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Towards the Conceptual Changes in Architectural Education: Adjusting to Climate Change

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Abstract: This article gives an insight into the problem of climate change awareness in the process of architectural education. The course Urban Structure at the University of Belgrade, Faculty of Architecture, is used as a case study that reveals a sensitive relationship between the university curriculum, teaching methodologies, students' experiences/obtained knowledge and the local background. The course included Problem Based Learning method in order to increase applicability of up-to-date knowledge on climate change. The results were tested before and after taking the course, via survey based on the semi-open type of questionnaire, distributed among 246 course attendees. The testing was conducted twice, during the school years 2013–2014 and 2014–2015. The comparison between the knowledge acquire via theory (the test results provided at the beginning of the course) and the knowledge obtained by Problem Based Learning (the results obtained after the course ended) confirmed the increased level of student's awareness of environmental problems, as well as the extended scope of their ability to respond to occurring problems caused by climate change. Furthermore, the results obtained by a questionnaire are used for setting of new educational guidelines.

Keywords: architectural education; climate change; problem based learning

1. Introduction

The carbon-intensive economies generated numerous problems, initiating a shift towards a climate-friendly environment. However, the limited perception of climate change still represents a problem [1] which could be overcome by the efficient knowledge acquisition and information exchange. The effects of global warming have become extremely visible in urbanized areas emphasizing the importance of a sensitive balance between the phenomenon of climate change and the complex features of contemporary cities. Consequently, it has been necessary to introduce a range of emerging topics into educational process on all levels. The education of architects has been modified in accordance with this trend, and the necessity of its continuous updating has been underlined by international and national documents [2].

Until recently, climate scientists have mostly dominated the discussions on climate change. The initiatives, such as IPCC, have introduced an interdisciplinary perception of the problem by including scientists from other disciplines and different regions. However, the success of these attempts has been questionable due to the limited and insufficient number of experts focused on developing both theory and practice. Consequently, there is also a growing need to provide more efficient education guidelines for the future engineers, targeting both the general level and adjacent fields—such as urban planning, geography, transport and energy [1].

The University of Belgrade—Faculty of Architecture also follows the latest professional recommendations [3] and this article provides an insight into the role and outcomes of the

climate-sensitive approach applied during the course Urban structure (2013–14 and 2014–15), positioned on the second year of bachelor studies. In order to summarize and evaluate students' experiences and opinions related to the applied methodology, a semi-open questionnaire was created and distributed, while the analysis of obtained answers revealed the students' perception of acquired knowledge and competences.

The first part of the article introduces the main characteristics of the current situation in architectural and planning education and its level of adjustment to the emerging demands of climate sensitive agenda. After the brief overview of the latest trends in Europe [4], US and developing countries [5], the possibilities of the Problem-based learning (PBL) are presented and analyzed. The focus is, then, shifted to the context of the Republic of Serbia and the initial hypothesis (to be tested in a case study) is formulated. The second part presents the selected conceptual framework of the case study (course Urban Structure), the modified learning methodology and its initial outcomes—through the analysis of the survey conducted after the application. The results are discussed in the third part, according to the previously formulated hypothesis. The fourth part provides the discussion of the findings in the context of local circumstances and limitations, i.e., the current Serbian socio-economic framework and professional practice. The concluding part summarizes the results of the study, providing an insight into possible modifications of architectural and planning education, in accordance with the imperatives of climate change adaptation and mitigation. The local context is again emphasized since it influences the level of environmental awareness, as well as the link between theory and practice.

The Alternative Learning Models: Motives for Exploration

The problem of climate change and sustainability in architectural design and planning has become increasingly topical during the last two decades, especially in the process of academic education [2]. Simultaneously, the challenges generated by climate change have imposed new imperatives to designers, architects and planners, who need to create or remodel outdoor spaces and buildings in order to achieve a higher resilience of urban spaces to future climates. The process of adaptation should also enhance the quality of life in the future communities, becoming an essential component of a truly sustainable development [1].

Architecture is a key profession in reducing the effects of climate change, as energy use in buildings is one of the major producers of greenhouse gases. Consequently, the main message of the Architects Council of Europe held in the European Parliament addresses the issue of the measures needed to ensure architects' role in the process of adaptation to climate change, especially during the period of economic crisis [3]. The importance of promotion and application of climate change mitigation and adaptation strategies in architectural profession is also underlined [3], while there is an on-going debate on the possible methods of architectural education which would merge theoretical and practical knowledge, facing the challenging reality of global warming [6]. Some authors stress the problem of the reduced possibility of linking different knowledge, without single definition of concepts and problems, and, consequently, the interdisciplinary approach to education is favored as an appropriate framework for the study of climate change [7]. It is especially suitable when architecture and urban phenomena are considered as an outcome of society [8]. In this context, the application of ex-cathedra model should be replaced by the educational methods which create a high level of interactivity and adjustability to emerging environmental concepts [9]. Furthermore, the education of architects and planners, as well as the pedagogical objectives addressing the sustainability of design, should be directed toward critical thinking [3,8]. For example, RIBA (Royal Institute of British Architects) defines pedagogical objectives of sustainable architectural design emphasizing the necessity of acquiring competencies and experiential abilities in order to synthesize knowledge on specific problems from practice. The early stages of an architectural education are underlined as crucial for developing new intellectual frameworks, abilities, conceptions and values [3].

Simultaneously, the Kolb's learning cycle (Figure 1) and a Social Cognitive Theory [10] are applicable.

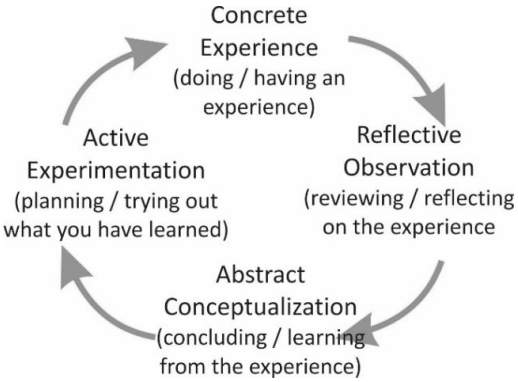

Figure 1. Learning cycle in the context of critical thinking [10].

Considering all these trends which tend to upgrade the educational process of future architects and planners, the necessity of introducing a holistic, multidisciplinary environmental knowledge becomes evident. The links between science and policy, new experiential frameworks and values should be established, interaction between theory and practice should be encouraged, while developing a new set of skills (allowing a comprehensive climate-sensitive and environmentally-friendly professional action), should be stimulated.

2. Materials and Methods

2.1. Methodological Approaches in Architectural Education—An Overview of Current Trends

In Europe, the prevailing educational approach to architecture in the age of climate change is based on the assumption of Anticipatory Learning Theory, i.e., an approach to solving problems that involves taking action and iterative reflecting upon the results. It also relies on prior knowledge. Furthermore, there is a tendency to relate the development of urban (architectural) concepts with different aspects of climate change and growing environmental challenges, while connecting the theoretical knowledge and practical work on case studies/specific problems [6]. Therefore, it is not surprising that one the major documents concerning the European Higher Education Area emphasizes the necessity of constant adaptability of architectural education to a changing environmental context, influenced by climate change, globalization, information exchange and new social relationships [4].

