

Each week a discussion session was conducted where students were encouraged to give their input about other groups' works allowing different observations and analytical views to be discussed in an open dialog. Groups presented their initial geometrical analysis and the problems they encountered during their process. Discussion sessions were created to allow students to share and compare their thoughts on the subject or other subjects that developed from their analysis. This allowed students to discuss subjects like definition of algorithms, algorithmic design, parametric design, parametric tools through reviews of analyses.

**Structural Analysis**

The assignment continued with a structural analysis of the elements of the structures and load distribution. It should be stated that before this selective structural course students have had five compulsory technology courses related to structures and materials. This step required each group to create a three-dimensional digital model of the structure of their buildings where only the structural elements of the structure were to be represented. In their analysis they were asked to identify the type of structure their building has and then determine the different elements of the system. Groups were asked to create two different images, the first showing the structural system's elements and the second illustrating the general load distribution of the system on a cross-section. Students were asked to model their structure the same scale as their geometrical analysis to facilitate the last step.

During this step's discussion sessions, in addition to the differences between structure types which was the main conversation topic, some groups shared their finding on the construction process of their structure because they found it very interesting.

**Comparison: Geometrical and Structural Analysis**

The last step of the assignment was to superimpose the form reached with the form-generation process and structure and to reach a conclusion about the relation/interaction between them. At the end of the semester students were asked to explain the degree of dependency between the form and structure over their final image during their presentation. While in some projects the form was directly a product of the structure, in others the exterior was more of a shell covering the primary load-bearing structure.

In both Figure 1 and Figure 2 different submissions from four groups can be observed. All four structures are different types of structures with different levels of interaction with the form. These differences opened discussions about the relation between the structure and the form underlaying the importance of the structure during the design process and that structure is not an *add-on* object but can be used as a means to create a form. Also, these overlaying analyses, displayed the role of the geometry in the structure and form design.

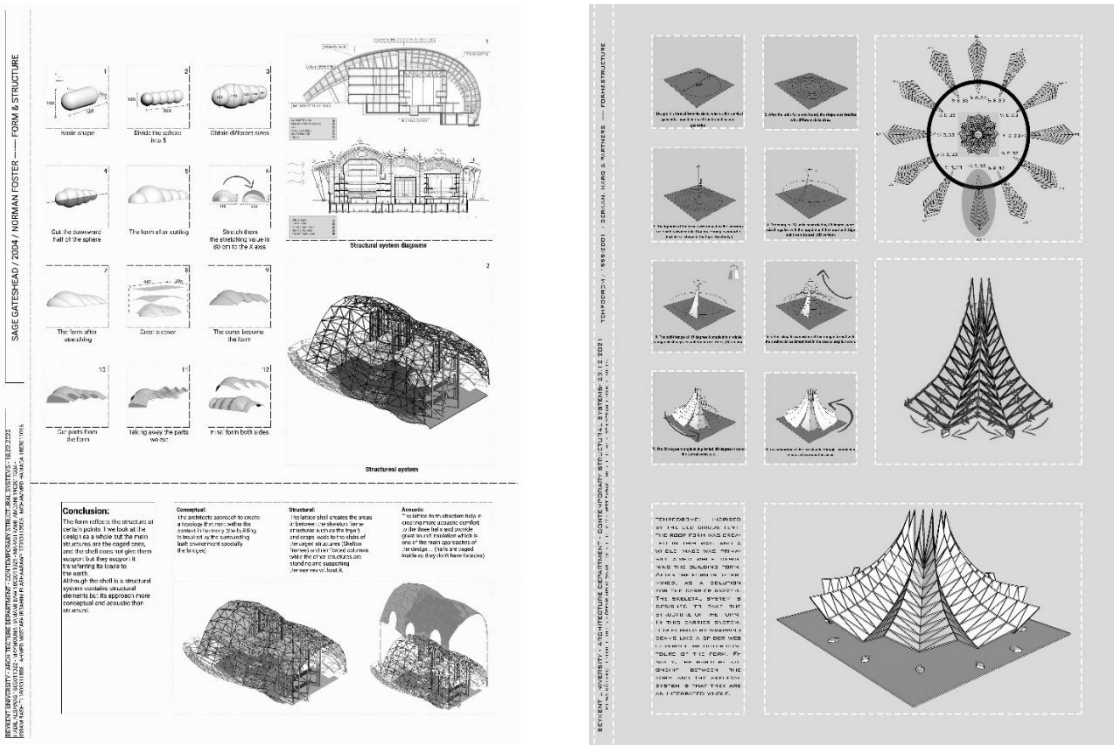

**Figure 1.** Left-Group 1: Sage Gateshead by Foster + Partners, right-Group 19: Tempodrom by gmp · Architekten von Gerkan, Marg und Partner

