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Integration of Engineered Wood Products Knowledge in Architectural Education: Evidence from North Macedonia

Integracija znanja o kompozitnom drvu u arhitektonsko obrazovanje: primjeri iz Sjeverne Makedonije

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ABSTRACT • Engineered wood products (EWPs) are wood-based materials created by engineering and combining wood elements into high-performance products with improved structural, functional, aesthetic, and environmental characteristics. They have become a very important segment in sustainable construction in recent years, which highlights the need for their integration into architectural education. Unfortunately, in many developing countries, including North Macedonia, their presence in architectural curricula, and in the design practice, remains limited and insufficiently explored. The aim of this study was to explore the knowledge, perception, and application of EWPs among architecture students, with a focus on the relationship between the theoretical insights and practical application. The research was based on a case study conducted at the Department of Architecture, Faculty of Engineering, at the International Balkan University in Skopje, North Macedonia. The methodology in this study comprises three steps to enable more holistic analyses. First, a survey questionnaire was distributed among architecture students at different levels of study to assess their familiarity with wood and EWPs, and their experience with their practical application throughout their studies. Second, analyses of the curriculum were conducted to evaluate the presence of wood-based topics in the courses of the study programme. Lastly, the study was further supported by research on the students' projects to detect the level of application of wood and wood-based materials. The results indicate that students have relatively high theoretical knowledge of wood and EWPs. However, their experience remains limited, with a tendency towards non-structural use and less frequent implementation of these structural materials. Although there has been a gradual increase in the consideration of timber-based solutions in recent years, further research is required. In addition, there is a lack of dedicated courses that specifically focus on timber construction, which is the reason for limited practical and technical knowledge related to their application. This study reveals that practice-oriented approaches, including project-based learning and exposure to contemporary timber construction, are crucial in architectural education for strengthening the integration of wood-based materials. Finally, the find-

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ings of this study can contribute to a better understanding of the role of education in promoting sustainable material choices and provide guidelines for future curriculum development.

KEYWORDS: timber; student projects; construction

SAŽETAK • Kompozitno je drvo materijal na bazi drva nastao inženjerskim oblikovanjem i spajanjem drvnih elemenata u proizvode visokih performansi i poboljšanih konstrukcijskih, funkcionalnih, estetskih i ekoloških svojstava. Posljednjih godina ti su proizvodi postali iznimno važan segment održive gradnje, što naglašava potrebu integracije znanja o njima u arhitektonsko obrazovanje. Nažalost, u mnogim zemljama u razvoju, uključujući Sjevernu Makedoniju, njihova je zastupljenost u arhitektonskim kurikulumima i projektantskoj nastavi i dalje ograničena te nedovoljno istraжена. Cilj ovog istraživanja bio je ispitati znanje, percepciju i primjenu kompozitnog drva među studentima arhitekture, s naglaskom na odnos između teorijskih spoznaja i praktične primjene. Istraživanje se temelji na studiji slučaja provedenoj na Odsjeku za arhitekturu Fakulteta inženjerstva Međunarodnog sveučilišta Balkan u Skoplju, Sjeverna Makedonija. Metodologija rada obuhvatila je tri koraka kako bi se omogućila holistička analiza. Prvo, među studentima arhitekture na različitim razinama studija provedeno je anketno istraživanje radi procjene njihova znanja o drvu i kompozitnom drvu te njihovih iskustava s praktičnom primjenom tih materijala tijekom studija. Drugo, provedena je analiza kurikuluma kako bi se utvrdila zastupljenost tema vezanih za materijale na bazi drva u kolegijima studijskog programa. Na kraju, istraživanje je dodatno potkrijepljeno analizom studentskih projekata radi utvrđivanja stupnja primjene drva i drvnih materijala. Rezultati pokazuju da su studenti u relativno visokoj mjeri teorijski upoznati s drvom i kompozitnim drvom. Međutim, primjena tih materijala je ograničena, uz snažnu tendenciju prema nekonstrukcijskoj uporabi i rjeđoj implementaciji u svojstvu konstrukcijskih materijala. Iako je posljednjih godina primijećen postupni porast konstrukcijskih rješenja na bazi drva, to još uvijek nije dovoljno. Osim toga, uočava se nedostatak namjenskih kolegija koji su specifično usmjereni na drvene konstrukcije, što je uzrok ograničenoga praktičnog i tehničkog znanja o njihovoj primjeni. Ovo istraživanje pokazuje da su za snažniju integraciju materijala na bazi drva u arhitektonsko obrazovanje ključni pristupi usmjereni na praksu, uključujući učenje utemeljeno na projektima i izloženosti suvremenoj drvenoj gradnji. Zaključno, spoznaje iz ovog istraživanja mogu pridonijeti boljem razumijevanju uloge obrazovanja u promicanju odabira održivih materijala te ponuditi smjernice za budući razvoj kurikuluma.