In the US, the criteria and outcomes leading to the climate-sensitive architectural education are even more specific, oriented toward Action Learning Theory, i.e., the process of learning through experience, specifically defined as "learning through reflection on doing" [5]. According to the US National Architectural Accrediting Board [5], the first step represents the understanding of a problem (capacity to classify, compare, summarize, explain or interpret information), followed by the ability to act (application of information, selection of proper information and its adequate use, the ability to distinguish information depending on the effects of implementation).

In developing countries (e.g., Serbia) these topics have not been sufficiently included into university curriculum and the development strategies were not associated with the mitigation of negative environmental effects on urban environment [11]. Therefore, it was necessary to extend the body of theoretical knowledge by introducing specific case studies and real problems. These two aspects (theory vs. practice) should not be separated in the process of architectural and planning education, especially in developing countries, due to the high level of vulnerability to climate change [12]. However, all new models of learning should be adjusted to existing circumstances and limitations (specific problems, available data, etc.), which means that the elements of Problem Based

Learning Theory should be emphasized because, in this case, the knowledge cannot be adequately articulated by verbal means, but only through practice [13].

2.2. Architectural Education vs. Climate Change: Problem–Based Learning (PBL)

In order to improve the learning process in architectural schools and incorporate all the important elements related to climate change adaptation and mitigation, it is necessary to analyze how the specific example/case study takes into consideration environmental problems, and, consequently, responds to climate change. According to Harris et al. [12], this approach enables students to confront a certain problem and understand it by discovering relevant knowledge, which creates a powerful a learning experience. The idea is that the interactive, problem-oriented learning (PBL) model may affect changes in the structure of knowledge developed by students. In this learning method two components of knowledge are especially important: cognitive (intuitive) and behavioral (experiential) [14]. These components have an important influence on successful understanding of climate change problems and their creative solving, while a complex interaction between the conscious and the unconscious components of knowledge is needed [13]—Figure 2a,b. Many aspects of professional performance depend on knowledge that cannot be defined as a set of rules, meaning that human cognition also involves the interpretation of knowledge that does not take the form of explicit definitions. Instead, these areas of knowledge are described as intuitive since they rely on experience and are exposed to criticism, iterations and corrections [14].

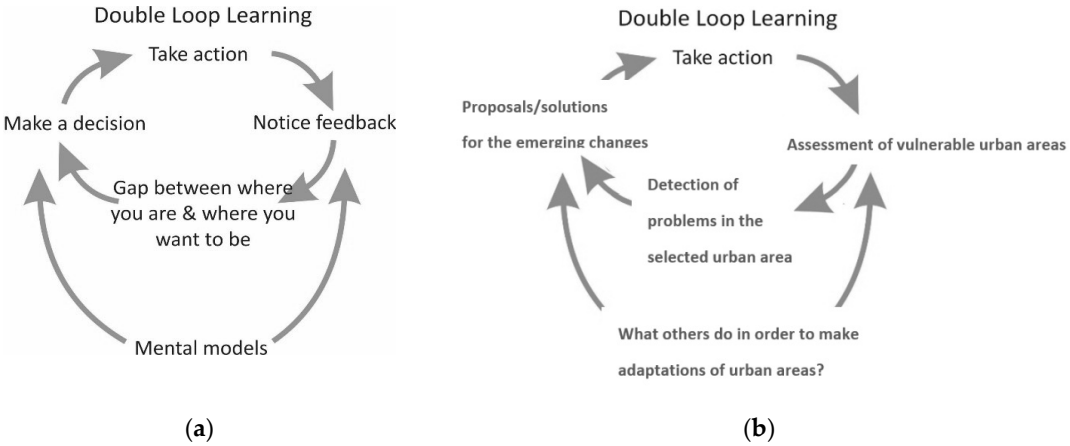

Figure 2. (**a**) Generative (double loop) learning model-interaction between conscious and unconscious components of knowledge [13]; (**b**) Application of generative model in a case study-course Urban Structure.

The contextual limitations in developing countries (e.g., the lack of resources both in education and professional practice, inefficient legal framework, uncoordinated actions on all levels of governance, delayed spatial and economic development) are calling for a holistic approach to learning. It is especially necessary in the case of generative learning, which assumes the acquisition of knowledge that constantly changes the existing assumptions about solution recipes—routines [11,15]. According to this approach, cognitive process in the context of climate change adaptation and mitigation should be conducted in four steps, while perceiving a city as a living organism [15]—Figure 3:

- detection and investigation of significant problems in the selected urban area;
- assessment of vulnerable areas, based on the data obtained through survey of terrain;
- observation of local experiences—what others do in order to adapt urban areas to climate changes (case studies, terrain analysis etc.);
- proposals/solutions for the emerging changes (in the form of sketches, diagrams, drawings and guidelines).

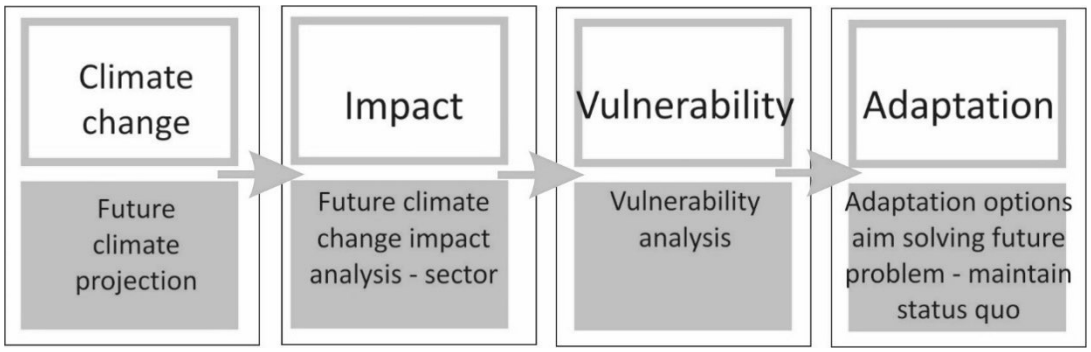

Figure 3. The framework for identifying and solving climate sensitive problems in urban structure [15].

2.3. The Initial Hypothesis

The analysis presented in this article is based on studies about the problems of architectural education. It considers the trend of integrating technical disciplines [16], within a framework of climate change adaptation in cities [17]. Since architectural education in Serbia has mainly lost its grounding in practice (tacit knowledge), the emphasis in this paper is on the connection between Problem Based Learning and understanding climate change adaptation in cities [17]. Interlinking education and imagination, creativity and innovation, as well as stimulating the capability of abstraction, become an imperative, especially in the phase of problem identification and the process of creating solutions. The assumption about the Problem Based Learning method applied in the field of architecture in the face of climate change implies knowledge that should be primarily obtained by facing the specific and urgent situations [18]. Therefore, in the following case study the following hypothesis will be tested: the application of Problem Based Learning stimulates students' interest in acquiring new knowledge on climate change challenges, enabling the course participants for the climate sensitive perception of urban phenomena and environmental design.

In the following section, the results of a survey on application course named Urban Structure will be compared, with the intention to prove the relationship between the application of PBL method and the students' growing ability to understand climate change, as well as to seek creative solutions in specific problem background.

