SHAPING A BETTER FUTURE: CONTEXTUAL LEARNING AND TEACHING OF STRUCTURAL DESIGN IN THE PROCESS OF ARCHITECTURAL EDUCATION

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ABSTRACT

An integrated building design requires the intensive early collaboration of architects with other disciplines in order to respond to sustainability requirements. Therefore, the education of architects should enable acquiring knowledge and skills essential to function effectively in an interdisciplinary team in practice. Integrating theoretical and practical knowledge within the course curriculum is one way to accomplish the above. Lecture-based courses in structural design within the Undergraduate Studies of Architecture at the University of Belgrade combine theoretical and practical knowledge within the traditional learning model by applying theoretical knowledge to individual non-contextual problem-solving. In the final year of the study, structural design learning is based on contextual problem-solving in teams in the studio, within which buildings and their structures are designed following sustainability requirements. This paper aims to present the applied approach of a combination of two models of learning, individual non-contextual and team contextual, and to assess, using surveys, the influence of applied learning method on the development of cognitive abilities, knowledge, skills, and motivation of architecture students, focusing the contribution of early project-based learning. A total of 230 final-year undergraduate architecture students participated in the survey. The analysis of the survey showed that the applied approach of early team contextual learning in the field of structural design contributes to the development of critical and creative thinking, understanding of the meaning of the subject matter, development of research and analysis, organisational, communication, independent learning and teamwork skills, and motivation to the acquisition of new knowledge and self-engagement. The above indicates the need for constant improvement of the architectural education methodologies and processes to respond to growing complex requirements in practice oriented towards sustainability.

KEYWORDS _ *Integrated design, Architect education, Structural design, Contextual learning, Competency development*

INTRODUCTION

Sustainability-oriented architectural practice implies intensive early collaboration of architects with other disciplines. In order to respond to complex requirements, architects must have the comprehensive abilities of rethinking, criticizing, and sensing (Bereiter and Scardamalia, 1993). In addition, they must have technical expertise, social awareness, and a bias toward innovation (Crawley et. al., 2007). This combined set of abilities, knowledge, skills, and attitudes should enable productivity, entrepreneurship, and excellence (Crawley et. al., 2007). Transversal skills are particularly emphasized among the above because they barely match the level needed to do the job (Cedefop). In this context, practical knowledge connected with the unique context of an authentic working situation (Lave, 1996) is gaining importance. Therefore, scholars should seek the best means to integrate theoretical and practical knowledge within the course curriculum (Yong, 2012), in ways that foster a more synthetic, concurrent, and dynamic integration of design issues, with a constant awareness that design is a creative activity, involving imagination, intuition, and deliberate choice (Arup and Partners, 1986).

Integration of theoretical (know-what) and practical (know-how) knowledge, as the basis of competency-based architectural education (Spiridonidis, 2007) in most subjects at the University of Belgrade - Faculty of Architecture (UB-AF), is achieved through work in the studio, in which students learn to develop design proposals with the help of their tutors (Wilkinson and Salama, 2007). The studio as a pedagogical construct involves three basic functions: information-seeking, new knowledge-generating, and decision-making. In addition, it simulates design practice based on users' needs and environmental concerns (Nenadović, 2014), that is, real-world projects, in order to integrate education, research, and practice into a single process (Incedayi, 2005). Conversely, theoretical subjects in structural design are lecture-based, where students apply theoretical knowledge to individual non-contextual problem-solving. This model emphasizes teachers' guidance and related coded knowledge transfer to students (Eraut, 2000). This approach is preferred for resource efficiency but criticized for its rigidity and pedagogical ineffectiveness, especially for design-related learning (Aparicio, 2007).

Bearing in mind the stated goals of architect education, one of the approaches that is gaining more importance when it comes to the engineering aspects of the discipline, including the field of structural design, is contextual learning. This type of learning should enable students to gain experience through solving real-world problems, which can give them real knowledge and provide conditions for knowledge valorization. The key strategies of contextual learning in the technical-technological field are learning in context (Crawford, 2001; Detri, 2019; Berns and Erickson, 2001; Cockrell, 2000) and teamwork (Detri, 2019). The mentioned strategies should contribute to reaching a higher level of knowledge (Detri, 2019), understanding the meaning of certain learning content (Johnson, 2002) and its critical evaluation, developing curiosity (Detri, 2019), understanding concepts (Crawford, 2001), understanding the design logic (Easterday, 2017), motivation for self-regulated learning and self-efficacy (Lam et al., 2012), authentic assessment of achievement (Johnson, 2002; Detri, 2019), and formation of adequate attitudes towards the professional technical area.