KLJUČNE RIJEČI: drvo; studentski projekti; graditeljstvo

1 INTRODUCTION

1. UVOD

The construction sector is lately oriented towards sustainable and environmentally friendly materials. Engineered wood products (EWPs) have gained significant attention in contemporary architectural design due to their advantages and overcoming the disadvantages of the primary processed wood such as sawn timber, veneer and different types of by-products from these main-product processes. EWPs have very good structural performance, offer design flexibility and reduce the negative environmental impact compared to the many non-biobased construction materials, such as traditional concrete and steel. Moreover, EWPs enable the development of efficient structural systems, functionality and better aesthetic qualities (Janakieska *et al.* 2024; Sandberg *et al.*, 2023).

Despite these advantages and the global growth of timber construction, the application of timber-based structural systems remains relatively limited in many regions, including North Macedonia, where reinforced concrete and steel continue to dominate in the construction practices (Janakieska *et al.*, 2021). There are numerous reasons for this, but some of the most important are market conditions and industry tradition.

Moreover, the architectural education is crucial for shaping the students' understanding of the structural systems, materials, their properties and their potential application in the projects. A comprehensive architectural education requires integrating design thinking with material and technological knowledge, allowing students to make informed decisions in the design process (Tzonis, 2014).

General wood material and wood-based products are often introduced as part of broader courses on structural systems and building materials within the architectural curricula. Therefore, their treatment is usually solely theoretical, with limited opportunities for practical application or detailed technical understanding. Without dedicated courses that focus specifically on timber as a construction material and its application in the structural systems and non-structural elements, students could feel more confident in using other materials, such as concrete and steel for which there are dedicated courses. Students often think that they are more familiar with concrete and steel, especially in primary load-bearing systems, since these materials are more included in the curricula.

In this context, it is highly important for architecture students to understand the perception of EWPs and the level of their application into their projects during

the studies. Some previous studies highlight the importance of materials knowledge and hands-on experience in architectural education, emphasizing the need to connect theory with practice (Fahmy, 2025; Fernández, 2023; Kalamkar and Sinhal, 2023). However, there is limited research addressing this topic in the local context of North Macedonia.

Therefore, the aim of this study was to analyse theoretical knowledge and practical application of EWPs among architecture students at the Department of Architecture, Faculty of Engineering at the International Balkan University in Skopje. Although the study is based on a specific institutional context, it addresses a broader challenge in architectural education, such as the limited integration of EWPs and sustainable construction practices in the curricula, particularly in institutions where timber construction is not a primary educational focus. The combined approach in methodology allows identification of existing gaps in the education and recommendations for improving the integration of EWPs in architectural curricula, with protentional applicability beyond the local context and relevance for institutions facing similar challenges in design education.

2 MATERIALS AND METHODS

2. MATERIJALI I METODE

The study uses a case study approach at International Balkan University in Skopje. A combination of quantitative and qualitative data is used. The methodology is divided into three different parts: (1) a survey conducted among architectural students from different levels of study, (2) analyses of the architectural curriculum through official documentation, and (3) evaluation of student design projects developed within a master-level course. This combined approach allows for a comprehensive understanding of the implementation of EWPs in the architectural education.

The collected data were analysed using descriptive statistical methods. The survey results were analysed using percentage distributions to identify trends in familiarity and the application of EWPs. These results were also compared with findings from the curriculum analysis and students' projects evaluation to identify consistencies and discrepancies between theoretical knowledge and practical application.

This comparative approach enabled a more comprehensive interpretation of the role of architectural education in shaping students' understanding and use of wood-based materials.

2.1 Survey methodology

2.1. Metodologija anketnog istraživanja

The participants in the survey included students at different levels of study, including bachelor's, mas-

ter's, and doctoral programmes. First-year students were not included, as their curriculum does not yet cover specialised courses related to building materials and structural systems.

Data were collected using an online questionnaire distributed via the SurveyPlanet platform (<https://surveyplanet.com/>). The questionnaire consisted of both closed-ended and open-ended questions, allowing for the collection of quantitative and qualitative data. The questions were structured into several sections, including general information about the respondents, familiarity with EWPs, their application in design projects, and students' perceptions of the sufficiency of knowledge gained during their studies.