2.4. Toward the Climate Sensitive Framework: Course Urban Structure, University of Belgrade—Faculty of Architecture

The Urban structure course represents a focus, i.e., strategic center according to the EU Regional Climate Change Adaptation Knowledge Platform [19]. It establishes a conceptual framework for linking different knowledge, experiences, concepts and approaches. This framework is designed to enable the architecture students to plan, control, and monitor the conditions and interventions in urban space. The course presents and analyzes the problems related to interventions in an area (in the context of climate change and sustainable development), defines and evaluates possible solutions and introduces the methods and tools necessary for implementing actions. The course is based on a functional approach, which includes diagnosis, proposals, implementation and the evaluation of effects. It includes social and political dimensions of the context, extending the students' abilities in conducting various activities (e.g., problem formulation, establishing a causal relationship) [11,15], and applying adequate instruments and techniques to deal with problems, objectives, goals and solutions. The course consists of lectures (combining the explanations of particular aspects/interconnections with students' debates and discussions of conflicting views etc.) and field work (observing/analyzing the interventions of users in selected areas).

The course takes into consideration the effects of climate change tackling several issues-physical structure, activities, users/actors relationships, spatial and natural resources, while applying a critical

approach. This approach introduces students to the basic factors of urban structure (e.g., methods and techniques of analysis, planning of spatial organization), simultaneously developing common sense and critical observations on users' actions (so-called "the autonomous adaptation"). The main task is to detect and analyze significant problems in the selected urban area (PBL method [20]) and to propose the adaptation of structures in a changing environment. The students should also recognize the changeability of socioeconomic components, according to the emerging conditions influenced by the economic activities, land use, infrastructure equipment, institutional framework, participating groups and individuals. In order to do this, the applied method of education includes experiences of both students and the participants in the transformation process. Consequently, the research context expands enabling better and more accurate identification of actors/participants affected by climate change. The method also includes the identification of jurisdictions, especially in the domain of construction, preservation, maintenance and control of nature and artifacts, as well as the evaluation of proposed options for intervention/problem solving (according to the Generative–double loop learning model [13]). As a result, students establish rules and recommendations for users' activities, as well as the guidelines and rules for land use in the form of sketches, diagrams, drawings and text. They also define recommendations related to the regulation of activities and responses/solutions for problems caused by climate change. Additionally, according to the encountered problems, they create rules and guidelines presented in the form of illustrations–sketches, targeting the construction of buildings and the land use and providing a certain users' manual for climate change adaptation.

Students intuitively relate problems caused by climate change to space (using observation and analysis). However, they are also supposed to select criteria for analysis and to establish goals which should guide users during the process of adaptation of urban structure (via allocation, construction and/or preservation of resources). It is important to notice that all these elements are considered in the context of a developing country (Serbia), including the socio-economic constraints and local experiences [11]. Due to the complexity of the local background, the preferred holistic approach is realized successfully mostly through PBL method [20].

The cognitive process is divided into four parts, regarding the city as a living organism [15]—Figure 4:

- anamnesis (history of the problem)—students get familiar with the site through observation and data collection;
- examination—the site is considered in the context of climate change and the interdependences between urban structure and climate change are determined;
- diagnosis—the assessment of potential, vulnerability and weaknesses based on the data obtained through the survey of the site;
- therapy—specific proposals are defined in order to overcome the problems of urban structure in the context of climate change.

All these steps are conducted through different spatial scales, emphasizing the aspect of vernacular architecture which always responds to the time/place limitations and provides a useful insight into the experiences from other geographical and cultural backgrounds (i.e., what others do in order to make the adaptations of urban areas—Figure 2b).

For example, the climate change adaptation on the conurbation scale will potentially benefit the whole city and is likely to include a variety of land uses. Opportunities for creating cost-effective and integrated solutions, as a part of an overarching climate change strategy (embedded within a Community Strategy, Open Space Strategy), may be greatest at this scale. Simultaneously, the neighborhood scale includes the development of separate groups of dwellings, including a mix of uses, and can vary in size from an individual block to a large estate. The adaptation of public realm and spaces between buildings represent a focus of these developments, while solutions are elaborated through an Open Space Strategy and a site brief or a master plan. Smaller developments, including individual dwellings, apartment blocks or commercial buildings, provide opportunities for integrating

climate change adaptation into or around buildings. Attention is given to the design of a building and its surroundings, as well as its use and management, in order to maximize current and future climate adaptation potential. Therefore, the design or building codes provide useful tools on this level.

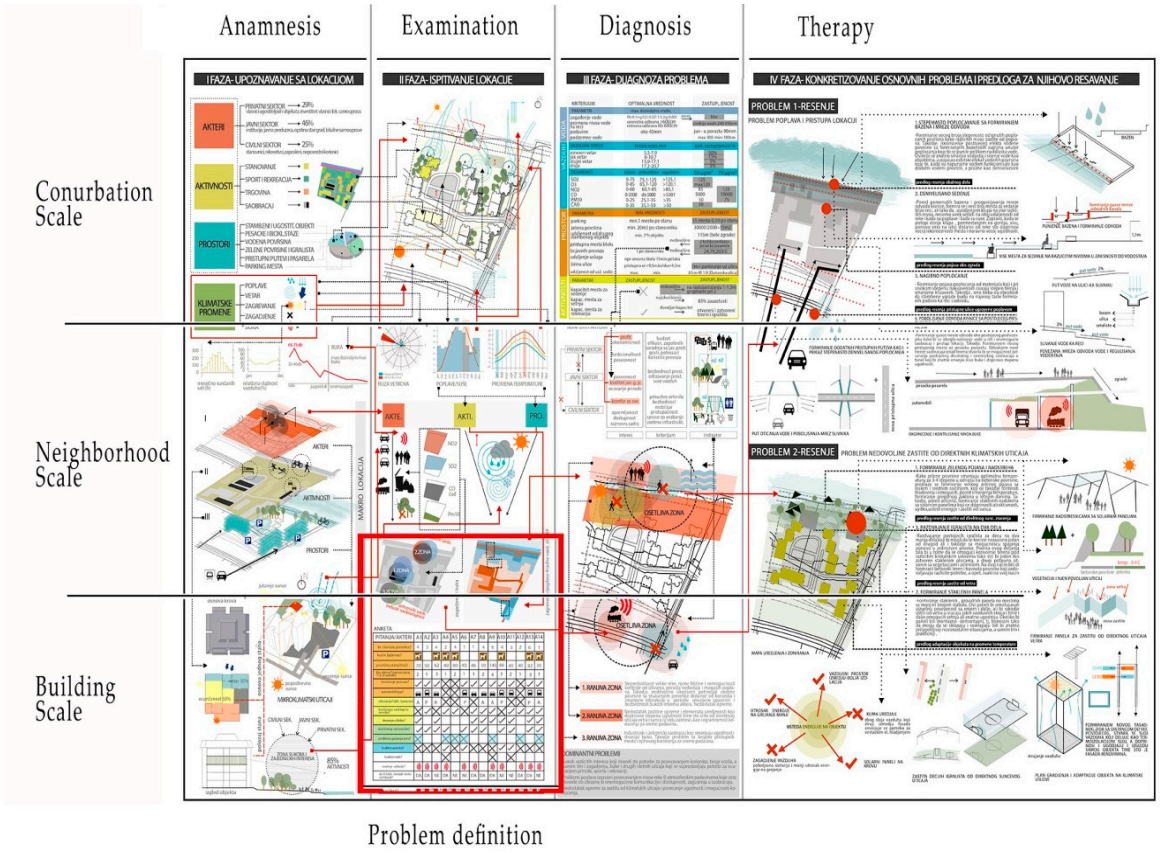

Figure 4. The example of the students' work (author BojanaSicovic), linked with the phases in PBL method: (1) Anamnesis—getting familiar with the location, through observation and data collection; (2) Examination in relation to climate change; (3) Diagnosis—assessment of potential, vulnerability and weaknesses; (4) Therapy—specific proposals are defined in order to overcome the problems of urban structure.

