

Mental models in the process of architectural education: user experience theory and architectural design

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ABSTRACT: Architectural design requires a reliable approach to the entire process, from engineering solutions to high-quality aesthetics. Throughout the process, the most important factor influencing the development of functional, spatial and aesthetic solutions is the user, who determines design decisions. The main goal of this study was to investigate mental models in the theories used by user experience (UX) and their transposition into the process of architectural education. The study used surveys with their qualitative and quantitative interpretation as research tools. It was carried out on the basis of conceptual designs from students prepared as part of the Research and Design Studio - Elementary Service Structures course in the Faculty of Architecture at Wrocław University of Science and Technology, Poland. The findings demonstrate that the workshop method implemented in this study improved the students' understanding of critical designer-user correlations.

INTRODUCTION

Starting in 2019, Polish technical universities offering degrees in architecture are required to introduce more than 1,245 hours of architectural and urban design studio courses in the first-level degree programme. Design studio courses are crucial because they offer a practical learning environment that enables students to apply what they have learned in theoretical academic courses. Most design studio courses are built as a simulation of an actual design challenge, with the instructor providing the framework. Students are expected to create design solutions in these courses by applying their critical thinking and creative abilities.

Architecture design studio courses typically focus on the entire design process, covering the ideation, research, development and communication of design concepts. Students learn to identify and analyse design problems, create and evaluate design alternatives, and effectively communicate their ideas through verbal and visual presentations. Collaborative work is also emphasised in project studios, fostering skills, such as time and resource management, teamwork, and giving and receiving feedback. Overall, design studio courses are essential to prepare students for successful careers as architects.

For design education, a course framework founded on innovative ideas and practices is essential. In this regard, providing students with the opportunity to explore various design studio frameworks through workshops offers significant advantages for both teachers and students. The knowledge gained during these workshops is beneficial for the development of design studio courses in the field of architecture [1-4].

The research presented in this article aimed to further advance design studio courses, through workshop formulas developed by the authors. The study's goal was to determine how user experience (UX) approaches can be integrated into the architectural educational design process and to assess students' awareness of design problems. The utilisation of UX techniques within the design process was examined during the Research and Design Studio - Elementary Service Structures course, one of 19 design studio courses hosted by the Faculty of Architecture at Wrocław University of Technology, Poland, in first-level engineering studies.

STATE OF RESEARCH

The research encompassed a comprehensive analysis of the literature on UX theory within the realm of architectural design, exploring the implementation of mental models and the application of user-centred design (UCD) and human-centred design (HCD) methodologies. Given the limited scope of the article, subsequent sections selectively present only the most critical information pertinent to each topic.

By integrating UX methodologies, such as wireframing, prototyping, surveying, testing and analytics into architectural design, practitioners can tailor UX principles effectively for architectural contexts. Successfully applying these strategies requires an understanding of organisational behaviour, designer traits, utility of design tools and resource availability. Adapting the UX typical hierarchical and sequential logic to architecture enhances profitability, diversity, solution orientation, and the ability to rapidly update architectural products [5].

The cognitive architecture for managing mental models encompasses three distinct levels: usage, adaptability and control. Designers can effectively integrate user experience into architectural design by creating internal simulations using mental models, refining these models through iterative learning or revisions, and overseeing the adaptation processes. This integration can be achieved through the application of metacognitive strategies [6]. Cognitive design, in the context of architectural design, refers to the mental processes and activities that go into creating architectural designs. It includes cognitive allocation and weighting in the design process, which are related to the creation of design knowledge and spatial language. Cultural and language differences influence the cognitive design, which is often subjective, recursive and heuristic [7][8].

PURPOSE OF THE STUDY

The goal of this study was to integrate UX design principles into the architectural education process. This integration builds upon existing knowledge and practices in both fields. In pursuit of this goal, various foundational laws of UX, including Jacob's, Hick's and Postel's laws, were analysed. This study focused on adapting the principles of Jacob's law for use within architectural education. Jacob Nielsen, an expert in end-user usability design, posits that users' expectations are shaped by their prior experiences with design conventions [9]. The notion of user experience in UX design is linked with the concept of mental models. Therefore, the application of tools associated with mental models, personas and proto-personas emerged as the central aim of this study.