The survey was conducted from 1st of October until 31st of December 2025 and was distributed among the students via email and quick response (QR) codes during student classes. The survey was distributed among 103 architecture students, and a total of 71 valid responses were collected. The respondents included students from different levels of study: 21 responses were obtained from second-year students, 13 from third-year students, 16 from fourth-year students, 19 from master's students, and 2 from doctoral students. 34 % of the respondents were male and 66 % were female. Participation was voluntary and anonymous, ensuring unbiased responses. The collected data were exported and used for further analysis.

2.2 Curriculum analysis

2.2. Analiza kurikuluma

To evaluate the educational context, an analysis of the architectural curriculum was conducted based on the official study programme documentation. The analysis focused on courses related to structural systems, building materials, and construction technologies offered during bachelor's and master's studies. The analysis of the architectural curriculum was based on a comparison of the accreditation documents from 2013, 2019, and 2025 (International Balkan University, 2013; International Balkan University, 2019; International Balkan University, 2025).

The reviewed courses included:

- Architectural Structures I–IV,
- Statics,
- Strength of Materials,
- Theory of Structures,
- Reinforced Concrete,
- Steel Structures,
- Building Materials, and
- Building Physics.

The course objectives and content were analysed to identify the presence and extent of topics related to wood and EWPs.

2.3 Analysis of student projects

2.3. Analiza studentskih projekata

Another method was used to understand the practical application of wood and EWPs in the student projects. Projects developed within the Architectural Structures course at the master's level were examined. As part of the exercises for this course, students are assigned to design a semester project – design of a building in which they select the structural system and the materials for both structural and non-structural elements based on their research, knowledge, and design approach. This course was particularly chosen for analyses, as it reflects students' final level of competence after completing a series of courses related to structures, materials, and construction during their bachelor studies.

Projects from 2020-2025 were examined in detail to identify trends in material selection among students. This examination included analyses of the materials used for the structural systems in the projects – concrete, steel, timber-based or other, and the application of wood or wood-based products on the building's façade. Moreover, selected student projects with EWPs in the structural systems were analysed in greater detail to illustrate specific design approaches and the practical application of timber-based systems.

3 RESULTS AND DISCUSSION

3. REZULTATI I RASPRAVA

3.1 Survey results: knowledge and perceptions of EWPs

3.1. Rezultati anketnog istraživanja: znanje i percepcija o kompozitnom drvu

Based on the survey results, familiarity with EWPs among architecture students at International Balkan University is high (72 % of students reported familiarity). A total of 89 % of the students reported learning about timber and EWPs during their architectural studies within the Department of Architecture, indicating a high level of theoretical knowledge.

In addition, students were asked to select the EWPs they were familiar with from a list that included photos. The results are given in Table 1. The cells with a percentage greater than 50 are marked in orange. The most familiar wood-based product for students is glued laminated timber (GLT or glulam), followed by cross-laminated timber (CLT). This can be seen as positive since both GLT and CLT are structural materials and are implemented as structural elements in building construction. Being familiar with these products is a good step towards implementing them in the projects. Students were less familiar with the following wood-based products: veneered particle board (VP), particle board (PB), laminated strand lumber (LSL), oriented

strand board (OSB) and parallel strand lumber (PSL), marked in grey.

Although, the results show high theoretical exposure during the studies, 31 % of students reported that they had not applied these materials in their design projects, suggesting a gap between knowledge and practical implementation. Among those who used EWPs, the majority used them as interior elements (51 %) and as part of the façade design (49 %). The implementation of EWPs in the structural systems was significantly lower (39 %), as shown in Figure 1. This suggests that students perceive the timber primarily as a non-structural material, where aesthetic and design aspects are more dominant. This can be explained by limited technical confidence in timber as a structural material and hesitation regarding its structural and load-bearing properties. In addition, reinforced concrete and steel are dominant in local construction practice, which further influences students' choices, as these materials are well known and widely used in the region (Janakieska and Kitek Kuzman, 2025). Similar findings have been reported in previous studies, in which architects demonstrate a positive perception of wood but limited knowledge of its structural application (Kitek Kuzman *et al.*, 2018), and where its use remains constrained by technical concerns and established industry practices (Ilgin and Karjalainen 2021).