2.5. Redefining the Course Methodology—The Outcomes

In order to examine the students' reaction to the applied PBL method, the survey on pedagogical model/curriculum outcomes was conducted during the school years 2013–2014 and 2014–2015. A semi-open type of questionnaire was created, consisting of 16 questions—13 with multiple choices and three allowing the possibility of additional individual answers. 246 students of undergraduate studies participated in the survey in two phases—before and after the completion of the course. The result of the analysis represents the (changed) perception of their knowledge, their interest and awareness of the environmental issues, as well as their interests and aspirations after the course was conducted.

It is also important to notice that the questionnaire emphasized the link between transmitted/obtained information on climate change problems, students' knowledge and the level of their creativity in providing solutions to specific problems. Consequently, the outcome of the survey indicates the influence of Problem Based Learning model to the increased quality of proposed climate-sensitive solutions in architecture and planning. Furthermore, the specificities of local context are considered, enabling PBL model adjusted to developing countries and their limitations.

3. Results: The Analysis of the Questionnaire

The following section will provide the interpretation of the results in relation to the initial hypothesis, i.e., how the acquired knowledge, obtained by PBL method, influenced students' ability to understand climate change and react to its challenges. The data was collected before and after the course and was analyzed by the bivariate statistical method.

QN No. 1. The professional field of action that you are most interested in (Figure 5):

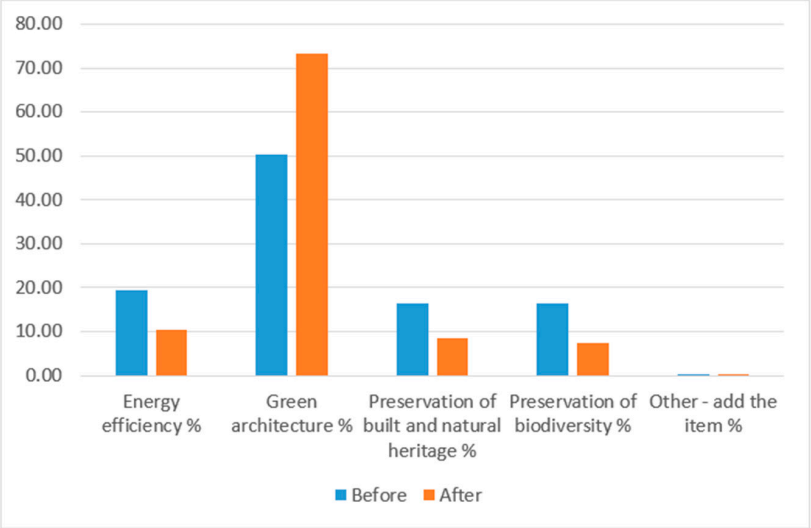

Figure 5. The comparison of answers to Question 1, obtained before and after the course (the structure is given in %).

The first question shows an increased interest in green architecture, after the course was completed (over 73.3% respondents). Simultaneously, the number of students who added another area of professional action increased, implying that the application of PBL method also stimulated their interest in environmental topics, focused on sustainable development and climate change.

QN No.2. Do you think that architects are able to do more than other professionals in order to reduce the sensitivity of urban structure and adapt it to climate change? (Figure 6).

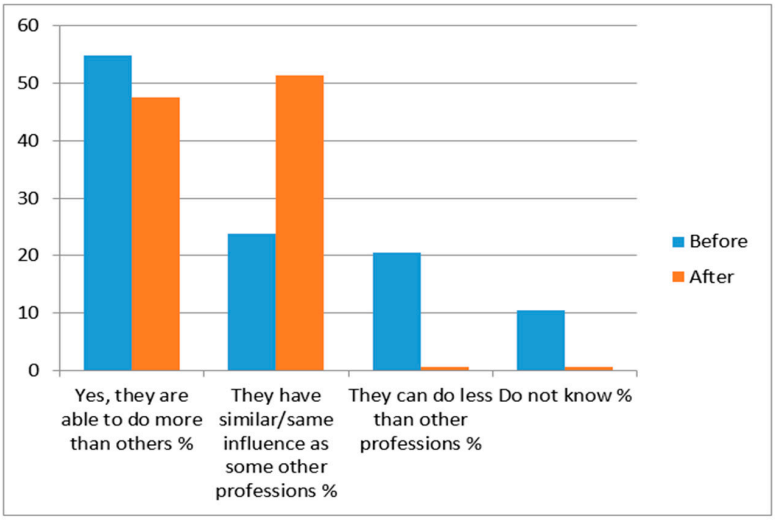

Figure 6. The comparison of answers to Question 2, obtained before and after the course (the structure is given in %).

The responses to this question clearly demonstrate students' awareness of the importance of their future profession regarding the sustainable development and climate change. 51.3% believe that architects can contribute as much as some other professionals, while 47.5% emphasized the ultimate importance of architects in environmental issues and climate change adaptation and mitigation.

QN No.3. Do you think that the topic of climate change is significant to your future work? (Figure 7).

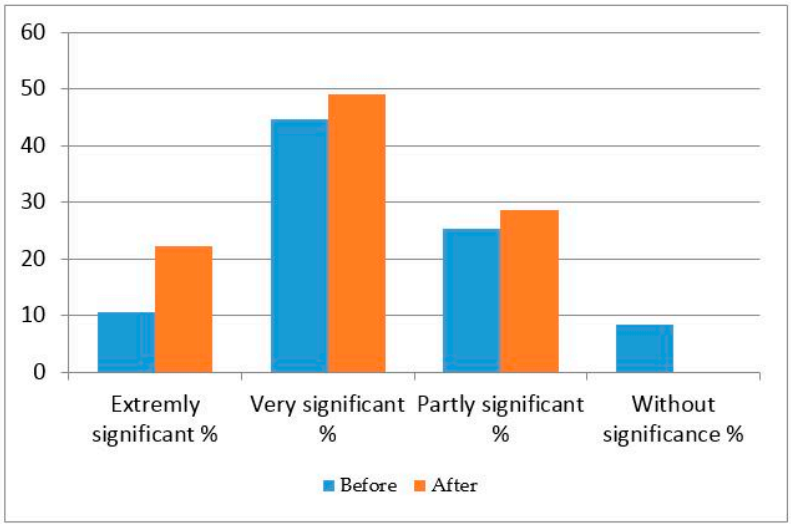

Figure 7. The comparison of answers to Question 3, obtained before and after the course (the structure is given in %).

After the course, almost half of students (49.1%) considered the topic of climate change very important for their future work, while 22.3% described it as extremely important. Consequently, we can conclude that the knowledge transmitted during the course increased their environmental and professional awareness.

QN No.4. The importance of climate change in teaching at the Faculty of Architecture—rank from 1–5 (Figure 8).