The concept of mental models brings a user-centred focus to architectural design, emphasising the need to understand the cognitive and perceptual ways through which people interact with physical spaces. By laying the groundwork for design decisions in understanding these mental frameworks, architects can enhance the quality of human experience in the built environment.

The objective of the study is relevant as it addresses the evolving needs of architectural education and the industry [10]. Given the increasing importance of user-centred design approaches in architecture, the integration of UX design principles into education ensures that students are equipped with the skills and knowledge needed to excel in their future careers.

RESEARCH METHODOLOGY

The study involved 30 students enrolled in the Research and Design Studio - Elementary Service Structures course during their third semester at the Faculty of Architecture. The course focuses on the design of simple public buildings, such as primary service facilities (kindergartens and primary schools). In such designs, it is crucial to emphasise the relationship between the designer and the user. The designer acts as a mediator and interpreter of the social, perceptual and physical needs of the users, integrating these into the design process. Therefore, the authors concluded, based on their own teaching and design experience, that this course was the appropriate setting for conducting the workshop discussed in this article.

A series of workshop sessions totalling ten hours was conducted. The workshops were held during the second month of the semester's project work. At this point, the students had already begun working on the project, initially focusing on the land use plan and developing preliminary concepts and ideas for the building.

To achieve the objective of the study, the authors employed methodologies modelled on those used in digital product development within the information technology industry. It concerns the user's identity and requirements, thereby reducing the risk of designers' subjective interpretations influenced by their previous experiences. Within the framework of the workshop, the students gained information on mental models, participatory design and user-centred design principles.

Participants engaged in the refinement of their mental models by simulating the perspectives of proto-personas. Proto-personas are preliminary representations of target user groups based on assumptions and educated guesses. Proto-personas are strategically designed to cultivate empathy, aid in the retention of user characteristics, and serve as a foundational framework for understanding users' traits, needs, motivations and behaviours. Such insights are invaluable to design teams, enabling them to shift from self-centric perspectives to prioritising user needs and objectives. This process facilitated a deeper understanding of end users and their specific needs.

The design process was documented by students through sketches, diagrams and written notes. Data analysis involved analysing the documentation collected throughout the workshop sessions. A pre- and post-survey was conducted to facilitate the comparison of study results. The findings were compiled into a comprehensive report summarising the study methodology, results and conclusions.

Regarding ethical considerations, several measures were implemented. The authors obtained informed consent from participants prior to their participation in the study. The surveys were carried out via computer-assisted web interviewing (CAWI) in a completely anonymous manner. Participants were given the opportunity to withdraw from the study at any time without penalty. Permission was obtained to use the materials collected in the workshop for the purposes of this study and publication.

WORKSHOP: APPLYING UX PRINCIPLES IN ARCHITECTURAL DESIGN EDUCATION

The workshop lasted ten hours; the time was divided into two workshop sessions of five hours each held over two weeks. The workshop programme encompassed five distinct parts (Figure 1).