Students were also asked whether the knowledge gained during their studies was sufficient for the practical application of EWPs. A total of 45 % of students considered their knowledge sufficient, 38 % partially sufficient, and 17 % insufficient. In addition, 56 % of the participants expressed a desire to gain more knowledge about different EWPs during their studies.

Students were also asked to identify the gaps they perceived in the curriculum, and their answers indicate several recurring themes. The biggest concerns were the lack of practical and hands-on training. Workshops,

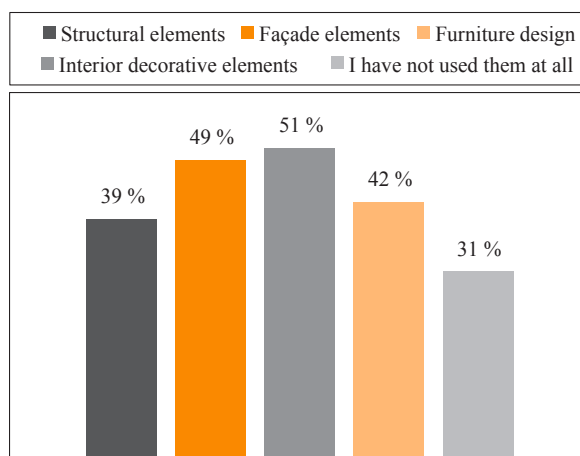


Figure 1 Application of EWPs in students' design projects
Slika 1. Primjena kompozitnog drva u studentskim projektima

Table 1 Students' familiarity with different EWPs**Tablica 1.** Upoznatost studenata s različitim kompozitnim drvom

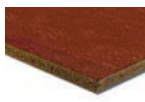
EWPs <i>Kompozitno drvo</i>	Number of students that are familiar <i>Broj upoznatih studenata</i>	Percentage of students that are familiar <i>Postotak upoznatih studenata</i>
GLT Glued-laminated timber (glulam) <i>lijepljeno lamelirano drvo</i> 	45	63 %
CLT Cross-laminated timber / <i>križno lamelirano drvo</i> 	44	62 %
PSL Parallel strand lumber / <i>drvo od paralelno orijentiranih dugih vlaknaca dobivenih od furnira</i> 	15	21 %
LSL Laminated strand lumber <i>drvo od slojevito lijepljenih vlaknaca</i> 	12	17 %
SWP Solid wood panel / <i>ploča od masivnog drva</i> 	40	56 %
LVL Laminated veneer lumber / <i>lamelirano furnirsko uslojeno drvo</i> 	16	23 %
PW Plywood / <i>furnirsko uslojeno drvo</i> 	43	61 %
LDF/MDF/HDF Low/ medium/ high-density fibreboard <i>ploča vlaknatica niske/srednje/visoke gustoće</i> 	37	52 %
VP Veneered particle board / <i>furnirana ploča iverica</i> 	8	11 %

Table 1 Continued
Tablica 1. Nastavak

EWP <i>Kompozitno drvo</i>	Number of students that are familiar <i>Broj upoznatih studenata</i>	Percentage of students that are familiar <i>Postotak upoznatih studenata</i>
PB Particle board / <i>ploča iverica</i> 	9	13 %
OSB Oriented strand board / <i>ploča s orijentiranim iverjem</i> 	13	18 %
LS Light sandwich panel / <i>lagana sendvič-ploča</i> 	23	32 %

model-making, visits to production facilities and construction sites were emphasised as essential components of the learning process. Besides the theoretical knowledge, that is generally provided, direct engagement with timber construction is also needed. Unfortunately, this is limited by the relatively low number of timber production facilities and construction sites where timber is implemented in North Macedonia (Petrovski *et al.*, 2019). However, the lack of timber construction sites could be compensated through analysis and presentation of contemporary international case studies or organised visits in the neighbouring countries where such examples can be observed.

Another frequently mentioned issue was the lack of technical knowledge, particularly in areas such as structural analysis, detailing, fire performance, moisture resistance, and durability, which greatly affects students' confidence in the application of EWPs, particularly as a structural material. Several respondents suggested that EWPs should be addressed with the same level of depth as reinforced concrete and steel within the curriculum.

Furthermore, some students pointed out the need for a deeper understanding of the sustainability aspects of wood-based materials. While this topic is introduced in existing courses such as *Sustainable Architecture* and *Energy Efficiency in Buildings*, respondents expressed interest in more comprehensive coverage.

A smaller number of respondents pointed out institutional and regional factors, specifically the limited use of timber in local construction practices in our country. Some of the students feel that learning about timber is unnecessary, given its limited practical application in North Macedonia and the fact that they will

not need it in the future when they start working as architects.