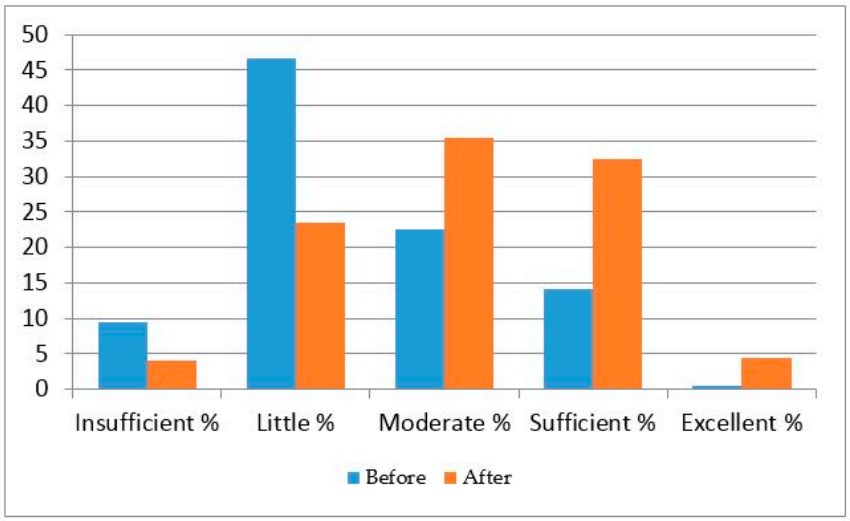

Figure 8. The comparison of answers to Question 4, obtained before and after the course (the structure is given in %).

The required ranking (1—insufficient, 2—little, 3—moderate, 4—sufficient, 5—excellent) shows that after the course, 61% of students considered that the importance of climate change in teaching could be mostly classified from moderate (35.5%) to sufficient (32.5%), which is a certain improvement in accordance to pre-course opinion (little 46.7%, moderate 22.5%). In total, it could be concluded that PBL method improved the prevailing perception of students before the course.

QN No.5. What does the adaptation to climate change assume? (Figure 9).

In this case, the participating students showed that they possess prior knowledge, which increased after the course. The post-course results reveal that 34.2% described climate change adaptation as the process of preparing for the impacts of climate factors, while 49.8% of them consider it as a way of providing resilience of natural systems.

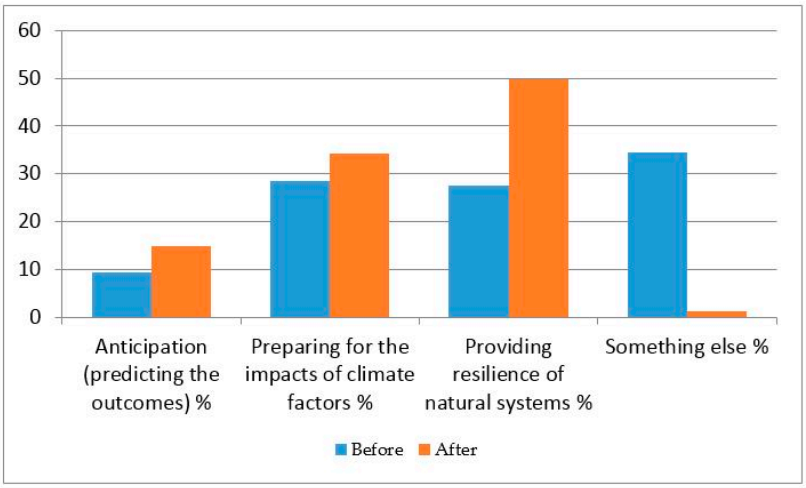

Figure 9. The comparison of answers to Question 5, obtained before and after the course (the structure is given in %).

QN No.6. How do you expect to improve your knowledge on climate change adaptation? (Figure 10).

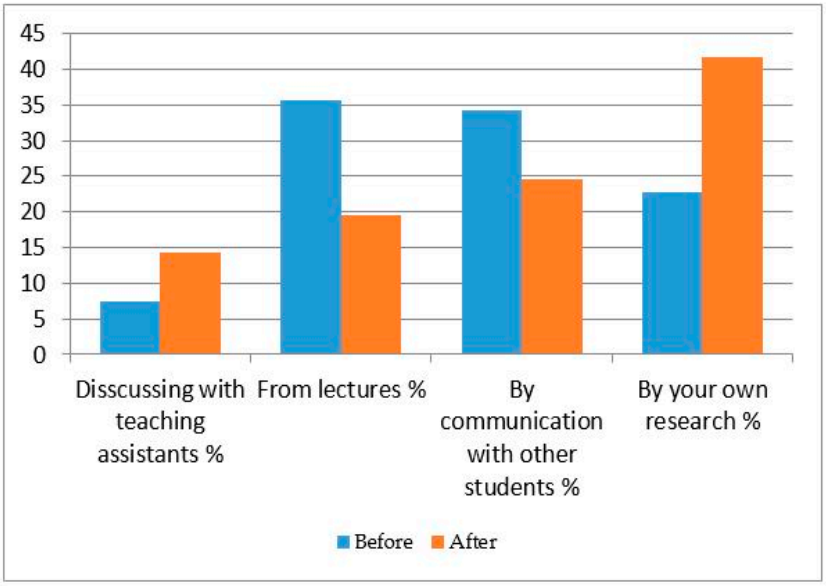

Figure 10. The comparison of answers to Question 6, obtained before and after the course (the structure is given in %).

Considering the preferable learning method, most of the respondents find their own research as the most suitable one (22.7% before, 41.7% after the course) which confirms the activation of their interest, as well as the obtained tacit knowledge. 24.5% of all students opted for the communication with other students, while data related to lectures decreased from 35.5% to 19.5%. These data show the importance of interactive approach to climate change issues, based on continuous exchange and updating of knowledge and available information.

QN No.7. Rank skills (necessary for conducting the process of climate change adaptation) which you have obtained during the studies on the Faculty of Architecture (Figure 11).

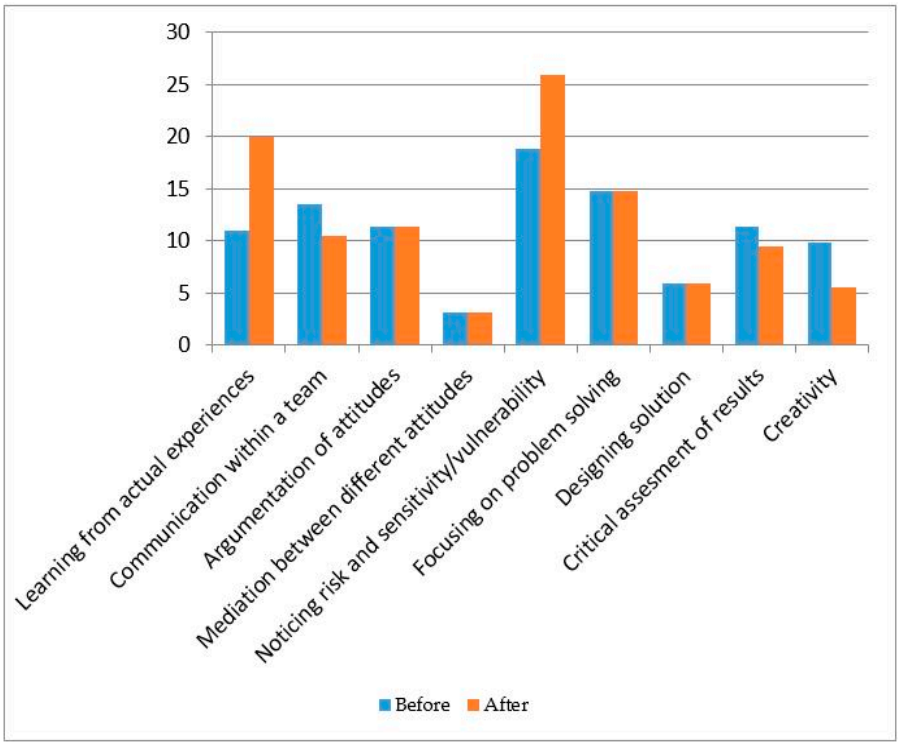

Figure 11. The comparison of answers to Question 7, obtained before and after the course (the structure is given in %).