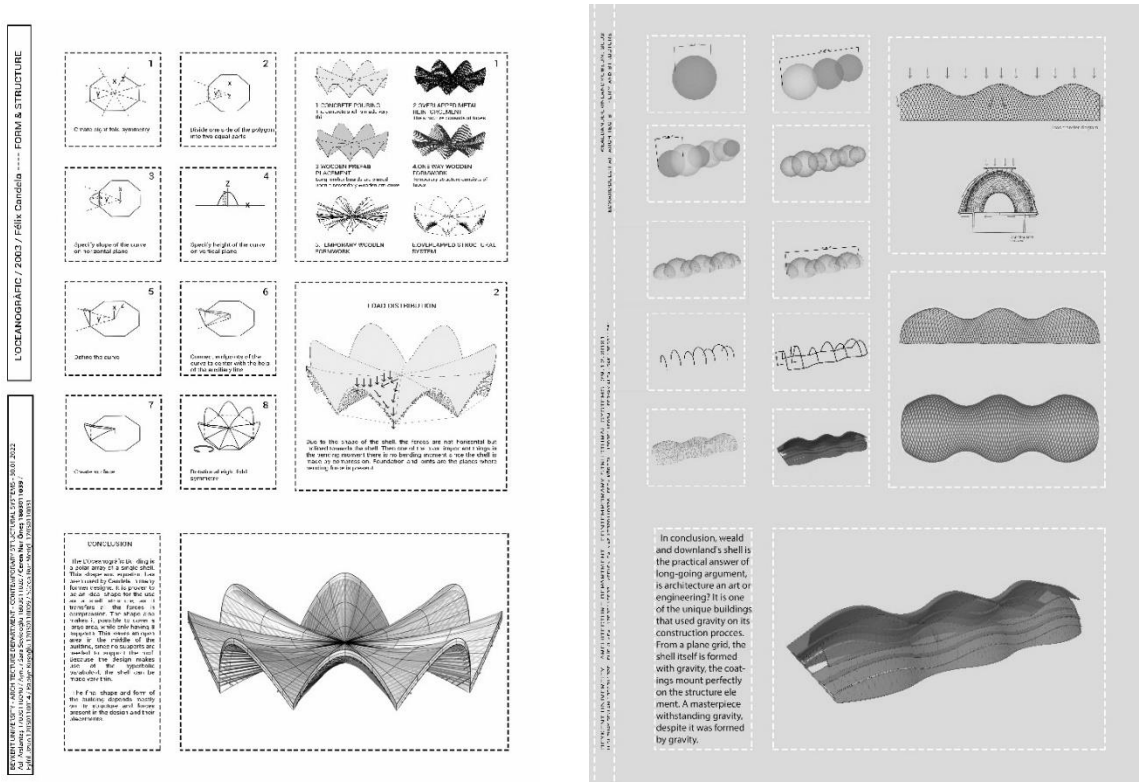

**Figure 2.** Left-Group4: L'Oceanografic by Félix Candela, right-Group2: Weald and Downland Living Museum by Cullinan Studio

**EVALUATION**

Contemporary Structural Systems course was designed to help student understand or have the "*feeling*" (Salvadori, 1958) for different structural systems with more complex geometries. The assignment was created to enable the students to understand the relationship between the structure and form demonstrating that structure is part of the design process and should not be treated as an add-on object. From the lecturer point of view the discussion sessions where fruitful and pushed the students to question and furthermore analyse the relations between form and structure. But the learning process was hindered by the online-learning environment limitations. As previously stated, one of the best method to teach structure to architecture students is the hands-on method where complex structure models can be constructed to be experimented with. The process of constructing a physical scaled model of a structure allows students to experience the limitations and resistances of the structure and material used to create it hence the difficulty of discussing a structural principle without the physical model. In future years the term assignment can be accompanied by a physical model of the structure allowing discussions and if necessary, experimenting on it.

At the end of the course an anonymous survey was conducted with voluntary participant students that aim to assess if the assignment answered the research questions. Seventeen students volunteered to answer the survey of ten statements which they rated with a 5-point Likert scale, as it can be observed in Table 1.