Finally, a minority of respondents answered that their current knowledge is sufficient and that there is no need for deeper information on the topic.

3.2 Curriculum analysis: integration of wood and EWPs in architectural education

3.2. Analiza kurikuluma: integracija drva i kompozitnog drva u arhitektonsko obrazovanje

The examination shows that the study programme includes several courses related to structural systems, construction technologies, and building materials throughout the first and second cycles of studies at the Department of Architecture. In the most recent curriculum (2025), an additional course, *Architectural Structures IV*, has been introduced, further expanding the coverage of contemporary structural systems, advanced non-structural elements and materials.

As shown in Table 2, the curriculum provides a comprehensive foundation in structural engineering principles through courses such as *Statics*, *Strength of Materials*, *Theory of Structures*, *Reinforced Concrete*, and *Steel Structures*. Moreover, the series of courses *Architectural Structures I – IV* progressively develops the students' knowledge of structural systems, structural elements, materials, and construction technologies. These courses are specifically designed to be adapted for architectural students. The syllabi for *Architectural Structures III* and *Architectural Structures IV* cover more advanced structural systems and innovative materials, including wood and EWPs. In addition, in these courses, the application of EWPs is ana-

Table 2 Curriculum analyses (International Balkan University, 2024)**Tablica 2.** Analiza kurikuluma (International Balkan University, 2024.)

Course <i>Kolegij</i>	Level of study <i>Razina studija</i>	Course objective (A brief description) <i>Cilj kolegija (kratki opis)</i>
Statics	2 nd year	Learning fundamental principles of forces, moments, and equilibrium in structures. Development of analytical skills for reaction, internal forces, and stability of the structural system in 2D and 3D.
Architectural structures I	2 nd year	Provides foundational knowledge of construction materials and basic structural systems. Focuses on understanding load-bearing elements, such as columns, beams, foundations, and slabs, and their role in forming simple architectural structures.
Strength of materials	2 nd year	Explores how materials behave under different loads, including stress, strain, and deformation. Equips students to evaluate material performance and structural safety.
Architectural structures II	2 nd year	Increases the knowledge of structural systems through detailed study of structural elements such as floors, roofs, and stairs. Emphasises integration of materials and construction methods into architectural design.
Architectural structures III	3 rd year	Develops advanced understanding of modern structural systems and materials, including steel, timber, and prefabrication. Introduces façade systems, fire protection, and seismic design principles.
Reinforced concrete	4 th year	Focuses on the behaviour and design of reinforced concrete elements and systems. Teaches basic analytical and design principles for structural applications.
Theory of structures 1	3 rd year	Introduces structural analysis concepts, including stability, determinacy, and influence lines. Develops analytical skills to understand complex structural behaviour.
Steel structures	4 th year	Provides knowledge of design principles and dimensioning of steel structural elements and connections. Enhances the ability to apply structural design methods in practice.
Building physics	3 rd year	Introduces principles of thermal performance, insulation, and energy efficiency in buildings. Focus on the application of materials for environmental control and sustainable design.
Building materials	3 rd year	Develops understanding of physical and mechanical properties of construction materials. Enables informed selection and application of materials in structural and architectural contexts.
Architectural structures IV	Master's studies	Advances knowledge of contemporary structural systems and materials in line with modern standards. Introduces Eurocodes and their application in structural design practice.

lysed not only from a structural point of view but also as a non-structural element in the façade or the interior design. These courses cover a wide range of materials and systems, including conventional and contemporary solutions, as well as aspects of façade design, fire protection, and seismic performance.

Despite this broad coverage in the general courses, the analysis shows that wood and EWPs are not addressed as a distinct subject within the curriculum. There are dedicated courses for reinforced concrete and steel, but unfortunately, none for timber. A positive thing is that they are at least introduced as part of broader courses, particularly in Architectural Structures II, III, and IV; unfortunately, in these courses, the focus cannot be solely on timber structures. Thus, their treatment remains relatively limited and generalised, without a specific focus on their characteristics, structural behaviour, detailing, or technical performance.

This absence affects the depth of students' knowledge and also their confidence in applying these materials in the design projects. The curriculum places greater emphasis on reinforced concrete and steel across course content, technical depth, and practical application. Consequently, wood and EWPs may be perceived as secondary or supplementary materials rather than primary structural solutions.