This question is focused on the relationship between experiential knowledge (Tacit and PBL) and ability to select the adequate methods for climate change adaptation in a specific context:

- gained knowledge through PBL—items 1,5,6,8,9;
- gained knowledge through application of other learning methods—items 2,3,4,7,8.

Considering the available results of the questionnaire, it is visible that the most important obtained skills are related to identification of risk/sensitivity/vulnerability (18.85%) and problem solving (14.79%). Consequently, respondents claim they received/adopted less knowledge through communication within a team (13.45%), argumentation (11.73%), critical evaluation of the results (11.39%) and learning from actual experiences (10.92%). The results also show that the issues of creativity and design should be better incorporated into the learning process, in order to stimulate genuine applicability of current environmentally sensitive theoretical concepts into practice.

QN No.8. During the education process at the Faculty of Architecture I received valuable knowledge in the field of climate change adaptation and mitigation (Figure 12).

In general, the response to this question is very positive and encouraging when it comes to the growing ability of students to understand the effects of climate change in a specific context. Obviously, the experiential knowledge (PBL), obtained during the previous studies, increased

environmental awareness and broadened the scope of information and skills related to the adaptation of built environment and environmental challenges. Respondents generally agree with the statement (18.5% before, 49.7% after), or partially agree (11.4% before, 16% after), while the share of those who totally disagree decreased from 26.9% to 1%.

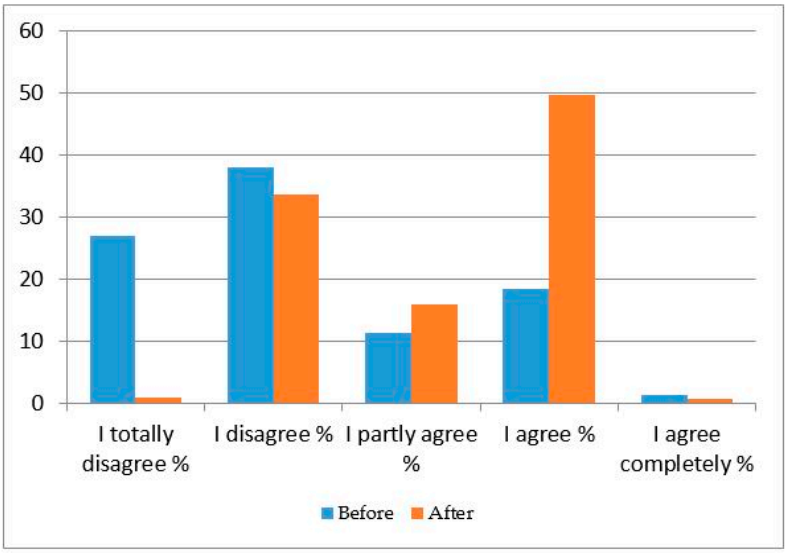

Figure 12. The comparison of answers to Question 8, obtained before and after the course (the structure is given in %).

QN No.9. Have you ever tried to find creative and innovative solutions in the field of planning and design, which would be sustainable and sensitive to climate change? (Figure 13).

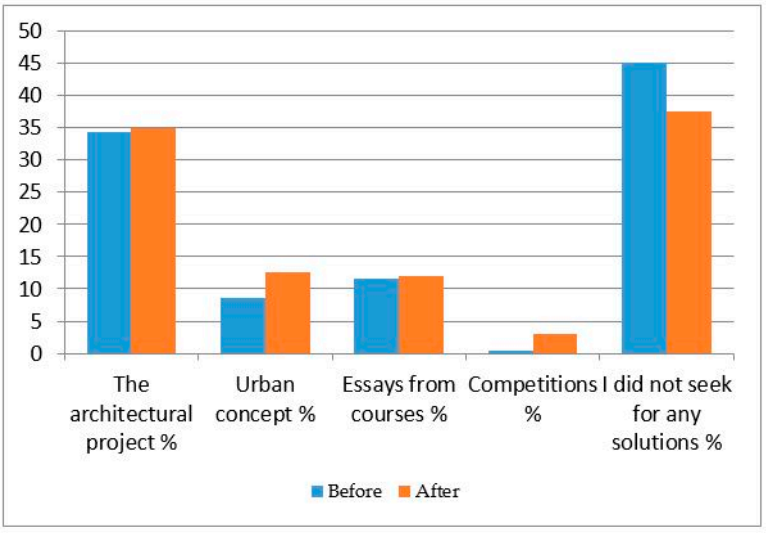

Figure 13. The comparison of answers to Question 9, obtained before and after the course (the structure is given in %).

The results after the course reveal that students are better at relating to options that stimulate their creativity–such as architectural projects (34.9%), while urban concepts/urban design (12.6%) or obligatory essays (12%), also included into curriculum, have a lower impact. However, as many as 37.5% students have no experience in this area, and only 3% tested their knowledge and ideas in

competitions. The situation was even worse before the course, with 45.1% of students without any interests or attempt to deal with environmentally challenging and climate sensitive topics.

QN No.10. Are you familiar with the various aspects of climate change adaptation? How did you obtain this knowledge? (Figure 14).

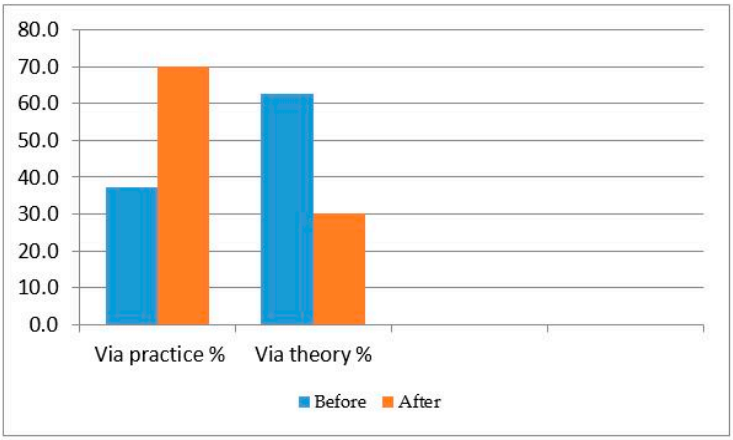

Figure 14. The comparison of answers to Question 10, obtained before and after the course (the structure is given in %).

This question gives an insight into the relationship between experiential knowledge (via practice) and ex-cathedra learning method (via theory). It is interesting to notice that the importance of the experiential knowledge increased from 37.2% to 69.97% which could be explained by the organization of the work at the course, as well as by the content of lectures which presented a number of up-to-date professional and theoretical information.

QN No.11. How do you decide about the solutions to the climate-sensitive problems? Please choose the option used in your own projects (Figure 15).

