Adapting education to a changing climate: preparing architecture students for climate-resilient design

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ABSTRACT: In this article, the authors explore the connection between climate change and the fields of architecture and urban planning. With the increasing frequency of flooding and extreme weather events, the built environment is confronting challenges in terms of sustainability and resilience. To meet these problems, it is necessary to prepare various specialists to assume responsibility for making future decisions. The authors of this article examine whether students in the Faculty of Architecture at Gdańsk University of Technology, Poland, are well-prepared for the posed challenges. For that purpose, a survey was undertaken to gather the students' viewpoints on the roles of architecture and urban planning in addressing climate change and their expectations concerning the coverage of this topic in their studies. The authors also analyse the methods used in the architectural education that facilitate an understanding of the interaction between climate change and the evolving urban landscape. Furthermore, they indicate the issues that should be incorporated into the curriculum to enhance students' ability to create under changing climatic conditions.

INTRODUCTION

Climate change has far-reaching effects on regions worldwide. It manifests in rising sea levels, extreme weather events like heavy rains, floods, fierce storms and unexpected heat waves [1]. These changes significantly impact urban structures, human life and the quality of living [2]. These effects will be even more severe since it is expected that 75 percent of the global population will reside in cities by the middle of the 21st Century [3]. The United Nations World Population Prospects report also warns that climate change will lead to a decline in overall living conditions in urban areas [3]. For several decades already, it has been possible to observe that the expansion of impermeable surfaces contributes to urban flooding [4]. Moreover, heat islands that are being formed became the cause of increased energy consumption and greenhouse gas emissions, and negatively affected human health and comfort [5][6].

In these scenarios, it becomes essential to reconsider urban structures as hubs for inventive approaches to cope with climate adaptation and mitigation. Representing both governmental officials and local bodies, numerous accords highlight these aspirations. As a result, many initiatives in research and development are dedicated to addressing challenges posed by the climate transition [7]. However, as researchers note, there are knowledge gaps in urban climate actions that still need to be addressed from both the modelling (simulation of future urbanisation scenarios, future climate pathways, etc) and technical implementation (new materials solutions, nature-based solutions, etc). In addition, the definition and evaluation of adequate climate mitigation strategies at the urban level are still challenging given limitations in the data (urban building stock and climate-related) that lack proper granularity and spatial differentiation.

Monteiro et al examined the impacts of IPCC Assessment Reports (ARs) on academic research on risk mitigation and adaptation concerns in urban areas [8]. The study found that many urban areas have become vulnerable to climate risk through the urbanisation process, thereby making risk mitigation and adaptation essential components in urban planning. Furthermore, as climate change intensifies, it becomes imperative for architects and urban planners to incorporate climate transition considerations into their design practices. In order to be able to meet future challenges, an important step in preparing a group of specialists in this field is education. It is also important to answer the question of whether the implemented measures for training architects are sufficient and adequately prepare for the profession.

STUDENT SURVEY

In order to ensure that students are sufficiently prepared for the challenges in their professional lives, the Faculty of Architecture at Gdańsk University of Technology (FA-GUT), Poland, is striving to develop an educational offer related to this issue. In order to better prepare dedicated classes for students, a survey was conducted to collect data - to learn the opinion of students of the FA-GUT on the issue of climate change and its impact on architecture and urban planning. The anonymous survey was conducted in May 2023 in the form of paper questionnaires. Students of engineering studies

from semester 2 (54 questionnaires), semester 4 (67 questionnaires) and semester 6 (47 questionnaires) participated in the survey, resulting in a total of 168 response sheets. The survey contained eight closed questions on the issue. The results are shown in Table 1.

Table 1: Results of the student survey.

1. Do you think climate change is a real threat to our world? Responses: 167			
Yes	Semester 2	Semester 4	Semester 6
Responses: 153 92%	48 (89%)	60 (91%)	45 (96%)
No	Semester 2	Semester 4	Semester 6
Responses: 7 4%	2 (4%)	3 (4%)	2 (4%)
I am not sure	Semester 2	Semester 4	Semester 6
Responses: 7 4%	4 (7%)	3 (5%)	0 (0%)

2. Do you think climate change threats will affect your life in the future? Responses: 168			
Yes	Semester 2	Semester 4	Semester 6
Responses: 147 87%	50 (93%)	55 (82%)	42 (89%)
No	Semester 2	Semester 4	Semester 6
Responses: 5 3%	1 (2%)	4 (6%)	0 (0%)
I am not sure	Semester 2	Semester 4	Semester 6
Responses: 16 10%	3 (5%)	8 (12%)	5 (11%)