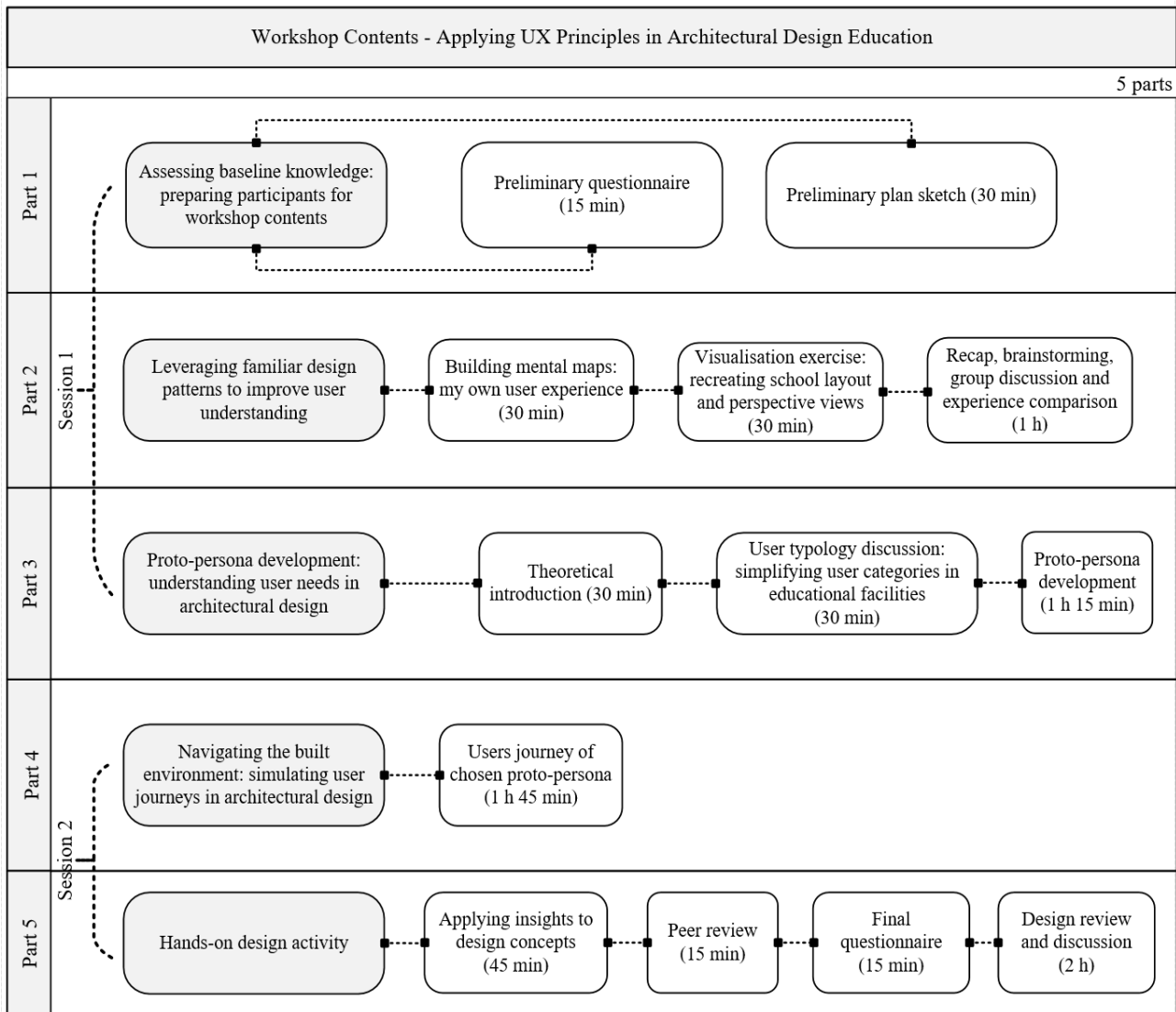


Figure 1: The workshop programme.

Participants collaborated to enhance their architectural concepts by incorporating insights derived from considering the needs and preferences of the end user. By iteratively refining their designs based on user-centric principles, participants worked towards creating more effective and user-friendly architectural solutions.

The first part of the workshop was entitled *Assessing baseline knowledge: preparing participants for workshop contents*. It lasted 45 minutes and was divided into two parts: preliminary questionnaire and preliminary plan sketch. Participants began by completing a preliminary questionnaire to assess their current understanding of the principles of UX and the approach to the architectural design project. A preliminary sketch of the architectural solution for the kindergarten/primary school building was created. The primary objective of this exercise was to establish a starting point for improvement and refinement.

The second part was entitled *Leveraging familiar design patterns to improve user understanding*. It lasted two hours and was divided into the following steps: 1) building mental maps: my own user experience; 2) visualisation exercise: recreating the school layout from participants' memories; drawing perspective views of mental images; and 3) recap and brainstorming, and group discussion and comparison of experiences.

During the introduction, instructors provided an overview of integrating UX-derived mental models into architectural design. Participants gained insight into the principles of user experience design and the significance of mental maps in shaping architectural solutions. Through discussion and examples, instructors explained how UX principles have been successfully applied in existing architectural projects, highlighting best practices and innovative approaches. Questions were encouraged, providing participants with the opportunity to clarify concepts, share information and discuss potential applications in their own projects.

During the exercise, participants individually worked to draw the floor plan of the elementary school or kindergarten they attended as children. They were tasked with recalling as many details as possible related to the place, including various aspects of the school's architecture and design, with a focus on elements, such as layout, signage, spatial organisation and usability. In the visualisation exercise, participants used mental maps to recreate their school plan and its most characteristic perspective views.