Overall, the curriculum provides a solid theoretical foundation in structural systems and materials, but the integration of wood-based materials remains limited.

3.3 Analysis of student projects: application of EWPs in design

3.3. Analiza studentskih projekata: primjena kompozitnog drva u projektiranju

Students' projects from the period 2020 – 2025 were analysed and the results show clear trends in the selection of the materials, as shown in Table 3. The cells that have a percentage higher than 50 are marked with yellow, while the cells that have a percentage less than 30 are marked with grey in the table. In the earlier period (2020 – 2021), timber-based structural systems were not applied at all in the designs. The building projects from that period feature structural system made of reinforced concrete and steel. From 2022 onwards, the timber and EWPs application has emerged, reaching 43 % in 2022, followed by fluctuating but consistent application in subsequent years. This is an indicator of growing awareness and willingness among students to explore alternative structural materials.

Despite this increase, the traditional materials remain dominant. Reinforced concrete and steel continue to be widely used, particularly steel in recent years (56

Table 3 Share of materials used by students in the structural system and in façades. Results from the Architectural Structures project course at the master's level between 2020 and 2025**Tablica 3.** Udio materijalâ koje su studenti primijenili u nosivoj konstrukciji i oblikovanju pročelja. Rezultati izbornog/obveznog kolegija Arhitektonske konstrukcije na diplomskom studiju u razdoblju 2020. – 2025.

Year Godina	Material used for the structural system <i>Materijal upotrijebljen za nosivu konstrukciju</i>				Material used for façade <i>Materijal upotrijebljen za pročelje</i>
	Concrete	Steel	Timber / EWPs	Other	Timber applied to the façade
2020	67 %	33 %	0 %	0 %	11 %
2021	43 %	57 %	0 %	0 %	29 %
2022	43 %	14 %	43 %	0 %	57 %
2023	50 %	29 %	21 %	0 %	50 %
2024	22 %	56 %	22 %	0 %	56 %
2025	11 %	56 %	33 %	0 %	56 %

% in 2024 and 2025), which may reflect both the emphasis in the curriculum and the country's dominant construction practices. Timber-based systems, while present, are used less consistently as primary structural solutions.

In contrast, the use of wood or wood-based products in façade design shows a more stable and higher prevalence across the analysed period, particularly from 2022 onwards, when more than half of the projects have incorporated wood as a façade material. In 2024 and 2025, the percentage of projects that include timber in the façade was 56. This suggests that students are more likely to adopt wood in non-structural roles, where its aesthetic and design qualities are more directly expressed.

Selected student projects further illustrate the potential of engineered wood products in architectural design. Figures 2 and 3 present projects that apply cross-laminated timber in the main structural system, demonstrating an understanding of its spatial and structural capabilities. Furthermore, these projects demonstrate a high level of creativity in their structure, with interesting shapes and connections among the structural elements. The CLT remains visible, further enriching the overall design aesthetics. The project for the pavilion presented in Figure 3 demonstrates a strong understanding of the structural system using EWPs, as evidenced by the technical drawings and connection details for the separate elements.

**Figure 2** Student project for Botanical Garden in Skopje – application of a CLT structure, designed by Faton Kalisi**Slika 2.** Studentski projekt Botaničkog vrta u Skoplju – primjena konstrukcije od križno lameliranog drva (CLT); autor Faton Kalisi