3. Do you think climate change is affecting architecture and urban planning? Responses: 166			
Yes	Semester 2	Semester 4	Semester 6
Responses: 155 93%	52 (96%)	58 (89%)	42 (96%)
No	Semester 2	Semester 4	Semester 6
Responses: 2 1%	0 (0%)	2 (3%)	0 (0%)
I am not sure	Semester 2	Semester 4	Semester 6
Responses: 9 6%	2 (4%)	5 (8%)	2 (4%)

4. Do you think architects and urban planners should take climate change risks into account when designing buildings and cities? Responses: 165			
Yes	Semester 2	Semester 4	Semester 6
Responses: 158 96%	49 (92%)	64 (96%)	45 (98%)
No	Semester 2	Semester 4	Semester 6
Responses: 4 2%	3 (6%)	1 (2%)	0 (0%)
I am not sure	Semester 2	Semester 4	Semester 6
Responses: 3 2%	1 (2%)	1 (2%)	1 (2%)

5. Do you think climate change affects the aesthetics of architecture and urbanism? Responses: 168			
Yes	Semester 2	Semester 4	Semester 6
Responses: 101 60%	31 (57%)	42 (63%)	28 (60%)
No	Semester 2	Semester 4	Semester 6
Responses: 25 15%	9 (17%)	12 (18%)	4 (8%)
I am not sure	Semester 2	Semester 4	Semester 6
Responses: 42 25%	14 (26%)	13 (19%)	15 (32%)

6. Do your projects take climate change aspects into account? Responses: 167			
Yes	Semester 2	Semester 4	Semester 6
Responses: 50 30%	10 (18%)	22 (33%)	18 (39%)
No	Semester 2	Semester 4	Semester 6
Responses: 38 23%	22 (41%)	14 (21%)	2 (4%)
Yes, but not all of them	Semester 2	Semester 4	Semester 6
Responses: 79 47%	22 (41%)	31 (46%)	26 (57%)

7. Do your projects take into account sustainable technologies, such as photovoltaic installations, heat pumps or rainwater harvesting systems? Responses: 168			
Yes	Semester 2	Semester 4	Semester 6
Responses: 66 39%	18 (33%)	30 (45%)	18 (38%)
No	Semester 2	Semester 4	Semester 6
Responses: 31 19%	17 (32%)	6 (9%)	8 (17%)
Yes, but not all of them	Semester 2	Semester 4	Semester 6
Responses: 71 42%	19 (35%)	31 (46%)	21 (45%)

8. Do your university classes address the topic of climate change risks in architecture and urban planning sufficiently in your opinion? Responses: 167			
Yes	Semester 2	Semester 4	Semester 6
Responses: 38 23%	7 (13%)	18 (27%)	13 (28%)
No	Semester 2	Semester 4	Semester 6
Responses: 80 48%	32 (59%)	29 (44%)	19 (40%)
I am not sure	Semester 2	Semester 4	Semester 6
Responses: 49 29%	15 (28%)	19 (29%)	15 (32%)

The first two questions were designed to examine whether students were familiar with the topic of climate change. The majority of the students (153 answers, 92%) believe that climate change is a real threat to the world (Table 1.1). Slightly fewer students (147 answers, 87%) responded that climate change will affect their lives in the future. In the answers given to the first question, a slight upward trend is evident - the higher the semester, the higher the percentage of affirmative answers. In the second question, the affirmative answers show a slight decrease in semester 4 and they rise again in semester 6, but remaining slightly lower than in semester 2 (Table 1.2).

The next two questions were designed to test whether students perceived the impact of climate change on the architectural and urban planning profession. The majority of the students (155 answers, 93%) responded that they believe climate change is affecting architecture and urban planning (Table 1.3). A similarly high number of affirmative answers (158 answers, 96%) were given to the question of whether architects and urban planners should take climate change into account when designing buildings and cities. In the third question, a similar number of students gave affirmative answers in percentage terms - in semesters 2 and 6; semester 4 showed a slight decrease in affirmative answers. In the answers given to the fourth question, a slight upward trend can be seen - the higher the semester, the higher the percentage of affirmative answers (Table 1.4).

The next three questions focused on issues related to the study programme - aesthetics, functionality and technological solutions used in architectural projects. More than half of the students (101 answers, 60%) answered that climate change is affecting the aesthetics of architecture and urbanism, while a quarter (42 answers, 25%) were not sure. The responses given by students of each semester show a slight increase in semester 4 and a slight decrease in semester 6, with the latter higher that in semester 2. The *I am not sure* responses also fluctuate, with a slight decrease in semester 4, and a sharper increase in semester 6, with the latter higher than in semester 2 (Table 1.5).