The last step of the second part involved a recap and brainstorming. During this phase, participants individually worked to summarise the key insights gathered from their mental visits, emphasising their relevance to user experience in architectural design. They were tasked with brainstorming ideas to improve the architectural design of the primary schools they had mentally visited, with the aim of addressing identified challenges and improving the user experience.

At the end of this part, a group discussion was stimulated in which participants shared their observations and insights from their mental visits. Students searched for examples where a misunderstanding of user needs led to ineffective design solutions.

The third part was entitled *Proto-persona development: understanding user needs in architectural design*. It lasted two hours and 15 minutes and was divided into three steps: 1) theoretical introduction; 2) user typology discussion; and 3) proto-persona development.

The theoretical introduction explained the task and detailed the process of creating proto-personas. The participants then engaged in a discussion to identify the various types of users present in educational facilities. They then collaborated in groups to create a simplified list of these users, which facilitated a clearer understanding of the diverse user groups within such environments. Finally, participants were asked to create their own proto-personas.

In the process of creating the proto-persona, participants worked in teams of two to three people. Through an introductory lecture and guided discussions, participants identified key characteristics, needs, preferences and behaviours of potential users relevant to the architectural project. They then developed proto-persona profiles that served as foundational frameworks for understanding and empathising with diverse user groups.

The fourth part was entitled *Navigating the built environment: simulating user journeys in architectural design*. It lasted one hour and 45 minutes. During this part, students explored users' journey of the chosen proto-persona. Based on the characteristics of the proto-personas, participants attempted to anticipate user behaviour and assess the level of user satisfaction with the architectural solution bit by bit. This activity offered insights to inform design decisions tailored to meet the needs of the intended users.

The fifth part was called *Hands-on design activity*. The workshop culminated in an iterative review of the design solutions developed during the course. Participants returned to the design studio course content prepared in earlier stages and evaluated the solutions, ensuring that they met the established user-centred objectives. This part lasted three hours and 15 minutes and was divided into four tasks: 1) applying insights to design concepts; 2) peer review; 3) final survey; and 4) design review and discussion.

Participants were encouraged to brainstorm ideas for improving the user experience in their assigned space. They developed design concepts and proposals to improve the architectural solutions of the kindergartens/primary schools they were designing. Participants worked individually or in pairs to create building plan concepts, considering factors, such as layout, signage, accessibility and spatial organisation. They had at their disposal preprepared functional blocks that enabled the efficient design of functional-spatial system diagrams and building floor plans. Functional-spatial blocks prepared at the appropriate scale were used as auxiliary tools. By working on the previously prepared functional blocks, the students were able to efficiently prepare a preliminary projection of the designed object using a heuristic method.

Next, participants exchanged feedback and suggestions on each other's designs, focusing on adherence to usability considerations. Each group delivered a brief presentation, showcasing how they integrated UX principles to improve usability and user experience while addressing encountered challenges. Participants were encouraged to reflect on their learning and explore ways to incorporate UX principles into future projects. At the end of the workshop, a final survey was conducted among its participants.

SURVEY RESULTS

Two surveys were conducted, which aimed to assess participants' understanding and knowledge at two key points: before and after the workshop. The study examined whether students use research tools during the development of

architectural projects. The results of the first survey indicated low tool applicability among students (below 25%, with only *field observation* showing a higher value of 50%).

The first survey question assessed participants' understanding of the project objectives and requirements (Figure 2). Initially, 19.2% rated their understanding as *very good*, 69.2% as *good*. In the final survey, 65% rated their understanding as *very good*, showing a positive change in participants' comprehension of the course content. The second survey question assessed participants' self-reported knowledge needed to complete the design studio course project (Figure 2). Initially, 3.8% rated their knowledge as *very good* and 19.2% as *good*. At the end of the course, those who rated their knowledge as *very good* increased to 10% and those who rated it as *good* increased to 80%. In particular, no participants rated their knowledge as *weak* in the post-survey, indicating a significant overall improvement in self-assessed knowledge.

The results show a significant shift in participants' views on architects considering user opinions in the design process, before and after the study (Figure 2).