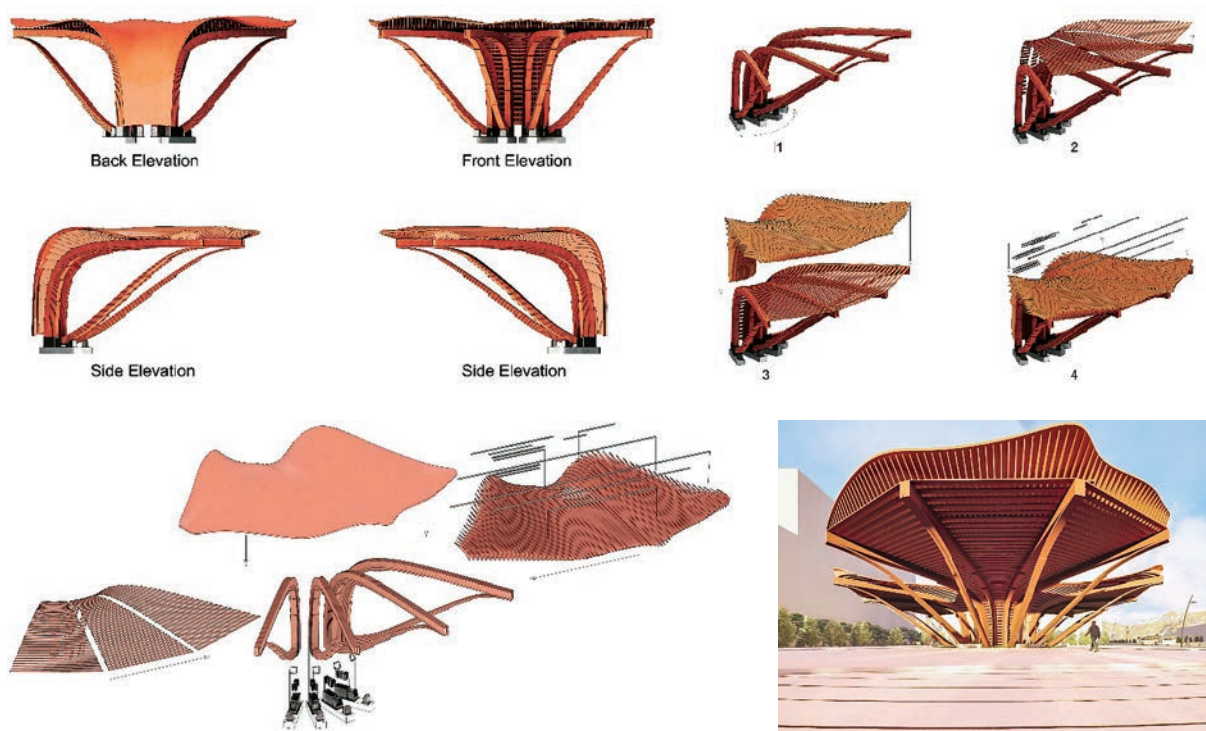


Figure 3 Student project for the Pavilion in Skopje – application of a CLT structure, designed by Eldin Fazliu

Slika 3. Studentski projekt paviljona u Skoplju – primjena konstrukcije od križno lameliranog drva (CLT); autor Eldin Fazliu



Figure 4 Students' project for the Pavilion in City Park, Skopje – designed by Qani Saiti, Arman Kačaniku, and Seadin Zendeli

Slika 4. Studentski projekt paviljona u Gradskom parku u Skoplju; autori Qani Saiti, Arman Kačaniku i Seadin Zendeli

Additional examples (Figures 4 and 5) show the use of wood in pavilion structures and lightweight design solutions, highlighting its flexibility and suitability for smaller-scale interventions. Both projects are designed in natural settings, demonstrating the choice of materials in relation to their contexts. The project in Figure 4 demonstrates a combined structure in which the organic columns are made of wood-based materials. The roof is made from a lightweight composite material in a wavy shape that compliments the wooden columns. The overall organic shape blends with the natural setting, following the nearby river course.

The pavilion shown in Figure 5 is entirely constructed from EWPs. The main structure consists of

parabolic carriers made of cross-laminated timber, strengthened and stiffened with secondary, smaller carriers in the horizontal direction. Between the secondary carriers, small segments of wood-plastic composite are added to create a semi-transparent pattern for the pavilion. This does not block the view of the natural setting, and it also creates interesting shadows on the base, which is a perfect example of a biophilic design pattern.

Overall, analyses of students' projects show a gradual, slow integration of wood and wood-based materials, especially in recent years. However, their application remains mostly limited to aesthetic elements in facades or small-scale structures such as pavilions, rather than complex load-bearing systems. These findings reflect the opportunities and limitations of the current educational framework and align with the survey and curriculum analyses.

4 CONCLUSIONS

4. ZAKLJUČAK

The holistic approach in this study yields similar results across three methods used during the research. There is a clear discrepancy between the relatively high level of theoretical knowledge and awareness of EWPs among students and their practical application in design practice, particularly within structural systems. Students demonstrate familiarity with key timber-based materials and express interest in their use. Nevertheless, the use of timber and EWPs as structural