Nearly half of the students (79 answers, 47%) admitted that they take climate change into account when designing, although not in all projects, and less than a third (50 answers, 30%) consider climate change issues in all projects. In the answers given to this question, there is a clear upward trend - the higher the semester, the higher the percentage of *Yes* and *Yes, but not all of them* answers (Table 1.6).

The seventh question showed that a large number of the students (71 answers, 42%) used sustainable technologies in a part of their projects, while a similar number of students (66 answers, 39%) used them in all projects. In this question, the students' answers make it possible to see a percentage increase in the answers *Yes* and *Yes, but not all of them* between semesters 2 and 4. Between semesters 4 and 6, a decrease in these responses can be seen, but still an increase relative to semester 2 (Table 1.7).

The last question asked about students' satisfaction with the level of university classes in terms of their connection to climate change topics. Almost half of the students (80 answers, 48%) answered that they were not satisfied and more than a quarter (49 answers, 29%) were not sure. There is a clear upward trend in the affirmative responses - the higher the semester, the higher the percentage of responses - the biggest jump is between semesters 2 and 4. The percentage of *I am not sure* responses remains similar regardless of the semester (from 28% to 32%) (Table 1.8).

THE CONTEXT OF THE CURRICULUM FOR THE ARCHITECTURE AND URBAN PLANNING STUDIES

When summarising the research conducted, it is important to highlight the context resulting from the implementation of climate change issues to the curriculum and changes made in this field. While the impact of climate transition on the built environment is becoming increasingly evident, architectural education must adapt to prepare future professionals to address these challenges. Analysing recent years, it is remarkable that there has been a tendency to incorporate issues related to sustainability and resilience in the course topics to an increasing extent and in different approaches [9-12]. According to the published sources, it is worth emphasising that there are different design methodologies and tools that can help achieve this goal, such as forecasting and backcasting, Architects Climate Action Networks and Architects Declare, and sustainability assessment frameworks [13-15].

It is worth mentioning that more than a decade ago the study of architecture was characterised by a limited focus on climate considerations. Furthermore, traditional architectural education often focused more on aesthetics, historical context and technical aspects of design, with less emphasis on the environmental impact of buildings and urban areas. Insufficient knowledge of sustainability may have resulted in graduates lacking the knowledge and skills to design sustainable, energy-efficient, and climate-resilient buildings and spaces. Lack of sufficient theoretical and practical experience may lead to difficulties for graduates in dealing with real-world climate challenges, which can limit their ability to translate theoretical knowledge into practical solutions.

What is important, is that architecture curricula in Europe closely follow the recommendations of influential organisations, such as the Royal Institute of British Architects (RIBA), UNESCO and the Architects Council of Europe (ACE), as well as local chambers of architects and accreditation commissions [16]. The debate on shaping the architectural profession and defining the knowledge and skills that architecture graduates have to possess continues. However, it is important to note that the European Directive 2005/36/EC, which mandates compliance in architectural curricula, does not directly address the competencies needed to effectively contribute to resilience and urban sustainability in the face of climate change [17].

Nevertheless, topics related to sustainability are being integrated into architectural education and are becoming a significant consideration during the development of numerous architectural and urban projects.

HOW ARE CLIMATE CHANGE ISSUES BEING INTRODUCED INTO THE CURRICULUM AT THE FA-GUT?

Upon reviewing the current curriculum in the Faculty of Architecture at Gdańsk University of Technology (FA-GUT), it is noteworthy that the educational programme comprehensively incorporates environmental education, sustainable design, climate protection and environmental considerations at every stage of study [18]. Both the Department of Architectural Design and the Department of Urban and Regional Planning in the FA-GUT, offer courses that familiarise students with climate change issues. The majority of architectural and urban planning courses are founded upon principles of sustainability, sustainable development and addressing environmental challenges [19]. Furthermore, it is worth acknowledging that since Professor Lucyna Nyka, Dean of the Faculty, posed an essential question in 2019, the expected changes are taking place.

> *However, the question arises: do architectural studies curricula properly address climate change challenges and are graduates prepared to participate actively in the formation of water-sensitive strategies?* [20]

When reviewing the courses offered at the Faculty of Architecture, it is important to highlight that the introduction to climate-related issues begins as early as the first year of engineering studies. For instance, during the second semester, classes held by the Department of Urban Architecture and Waterscapes, GUT, task students with designing a house capable of withstanding fluctuating water levels. Furthermore, topics such as floating architecture and adapting urban waterfront public spaces to changing water levels and weather conditions, including scenario planning, continue to be explored in subsequent semesters [21]. Moving forward to the third semester, the Architectural Design 3 classes, supervised by the Department of Environmental Design, GUT, address sustainability issues as an integrated aspect of every design process. In their projects, students are obligated to incorporate solutions that aim to minimise the negative impact of buildings on the environment. This consideration extends to issues, such as energy efficiency and the appropriate natural and cultural context.