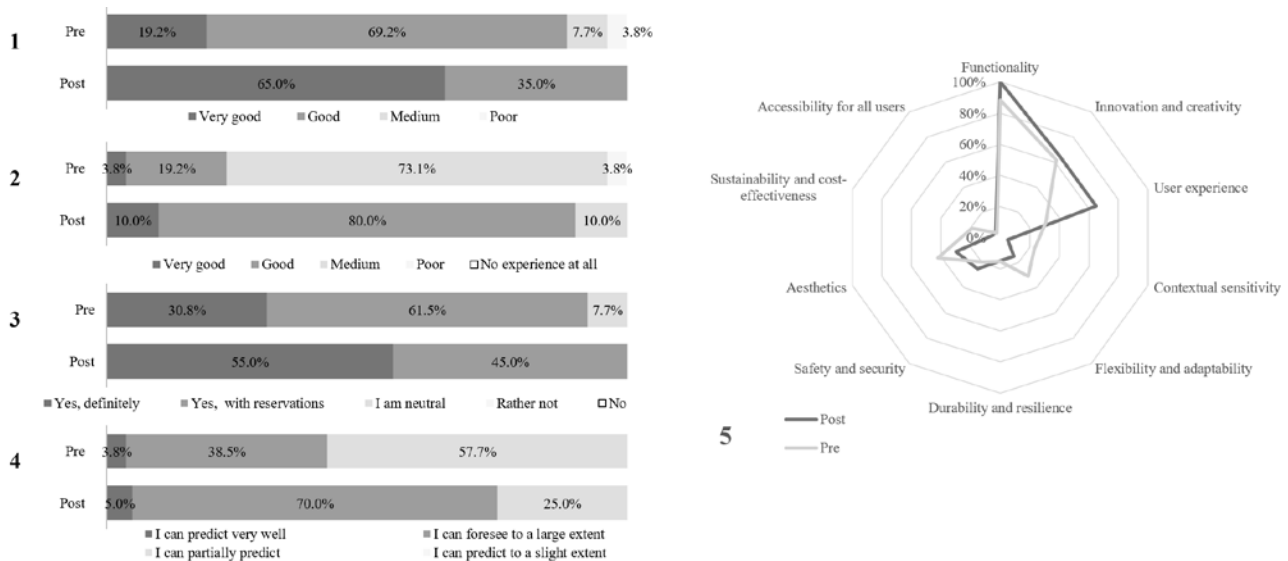


Figure 2: Results of selected survey questions.

Initially, 30.8% of the participants strongly agreed with considering user opinions, which increased to 55% after the study. Additionally, there was an increased percentage of users who were knowledgeable about concepts, such as persona and mental models. The survey indicates marked improvements in participants' confidence in predicting user interactions with designed spaces (Figure 2). The confidence in predicting *very well* increased slightly by 1.2%, while those confident to a *large extent* increased by 31.5%. In contrast, those who felt they could only *partially predict* user interactions decreased by 32.7%.

The results shown in Figure 2 concern the following questions:

- 1) How would you rate your understanding of the objectives and requirements of the project in the Research and Design Studio course?
- 2) How would you rate your knowledge required to carry out the project in the Research and Design Studio course?
- 3) Do you think architects should consider the opinions of future users in the design process?
- 4) How would you rate your ability to predict how users will use the space you have designed?
- 5) Which of the selected criteria would you consider most important in the context of your project developed within the Research and Design Studio course?

Moreover, the self-assessment of the workshop participants of their knowledge of the newly introduced tools was checked (Figure 2). The self-assessment revealed that 70% of the participants demonstrate in large part the ability to anticipate user utilisation of their spaces, while 80% assess their proficiency in understanding the needs and expectations of various user groups positively. All participants rate their ability to utilise personas in the architectural design process as *good* or *very good*, likewise 100% feel better prepared for architectural design. Ninety-four point seven percent of the participants feel more confident in determining the steps to take in the architectural design process. It can be inferred that conducting the workshops positively influenced students' self-assessment in such a crucial area as design confidence.

In the fifth survey question, respondents selected the top three of ten criteria most important in their architectural design projects (Figure 2). By the end of the workshop, *functionality* was considered most important by all respondents (100%), up from 88.5%, and *user experience* (UX) doubled from 30.8% to 65%. The results highlight a shift toward

prioritising functionality, safety, innovation and UX, while deprioritising aesthetics, sustainability, cost-effectiveness and flexibility.