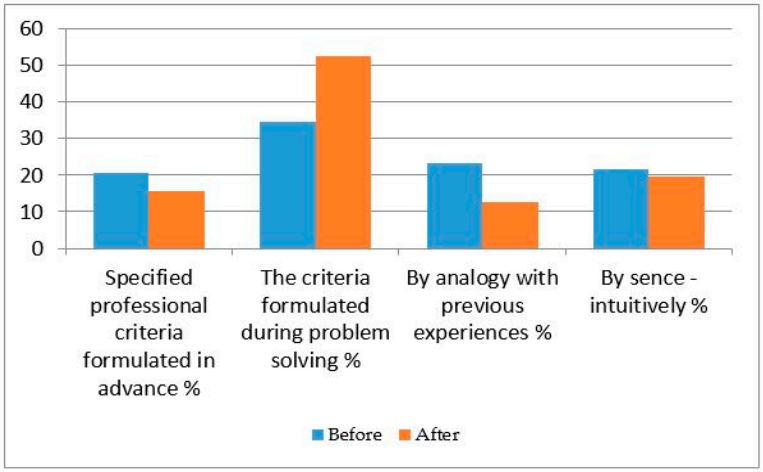

Figure 15. The comparison of answers to Question 11, obtained before and after the course (the structure is given in %).

The aim here was to relate the experiential knowledge (observing and analyzing the site and good practice) with the ability to solve climate sensitive spatial problems intuitively, via creative solutions determined by local background. Having in mind the selected methods of education (PBL, tacit knowledge), the largest share of respondents (34.5% before and 52.5% after the course) claimed they selected solutions following the criteria formulated by themselves. This result could be seen as

an effect generated by the applied teaching/learning method during the course which stressed the importance of site-specific conditions. Approximately one fifth of students used the intuitive approach, while a significant share of respondents relied on the analogy with previous experiences (decrease from 23.3% to 12.5%). Meanwhile, 15.5% of students used the template, i.e., the ex-cathedra pre-formulated professional criteria (23.3% before the course).

QN No.12. When do you think that climate change will begin to affect life patterns in Serbia? (Figure 16).

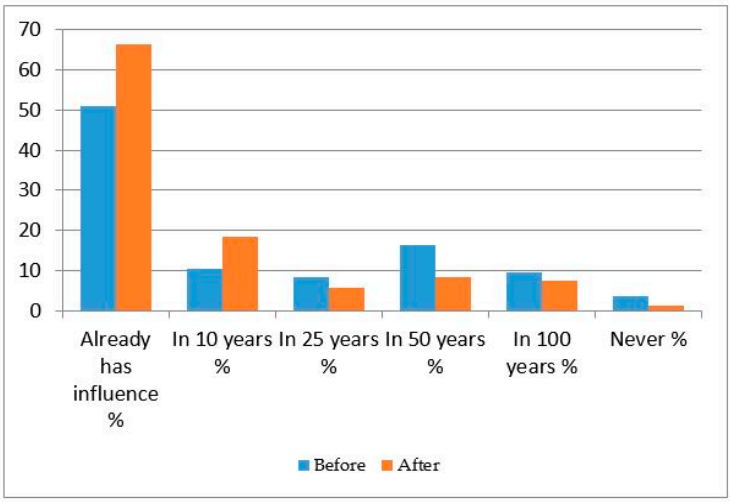

Figure 16. The comparison of answers to Question 12, obtained before and after the course (the structure is given in %).

The most of the students showed they were informed and conscious about climate change effects (even before the course). 66.3% of respondents answered that climate change was already affecting life patterns in Serbia, 18.5% think that effects will be visible in 10 years, while 22.9% anticipated period of 25 and 50 years. Obviously, most students intuitively relate climate sensitive problems to space (PBL and Tacit Learning method), but their ability to understand climate change also increased after the course.

QN No.13. Which are the suitable examples of successful climate change adaptation in Serbia (add/name plans, projects, actions ...)? (Figure 17).

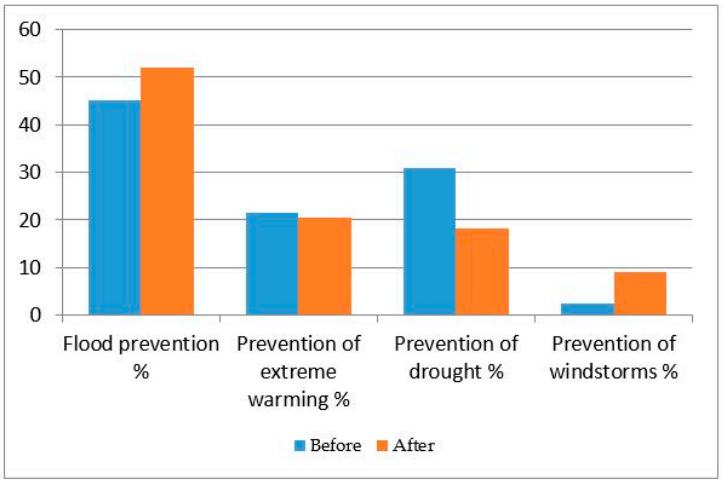

Figure 17. The comparison of answers to Question 13, obtained before and after the course (the structure is given in %).

When asked to add/list plans, projects or actions representing appropriate examples of successful climate change adaptation, most students, both before and after the course, specified cases related to flood prevention. That could be explained by the fact that the curricula in several previous courses included this topic, while the course Urban Structure used a research polygon exposed to flooding (the area of Ada Ciganlija). The prevention of windstorms was generally neglected as a possible area of interest/knowledge, although its share increased from 2.5% to 9.1%. These outcomes clearly show the relation between the applied/adequate educational methods and obtained knowledge on specific contextual problems.

QN No.14. Have you ever heard of any activity/research in Serbia focused on the reduction of climate vulnerability? (Figure 18).

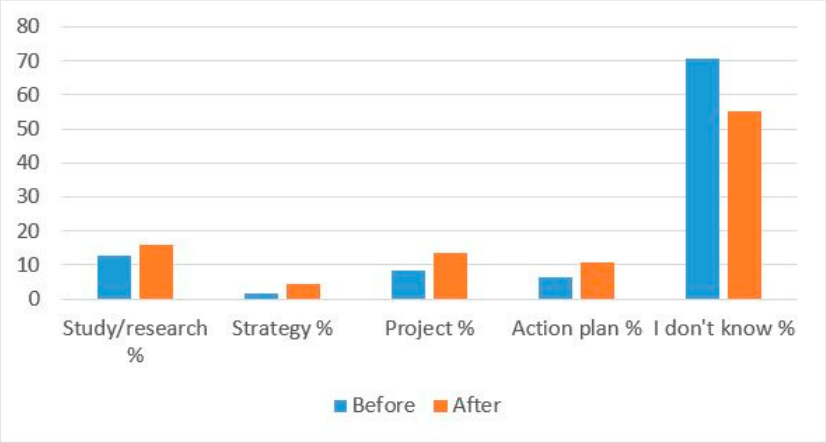

Figure 18. The comparison of answers to Question 14, obtained before and after the course (the structure is given in %).

According to the outcome of this question, which tends to relate experiential knowledge (local experience) and the process of seeking creative solutions in a specific/local background, students are not familiar with local experiences and the research related to climate change adaptation and mitigation. Even though the share of informed students increased after the course, 55% of respondents were unaware of current Serbian practice, while some of them knew about certain projects (13.7%), action plans (10.9%), study /research (15.9%) and strategies (4.5%).

QN No.15. In order to solve the problems associated with climate change you usually consider successful international examples or local conditions? (Figure 19).