Based on the previously stated starting points, a new structural design learning model is applied to the Undergraduate Studies of Architecture. This model is a combination of two learning models – lecture-based and studio-based. Students first acquire competencies in lecture-based courses through individual non-contextual learning, and then in the final year, they apply and improve their competencies by solving real-world problems (Whitehead, 2015; Roozenburg, 2008; Tempelman, 2010) within studio design course (Chance, 2016). This project-based learning (Mills and Treagust, 2003; Graham, 2010) aims to bridge the gap in knowledge transfer between theory and practice, that is, to better prepare students to solve emerging problems under different contexts. This paper aims to present the applied approach of combining two models of structural design learning, individual non-contextual and team contextual, i.e, the means and methods of these specific

learning formats. Also, a study aims to assess, using a survey, the influence of applied learning methods on the development of cognitive abilities, knowledge, skills, and motivation of architecture students, representing the key elements of competency-based architectural education and the key indicators of teaching success.

STRUCTURAL DESIGN LEARNING MODEL

The means and methods of the specific learning model, which represents a combination of two learning models, individual non-contextual and team contextual, applied within the Undergraduate Studies of Architecture at the University of Belgrade, are presented.

Lecture-based structural design learning model

In lecture-based structural design courses, which include lectures and exercises, students acquire theoretical and practical knowledge in the traditional way. During lectures, students must understand, memorize, and reproduce the theoretical data. Then, students apply theoretical knowledge to individual non-contextual problem-solving during auditive exercises that follow the lectures. They solve generic numerical examples related to dimensioning of structural elements. This process is guided by teachers who transfer coded knowledge to students (Eraut, 2000).

Studio-based structural design learning model

In the final year of Undergraduate Studies, within the studio-based course named "Studio Design – Project Development," students apply and improve the acquired theoretical knowledge in structural design through contextual learning, by work on specific real-world projects and by sharing informal learning experiences through teamwork. This contextual, team learning-by-doing approach combines theoretical and practical knowledge, refocusing on more applied forms of learning and teaching (Graham, 2010). The studio combines three methods of education. First is a teacher-centered method in the function of theoretical knowledge transfer. Second is a student-centered method in the function of search, collection, and aggregation of knowledge, especially in the phase of concepts creation, whereby the design is seen as a competition (Anthony, 1991), and finally, a teamwork-centered method that implies team's creation, construction, and development of knowledge, in order to encourage innovation. Teamwork should prepare students for practice, given that effective architectural practices are associated with a culture of teamwork and collaboration (Nicol and Pilling, 2000).

Students in the studio first work on building concepts in compliance with sustainability requirements. Work starts with critically rethinking examples from architectural practice while simultaneously comprehending the given design program and the environment, after which concepts are created. After tutors select the best design proposals, students collaborate in teams to develop the project, including the design of the building structure. Then, through consultations with tutors and independent teamwork, by applying knowledge from previous years of study, students work on positioning and calculating structural elements and structural details in a process that simulates design practice. Since two fields of research are integrated into the studio, architecture and structural design, the participation of tutors from both disciplines is foreseen. The process occurs through a design charrette, i.e., through focused and collaborative brainstorming sessions that encourage the exchange of ideas and information and enable the creation of truly integrated design solutions (Nenadović, 2017). Previous is a framework in which students integrate architectural and structural aspects of design into their design proposals (Herr, 2012; Herr, 2011) and develop a structural sensitivity, not typically taught in lecture-based modules (Herr, 2011; Herr, 2013).

ANALYSIS OF STRUCTURAL DESIGN LEARNING MODEL ON COMPETENCE DEVELOPMENT

This study aims to find out how architecture students rate the importance of certain activities in lecture-based and studio-based courses and to assess the influence of applied learning methods on the development of cognitive abilities, knowledge, skills, and motivation, as key elements of competency-based architectural education (Spiridonidis, 2007), focusing the contribution of early project-based learning.

The analyzed indicators to access the influence of the learning model in the technical-technological field are:

- Element 1 – Abilities - Indicators: cognitive reasoning (Ul-Haq, 2015) and intuition and creativity (Ul-Haq, 2015; Sternberg, 1998);
- Element 2 – Knowledge - Indicators: understanding of knowledge (Detri); comprehending the design logic (Easterday, 2017), understanding the meaning of the subject matter (Johnson, 2002);
- Element 3 – Skills - Indicators: research and analysis, problem-solving, organization, communication, independent learning, and teamwork skills (Cedefop), self assessment and self-criticism (Johnson, 2002; Detri, 2019);
- Element 4 – Motivation – Indicators: motivation for the acquisition of new knowledge (Detri) and self-engagement (Lam et al., 2012; Britt et al., 2007).

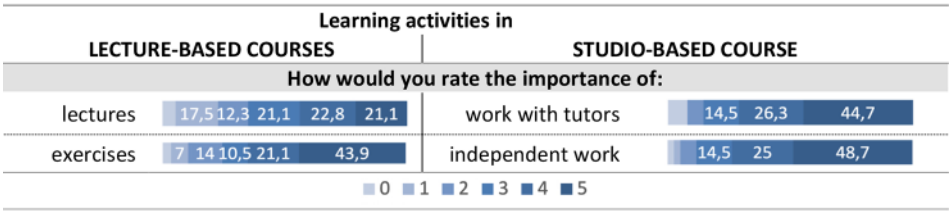
METHODOLOGY

In order to evaluate students' structural design learning experience in lecture-based and studio-based courses, that is, the influence of learning methods on the development of abilities, knowledge, skills, and motivation, focusing on the contribution of early project-based learning, the survey was conducted. A quantitative research strategy is applied to collect information from a representative sample (Ponto, 2015). A total of 230 final-year undergraduate architecture students anonymously responded to questions (Check and Schutt, 2012). The questionnaire is formed with a modified Likert scale. The range consists of starting from 0 (none) and points 1-5 as five possible answers to the question that allows students to indicate their minimal (1) to maximal (5) strength of feeling (Katajavuori et al., 2006), that is, to find out how students rate the importance of certain activities in lecture-based and studio-based courses, and to find out to what extent students felt their learning fostered the development of abilities, knowledge, skills, and motivation.