In response to the open-ended question regarding the most helpful elements of the workshop, participants provided a range of responses that highlight the diverse benefits of the workshop. The selected responses of the participants are shown in Figure 3.

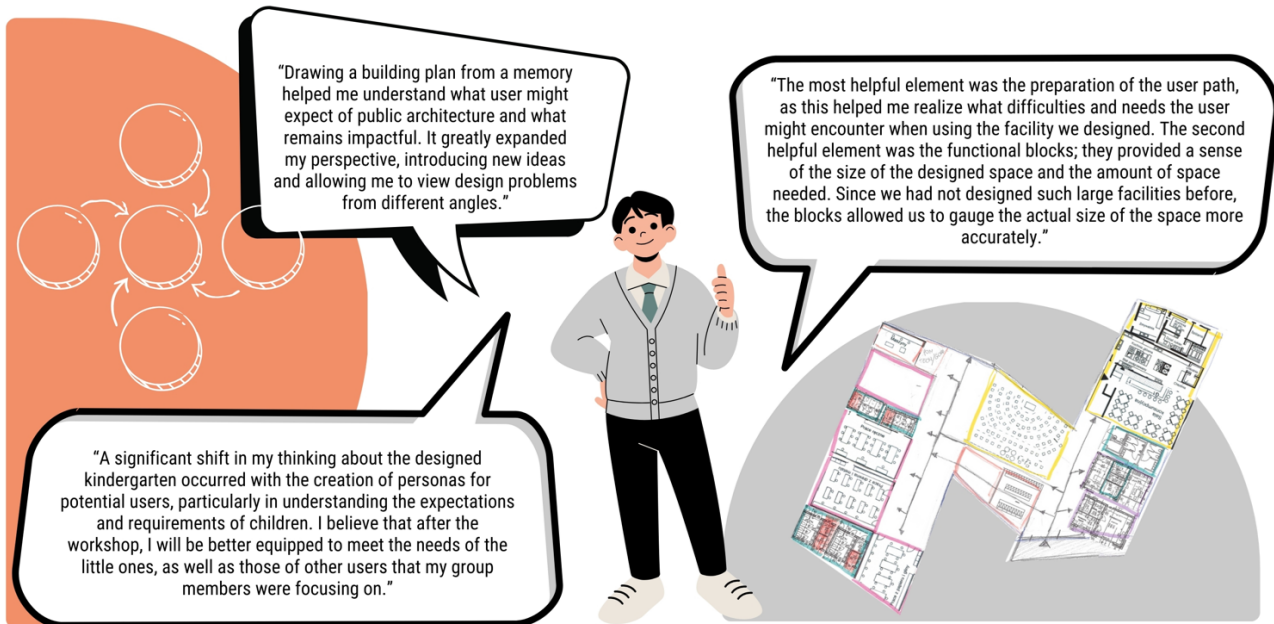


Figure 3: Feedback from selected workshop participants.

LIMITATIONS

Limitations of this study relate to a small sample size and a specific context that may impact the generalisability of the findings. Additionally, there is a potential for bias due to the influence of workshop topics on survey outcomes, as participants' exposure to UX methodologies during the workshops could have influenced their responses.

CONCLUSIONS

The study successfully achieved its objective of integrating UX design principles into architectural education. Through the utilisation of methodologies rooted in digital product development, students gained practical insight into user-centric design approaches within the architectural context. Students demonstrated a better understanding of user needs and experiences, as evidenced by their engagement with concepts, such as mental models, participatory design and user-centred principles.

The workshop sessions, which totalled ten hours, proved to be an effective means of imparting knowledge and experience related to UX-derived methodologies in architectural design, ultimately contributing to the improvement of design studio courses overall. Participants saw improvements in their work and the structured and creative environment increased participation and facilitated meaningful interactions between students. Feedback from participants demonstrates the high value of user-centred activities within the workshop. Each element of the workshop, from user path preparation to persona creation, not only equipped the participants with practical tools but also profoundly influenced their conceptual understanding of user needs in architectural contexts.

Despite the-above mentioned limitations, the insights lay the foundation for future research. Future studies should explore varied methodologies and extend the study duration with larger, diverse participant samples to further understand UX's role in design education and build on the initial findings.

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