Similarly, in the urban design classes (semester 4) conducted by the Department of Urban and Regional Planning, GUT, a strong emphasis on sustainability serves as the foundation for creating an urban structure resilient to flooding. Whereas when working during semester 6, students face the challenge of exploring functional and spatial solutions of a multifunctional object in the context of adaptation of urban polder areas to climate change. They propose the layout of the vulnerable site and apply solutions to ensure the resilience of designed structures to different climatic conditions, understanding at the same time the impact of the implemented solutions and how climate changes affect the design objectives (Figure 1 and Figure 2). The approach adopted during project development aims not only to foster students' architectural skills, but also to cultivate an understanding of the intricate relationship between design, the environment and community well-being.

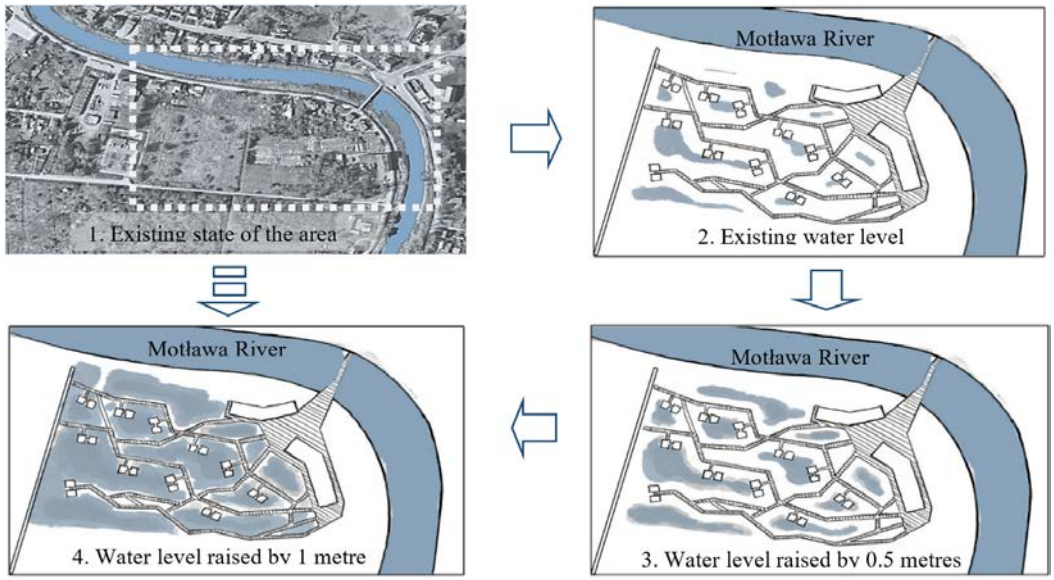

Figure 1: Example of students' projects: a view of the study area with a scheme of the strategy for the transformation of the site (FA-GUT students: K. Kapitańska and A. Żurańska).

Furthermore, to delve into specific topics concerning climate-sensitive approaches, the curriculum includes additional classes and elective seminars. Moreover, to provide students with a deeper understanding of the changing climate and its implications for architecture, they actively participate in various international initiatives. For instance, an annual event in which students are involved is the Arturbain.fr international competition organised by the French association L'Art Urbain dans les Territoires. This competition focuses on diverse design aspects within a changing environment,

and not only offers a platform for showcasing creative solutions, but also encourages students' critical thinking and innovative design approaches towards fostering sustainable, resilient architectural and urban structures [22]. Equally significant is the integration of students into various international research projects and workshops. This integration, which involves students in scientific research endeavours like the SOS Climate Waterfront project, has proven invaluable in raising awareness about water-sensitive strategies.