RESULTS

Results of students' evaluation of specific learning activities in structural design lecture-based and studio-based courses are presented in Table 1.

Table 1: Students' evaluation of activities in lecture-based and studio-based courses



Results of students' evaluation of the development of abilities, knowledge, skills, and motivation in structural design lecture-based and studio-based courses are summarized in Table 2.

Table 2: Students' evaluation of competency development in lecture-based and studio-based courses

	Structural design learning in LECTURED-BASED COURSES	Structural design learning in STUDIO-BASED COURSE
Element 1 ABILITIES	**To what extent did you improve the following abilities:**	
reasoning	7 17,5 38,6 28,1	15,8 28,9 47,4
intuition	12,3 31,6 28,1 21,1	6,6 21,1 34,2 32,9
creativity	24,6 26,3 10,5 22,8 8,8 7	9,2 17,1 25 39,5
Element 2 KNOWLEDGE	**To what extent did you improve the understanding of:**	
subject matter	14 35,1 22,8 21,1	11,8 22,4 32,9 7
design logic	15,8 28,1 21,1 28,1	7,9 17,1 35,5 34,2
learning goals	24,6 26,3 10,5 22,8 8,8 7	6,6 9,2 22,4 22,4 7
Element 3 SKILLS	**To what extent did you improve the following skills:**	
research and analysis	12,3 14 22,8 22,8 14 14	9,2 25 27,6 27,6
problem-solving	7 10,5 19,3 28,1 21,1 14	13,2 21,15 30,3 7
organization	10,5 12,3 19,3 19,3 28,1 7	6,6 9,2 13,2 19,7 25 26,3
communication	21,1 21,1 21,1 19,3 14	9,2 11,8 11,8 23,7 22,4 7
independent learning	19,3 8,8 8,8 26,3 15,8 21,1	6,6 10,5 7,9 13,2 28,9 32,9
teamwork		6,6 9,2 6,6 26,3 17,1 34,2
Element 4 MOTIVATION	**To what extent did you improve the motivation for:**	
self-engagement	15,8 15,8 8,8 28,1 14 7	7,9 7,9 17,1 26,3 35,5
knowledge acquisition	14 8,8 22,8 14 19,3 21,1	7,9 6,6 17,1 30,3 34,2
	0 1 2 3 4 5	

DISCUSSION

The content analysis of the survey showed that:

- Students attach more importance to exercises than lectures on lecture-based courses, while on studio-based courses, almost equal importance is given to work with tutors and independent work. Problem-solving is given more importance regardless of the learning method.
- Students feel that team contextual learning in the studio contributes to greater development of reasoning, intuition, and especially creativity, which they feel is insufficiently developed in lecture-based courses through non-contextual problem-solving.
- Students think that team contextual learning in the studio contributed to a lesser extent to the understanding of subject matter but contributed to a greater extent to understanding design logic and learning goals that are insufficiently understood in lecture-based courses.
- Students opine that team contextual learning in the studio contributed to developing research and analysis, organization, communication, independence in learning, and teamwork skills, but to a

lesser extent, to developing problem-solving skills. They also feel that lecture-based courses do not contribute sufficiently to the development of research and analysis, and communication skills.

- Students feel that team contextual learning in the studio greatly contributed to the motivation for self-engagement and new knowledge acquisition, with the simultaneous feeling that lecture-based courses insufficiently motivate students to the above.

CONCLUSIONS

The applied approach of combining two models of structural design learning, individual non-contextual in lecture-based courses and team contextual in studio-based course, where theoretical knowledge, research, and practical work integrate through real-world problem-solving, improves architecture students' ability to transfer knowledge between theory and practice. The analysis of the survey showed that the applied approach of early team contextual learning contributes to the development of critical and creative thinking, understanding of the meaning of the subject matter, development of research and analysis, organizational, communication, independent learning, and teamwork skills, and motivation to the acquisition of new knowledge and self-engagement, which are all important elements of competency-based architectural education. On the other hand, this approach contributes to a lesser extent than excepted to the understanding of subject matter and problem-solving, indicating the need to explore further the potentials and limitations of the presented educational model to find ways to bring this complex matter closer to architecture students. The above also indicates the need for constant improvement of the architects' education methodologies and processes, including project-based, problem-oriented, situation-oriented, and work-based learning, so that architects can respond to growing complex requirements in integrated practice oriented towards sustainability.

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