Table 1: Survey answers

| Statements | Strongly Disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree | Total number of answers |
|---|---|---|---|---|---|---|
| 1. The term assignment was challenging | 0 | 4 | 5 | 7 | 1 | 17 |
| 2. The first assignment "form generation" helped me understand geometry in architecture | 0 | 1 | 2 | 2 | 12 | 17 |
| 3. The second assignment "structure analysis" helped me understand physics in architecture | 0 | 1 | 2 | 4 | 10 | 17 |
| 4. I know now what algorithm is | 0 | 1 | 3 | 6 | 7 | 17 |
| 5. I understand form generation from an algorithmic point of view | 0 | 1 | 1 | 10 | 5 | 17 |
| 6. I understand the relation between geometry and form | 0 | 0 | 0 | 7 | 10 | 17 |
| 7. I understand the relation between form and structure | 0 | 0 | 1 | 3 | 13 | 17 |
| 8. I understand the relation between mathematics and architecture | 0 | 0 | 5 | 6 | 6 | 17 |
| 9. The term assignment helped me develop a new approach to problems | 1 | 0 | 5 | 2 | 9 | 17 |
| 10. The term assignment helped me develop my computer modelling skills | 1 | 0 | 0 | 6 | 10 | 17 |

The first statement of the survey measured if the assignment was designed for a fourth-year architecture student. As it can be observed from the table less than half of the participants (41.2 %) found the term assignment challenging by agreeing while 29.4 % were neutral. This showed that the assignment needs to be refined especially with the return to the traditional learning environment.

The second statement was if the first step of the assignment 'form generation' helped them understand the role of geometry in architecture to which 70.6 % of the students strongly agreed with. This showed that a geometric analysis of complex architectural forms allows students to understand a form and the geometry behind it.

The third statement was if the second step of the assignment 'structure analysis' helped them understand the role of physics in architecture to which ten out of seventeen students strongly agreed. In a traditional learning environment physical model making would increase the understanding of structural principles.

The fourth statement was developed considering topics like algorithms, algorithmic thinking and parametric design introduced during discussion sessions. Answers to the statement 'I know now what an algorithm is' were divided between agree and strongly agree with percentage of 35,3 % and 41,2 % respectively. This demonstrated that online discussion over the subject was not enough and that a more detailed content should be implemented.

In correlation to the answers to the previous statement the fifth statement 'I understand form generation from an algorithmic point of view' where 58.8% student agreed to shows that the subject needs to be detailed and that learning-by-doing exercises need to be applied within the course content.

The sixth and seventh statements are about the relationship between 'geometry and form' and 'form and structure' respectively. To the sixth one all students with a majority leaning to strongly agree, agreed with the statement, to the seventh statement 76.3 % of the students strongly agreed leading to a validation that the assignment attained its purpose of teaching the interaction and relationship of the structure and form through geometry.

Even though all students agreed or strongly agreed to the previous statements, they were divided on the eight statement: 'I understand the relation between mathematics and architecture'. 35.3 % strongly agreed, again 35.3 % agreed and 29.4 % were neutral. This shows a lack of understanding on the role of mathematics in the architecture discipline. Also, it shows that there is an dissociation towards mathematics in structure courses.

The ninth statement was developed to understand if this term assignment helped them to 'develop a new approach to problems' especially when faced with designing complex geometries. 52,9 % of the students strongly agreed with the statement while a small percentage agreed and a 29.4 % neither agreed nor disagreed.

The last statement was included to the survey to see if this assignment encouraged students to develop their modelling skills. Sixteen students agreed and strongly agreed with this statement. Even though this statement shows a high positive result in some discussion sessions students were expressing working in groups created problems because some students were not able to participate to all of the process of the assignment steps leading them to be unable to work on the modelling part or in some cases a student finding themselves doing all the modelling due to the lack of enthusiasm from the rest of their group.

## DISCUSSION AND REMARKS

The course was conducted in an online-learning environment due to the pandemic creating difficult learning and teaching conditions. The difficulties and challenges originated by this environment were debated during the discussion sessions but one of the most voiced problem was working in group. The groups consisted of four to six students but based on their statements the more the number the more the problems occurred. For future courses the number of students in a group should be reduced to two or three to minimize internal disputes.

The assignment was successful in answering the third research question when answers to the sixth and seventh statements are examined. So, it is possible to demonstrate the relationship between structure and form through geometry with an assignment which in turn will lead to a better understanding of the holistic approach of design. However, this

kind of assignment should be given to first- or second-year architecture students to overcome the alienation between structure courses and design courses or even stop it before it is developed.

An assignment with a case-study method can emphasize the holistic approach within the context of a structure course if hands-on methods are not applicable during a pandemic. The holistic approach of architectural design should not be just emphasized in structure courses but also in studio-based courses where an approach of integrating structure to the design problem should be employed which will consolidate the comprehension of design process.