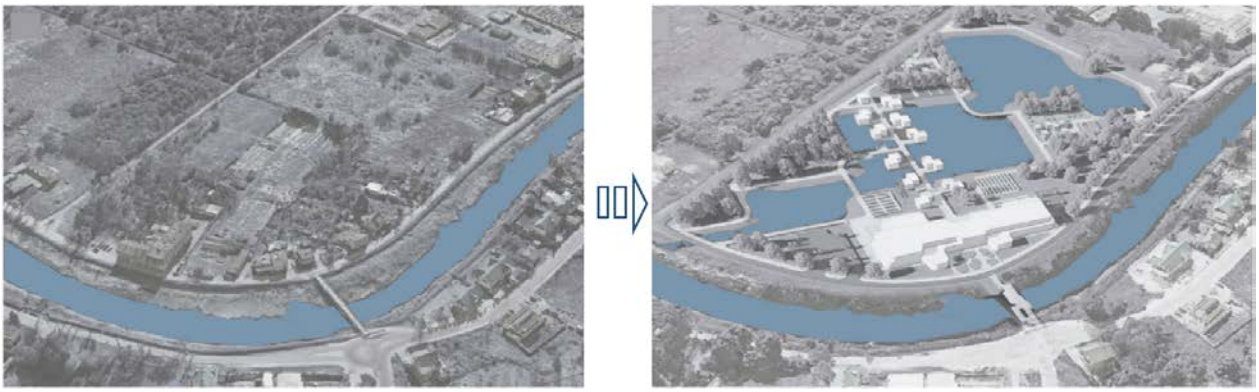

Figure 2: Example of students' projects: a current view of the area with a student proposal assuming high water levels (FA-GUT students: M. Kalantai and D. Karpovich).

It is important to note that accumulating subjects in consecutive semesters that deepen the understanding of how to design for a changing climate, as indicated by Table 1.7 is effective. This gradation of knowledge makes students more familiar with these important issues as they progress with their studies. However, it is clear from the questionnaire that students report a deficiency of technical knowledge. It is sufficient until semester 4, whereas in semester 4 there is a stratification between what students would like to do and the technical knowledge they represent. It shows that despite a programme that is apparently rich in issues for a changing environment, changes to the curriculum are needed. Interdisciplinary classes are necessary, where students could learn about technologically advanced solutions that would allow them to design, for example, climate-neutral neighbourhoods or urban environments capable of absorbing flush flood waters based on comparative data.

DISCUSSION AND CONCLUSIONS

As indicated by the survey results, most students in the 2nd, 4th and 6th semesters of the FA-GUT believe that climate change presents a challenge that affects both the global community and themselves personally. They recognise its direct relevance to the field of architecture and urbanism, and understand the imperative for architectural and urban planning to evolve and adapt to modern environmental and climatic realities. Responses addressing aesthetics, functionality and technology utilisation, as highlighted in the survey, indicate that the curriculum incorporates climate change-related issues that influence students' design approaches. However, the notable increase in responses, such as *I am not sure* and *Yes, but not all of them* to questions 5 and 7 suggests a lack of knowledge regarding technical solutions.

The review of topics dedicated to climate change and sustainable design reveals an ongoing process of curriculum updates at the FA-GUT, to include climate-related subjects. Nevertheless, the extent of these updates heavily relies on individual educators and the subjects they offer to students. Considering the results of the eighth survey question alongside the aforementioned aspects, the necessity for a more comprehensive integration of climate change topics into the curriculum becomes evident. Despite the students' growing interest in the influence of climate change on architecture and urban planning, their dissatisfaction with the current level of incorporation of this theme into the design aspects of their studies is evident.

A solution might entail introducing dedicated courses that address the impacts of climate change on architecture and urban planning. Such courses should encompass all students within a semester, rather than only focusing on individual project groups. The course's focus should be on fostering a deep understanding of climate literacy within the profession. This aligns with the findings of the Australasia-wide survey on Climate Literacy and Action in Architecture Education [23]. However, the most significant concern lies in the low percentage of students utilising technological solutions in the realm of sustainable design. The development of technology is constantly evolving, presenting new solutions that academics should impart to students in a practical manner. This goal can be effectively achieved through workshops that focus on demonstrating the impact of these solutions on buildings and urban spaces. These observations are aligned with the research of W. Celadyn, whose investigations reveal that a heightened emphasis on technical subjects related to sustainability and techniques for achieving environmentally friendly construction correlates with the production of high-quality architecture [24].

In conclusion, it is important to highlight the continuous necessity of updating educational programmes at each architecture faculty to integrate climate considerations. This measure is crucial for preparing future architects who must be equipped to address the posed challenges. Such updates are essential to ensure that graduates are well-prepared to

meet the urgent demands of climate change in their professional careers. The integration of climate considerations into architectural education fosters innovation in design and planning. It encourages the development of creative solutions aligned with environmental objectives and long-term sustainability goals. Additionally, the industry's increasing demand for professionals capable of designing environmentally responsible and resilient buildings enhances graduates' competitiveness in the job market.

ACKNOWLEDGEMENTS

Funding for this project was received from the European Union's Horizon 2020 research and innovation programme under the Maria Skłodowska-Curie grant agreement No. 823901.

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