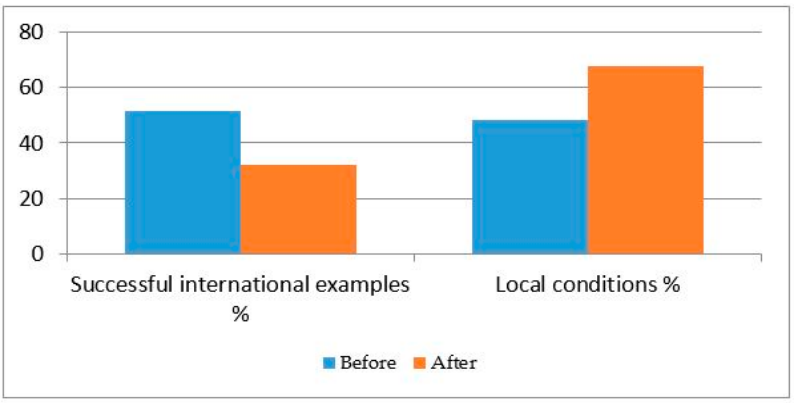

Figure 19. The comparison of answers to Question 15, obtained before and after the course (the structure is given in %).

According to the collected answers, students expressed an understanding of local background, and 68% were prepared to adjust to local specific conditions (48.5% before the course), while only 32% preferred ready-made recipes/models. This significant decrease (from 51.5%) clearly demonstrates the relationship between the used teaching methodology (PBL, tacit learning) and the developing comprehension of specific local contexts and environmental challenges.

QN No.16. Do you see your involvement in solving problems related to climate change in the future professional work? In what way?

The information collected before and after the course show that 82.3% of students participated in certain activities related to the environmental issues and climate change challenges, comparing to 68.6% before the course. Obviously, the acquired knowledge on climate change influenced both a better understanding of the phenomena and the role which profession has in a current global setting, although the applicability of their knowledge still seems to be questionable and insufficient.

4. Discussion

The results of the conducted survey reveal the interdependence of the skills attained during the course Urban Structure and the applied PBL educational method. Most respondents have recognized two skills as necessary for adaptation to climate change-identifying risk and sensitivity of urban environment (18.85%) and focusing on solving specific problems associated with climate change (14.79%). Meanwhile, 13.45% emphasize the importance of obtaining knowledge through communication within the team, the argumentation of attitudes (11.73%), the critical evaluation of the results (11.9%) and learning from actual experiences (10.92%). Some of the students, however, underline an insufficient role of creativity (only 9.86%) and formal aspects (5.95%), which, in their opinion, should play a bigger part in the curriculum. Additionally, most respondents stated that their own research represents the most suitable approach to improving their knowledge on climate change adaptation, which confirms the concept of PBL and the thesis about activation of students' interests of climate changes, as well as the necessity of enrolling them into professional practice. Consequently, 24.5% of students would like to improve their knowledge through communication with other students, through lectures (19.5%), while only 14.3% would rely on interaction with teaching assistants (14.3%).

When arguing about new knowledge that students gained on strategies for solving climate change in Serbia, a great majority of respondents did not agree that the adequate monitoring of climate factors is applied (42.2%). Additionally, 64.6% think that Serbia has not implemented different methods of climate change adaptation in the planning process. Students are also aware that an adequate information base on climate change does not exist (45.2%) but they are informed that certain standards and reports on the implementation of plans in Serbia are implemented (51.4%) (see table chart below QN No. 14–Figure 18). These results might be explained by the fact that during the course they learned about the variety of activities on climate change adaptation.

Considering the success of the applied methods of education, the opinions were divided - 29.97% emphasized the role of theoretical knowledge, 27.48% preferred the teamwork for solving specific practical problems, while 25.16% of the subjects practiced individual approach or were acquainted with the problems in practice (17.39%). Furthermore, considering the learning method, the architectural project seems to be the most suitable and preferred in the climate change adaptation of urban structure (34.9%), for 12.6% it is urban design projects, while 12% find course essays as the best medium. However, 37.5% of students did not gain any experience related to climate challenges and only 3% participated in competitions with that focus. After the course which provided new information and enabled better merging of the climate problems and their professional treatment, 82.3% realized their professional role in solving problems related to climate change,44.1% were aware of their future engagement (although in a general sense), but only 38.2% considered themselves able to participate in defining the professional, detailed guidelines. Still, 17.7% of students did not recognize their professional engagement in the problem solving.

When considering methods of education (PBL, tacit knowledge), the highest percentage of respondents claimed that they adopted the solution by using the criteria that they formulated during the problem solving (52.5%, indicating the specificity of the problem and a unique approach to every problem). 19.5% of students worked intuitively and a significant number used the analogy with previous experiences (12.5%). Only 15.5% of students used the template/pattern or pre-formulated professional criteria.

The results of the survey support the claim that the application of PBL educational method in solving climate change adaptation problems stimulates students' interest in acquiring new knowledge. It also successfully enables course participants to contribute to climate change adaptation of urban structure, which is especially important in the context of a developing country (Serbia), with limited resources, lower environmental consciousness and transitional legislation framework.

5. Conclusions

The presented analysis provides an insight into an emerging area of architectural education which introduces elements of the climate change adaptation and mitigation in the Problem Based Learning method, in the context of a developing country, with sensitive socio-economic and legislative backgrounds. The impact of recent efforts conducted at the University of Belgrade-Faculty of Architecture was tested during the course Urban Structure, revealing the initial effects on students' perception of environmental problems which are still insufficiently included in the professional practice, general awareness and governmental mechanisms. Therefore, their inclusion in the university curriculum represents an important step in achieving higher level of integration between theoretical knowledge and challenges from the architectural and planning practice, which is certainly one of the long-term objectives of contemporary architectural education. Furthermore, the results obtained by a questionnaire may be used for indirect conclusions which would direct setting of new educational guidelines, supported by the agendas of referential institutions, e.g., RTPI (Royal Town Planning Institute) or EDUCATE—Framework for Curriculum Development Environmental Design in University Curricula and Architectural Training in Europe. Applied in developing countries (e.g., Serbia), they can provide a necessary adjustability of professional (re)actions in the context of uncertainty (in social, political, environmental and economic sense), leading to a more sustainable and resilient urban development and transformation.

The survey of the students' perception of acquired knowledge and competences is interpreted in relation to student's ability to understand climate change and its effects on environment, as one of immediate goals, and to seek creative solutions in specific contexts (both as immediate and long term goal). Through the analysis of the obtained results, it is confirmed that the education of architects, oriented towards the issues of climate change adaptation and mitigation, demands the application of alternative pedagogical models, especially Problem Based Learning method. Simultaneously, the perception of the problem(s) also changes after the application of these methods. In Problem Based Learning method, students face a problem which they have to understand completely and that motivates them to disclose relevant knowledge, without pre-determined models/recipes. This learning path is especially important in a specific local context which needs creative solutions to complex problems caused by climate change, but faces different types of limitations on all spatial and governmental levels.

Problem Based Learning method certainly stimulates a more powerful experience than the application of abstract knowledge and general models, but several dilemmas remain. For example, when is the right moment to detect and expose a problem and research question—before, after, or during the process of acquiring knowledge about the site? If the research question is posed after adopting knowledge, an opportunity to shape the creative abilities of students will be missed. However, exposing a problem too early might discourage students, or push them to give incorrect answers which are not based on accurate information. Therefore, formulating a research question in the right moment is crucially important for the momentum of learning process because it helps students shape their

opinion on the relationship between urban environment and climate change, sustainable mechanisms and preferred scenarios of problem solving. Finally, the special value of this teaching method could be found in a problem-oriented work. As a result, students avoid using generalized solutions but produce specific design proposals and ground rules for land use. Adjusting to local conditions, they remain open and flexible for the necessary iterations during the design and planning process, generated by circumstances and continuous upgrading of knowledge, experiences and innovations.

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