Although the assignment was successful in answering two of the research questions it failed to answer the second question: the dissociation towards structure course due to the mathematical nature. The eighth statement shows that the geometrical analysis of a project is not enough to demonstrate the relation between mathematics and architecture. This question may be answered by creating a specified mathematics course that teaches mathematics in relation to architecture (Döşemeciler and Kartal, 2022).

The discussions and the answer to the fourth statement demonstrate that parametric design is an interesting subject for students thus the authors propose that an assignment introducing parametric design can be given to first- or second-year architecture students then a more particularized course like the one presented by Ostrowska-Wawryniuk, Strzała, and Słyk (2021) can be created to answer the need for a parametric design course.

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**REFERENCES**

Castellón González, J.J. (2022). Structural models in architectural education: Experimental explorations between the physical and the digital realms. In Hvejsel, M.F., & Cruz, P.J.S. (Eds.). *Structures and Architecture A Viable Urban Perspective?* (1st ed.). pp.202-209. CRC Press. https://doi.org/10.1201/9781003023555

Chiuini, M., (2006). Less Is More: A Design-oriented Approach to Teaching Structures in Architecture. In *Proceedings of the 2006 Building Technology Educators' Symposium: August 3-5, 2006, University of Maryland, School of Architecture Planning and Preservation*. pp. 205-212.

Döşemeciler, A., Kartal, A.S.K. (2022). A Mathematical Course Model for Architectural Education: Geometry of Design. *Nexus Network Journal.* 24. Pp. 717–732. https://doi.org/10.1007/s00004-022-00620-0

Emami, N. and von Buelow, P. (2016). Teaching structures to architecture students through hands-on activities. *Canadian International Conference on Advances in Education, Teaching, and Technology*.

Frances, Rosa. (2009). *Structural Design in Architectural Education - Workshop - the learning-through-play approach*. Architectural Design & Construction Education: Experimentation towards Integration, Transactions on Architectural Education No:45. Editors: Constantin Spiridonidis, and Maria Voyatzaki. EAAE (European Association for Architectural Education). Pp. 455-467.

Guerguis, M. S. and Pitts, K.K. (2021). Visualizing Structures: Integrative Methodology for Teaching Structural Principles to Architecture Students. *Proceedings of the IASS Annual Symposium 2020/21 and the 7th International Conference on Spatial Structures, Inspiring the Next Generation*, 23-27 August.

Ilkovič, J., Ilkovičová, Ľ., & Špaček, R. (2014). To think in architecture, to feel in structure: Teaching Structural Design in the Faculty of Architecture. *Global Journal of Engineering Education.* 16(2), 59-65.

Maor, Sarah, and Igor M. Verner. (2007). Mathematical aspects in an architectural design course: The concept, design assignments, and follow-up. *Nexus Network Journal* 9(2): 363-376.

Ostrowska-Wawryniuk K, Strzała M, Słyk J. (2021). Form Follows Parameter: Algorithmic form-finding methods in architectural education. In K. Williams, & C. Leopold (Eds.), Nexus20/21. *Architecture and Mathematics*. Conference Book. Kim Williams Books. pp. 133-138.

Salvadori, M. (1958). Teaching Structures to Architects. *Journal of Architectural Education* (1947-1974), 13(1), pp. 5–8. https://doi.org/10.2307/1424174

Severud, F. N. (1961). Structures: The Feel of Things. *Journal of Architectural Education* (1947-1974), 16(2), pp. 18–22. https://doi.org/10.2307/1424148

Vandana, S. and Thurman, A. (2019) How Many Ways Can We Define Online Learning? A Systematic Literature Review of Definitions of Online Learning (1988-2018), *American Journal of Distance Education*, 33:4, pp. 289-306, DOI: 10.1080/08923647.2019.1663082

Vrontissi, M., (2015), The Physical Model in Structural Studies within Architecture Education: Paradigms of an Analytic Rationale?, *Proceedings of the International Association for Shell and Spatial Structures (IASS)*, 17 - 20 August

Vrontissi, M., Castellón González, J.J., D'Acunto, P., Enrique Monzó, L., and Schwartz, J. (2018). "Constructing Equilibrium": A methodological approach to teach structural design in architecture. *Proceedings of the IV International Conference on Structural Engineering Education Without Borders* pp. 606–617.

Wetzel, C. (2012) Integrating Structures and Design in the First-Year Studio. *Journal of Architectural Education*, 66:1, pp. 107-114. DOI: 10.1080/10464883.2012.715980