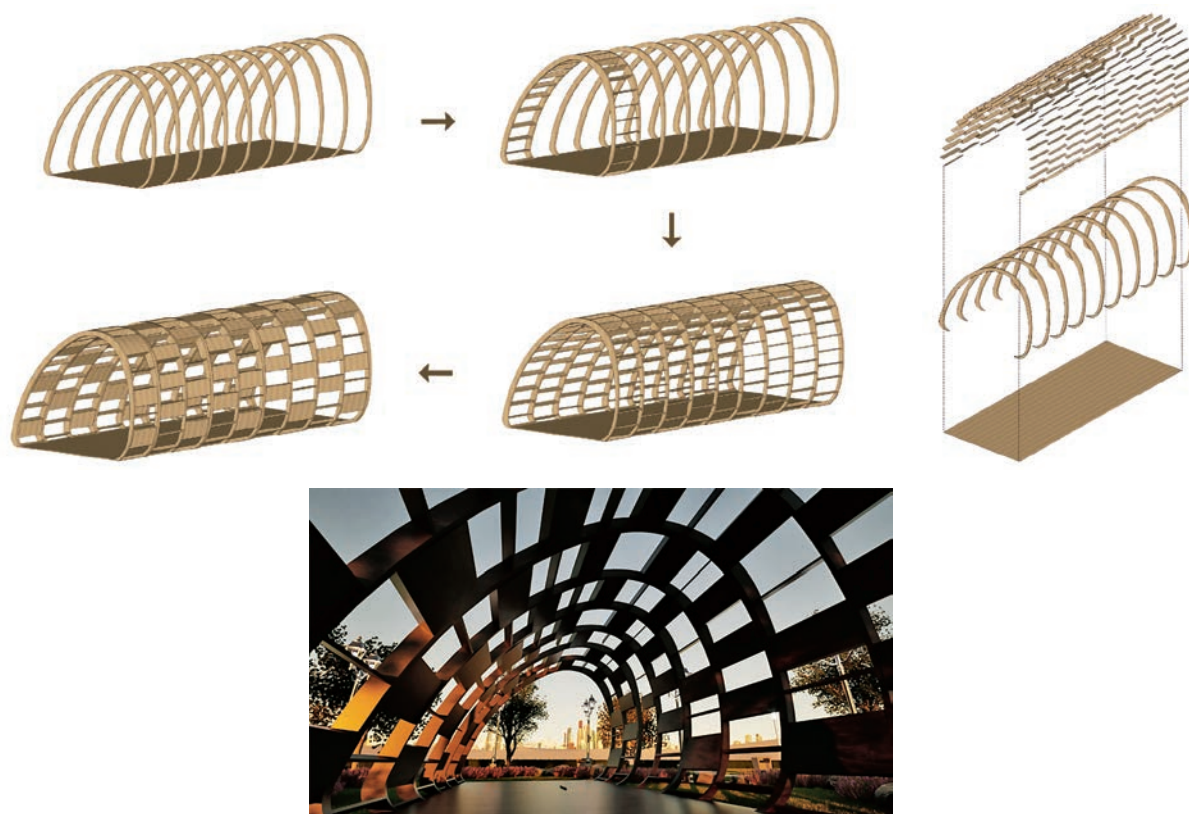


Figure 5 Students' project for the Pavilion in Skopje – designed by Ivona Atanasoska and Devleta Shabani
Slika 5. Studentski projekt paviljona u Skoplju; autorice Ivona Atanasoska i Devleta Shabani

materials in the students' projects remains relatively low. This can be concluded from both the survey questionnaire and the analyses of the student projects, where wood-based products are mostly used as decorative materials in the exterior or interior of the building.

The architectural curriculum analyses demonstrate that there is a solid theoretical foundation in materials, structural systems and construction technologies during the studies. Still, there is insufficient depth and focus on timber construction. The absence of dedicated courses and limited opportunities for hands-on experience appear to be key factors influencing students' design decisions and material preferences. However, despite this absence, there has been a gradual increase in the use of timber-based systems in recent student projects, which is a positive shift.

The novelty of this study lies in its integrated approach, which combines three methods to allow results to be viewed from different perspectives. Although the approaches differ, they indicate the same gaps in architectural education. Another important aspect of this research is that these analyses have not been conducted in North Macedonia to date. By combining students' perceptions, curriculum analysis, and students' projects, this study compares educational backgrounds with design practices. It provides valuable insights into how the situation in North Macedonia can be improved.

The results show that the application of EWPs in architectural education can be strengthened through targeted curriculum development, including dedicated courses focused on timber structures, practical training, hands-on experience and exposure to contemporary timber construction and production facilities. This can significantly enhance students' competencies and confidence, and support a broader transition towards more sustainable design practices in the country.

Finally, the proposed methodology can be applied in other academic contexts to evaluate students' knowledge and perceptions of timber-based materials, identify existing gaps, and support the development of more effective educational strategies.

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