Perception of a remodular sustainable building unit using in a university campus environment: A Questionnaire Survey

Ivana Halaszova[1*], and *Maria* Kozlovska[1]

[1] Technical University of Kosice, Faculty of Civil Engineering, Institute of Construction Technology, Economic and Management, Vysokoskolska 4, 042 00 Kosice, Slovakia

Abstract. Modular construction within the framework of sustainable building represents a significant step towards the creation of sustainable, environmental friendly, and economically efficient buildings and structures. Based on these principles, a hexagonal re-modular construction was developed at the Faculty of Civil Engineering in Košice, the testing of which will take place in the environment of the university campus. This contribution focuses on the perception of such units by their surroundings. The aim of the article is to analyze the perception of various variations of the modular unit (considering their purposes and material variation) from the perspective of potential users - university students. The method of questionnaire survey was employed to obtain results. The survey results serve as a basis for understanding the subjective perception of the unit in the environment for which it is designed.

1 Introduction

Modular construction represents an innovative approach to construction projects, allowing for the efficient utilization of standardized modules for the rapid and flexible creation of various structures and buildings. Generalova and col. [1] discuss two main levels in relation to modular construction. The first level involves the use of modularity in standardizing individual elements manufactured off-site (e.g., wall panels, floor panels, beams, etc.) with subsequent disassembly and installation on-site. The second, higher level of modular construction is defined by the utilization of 3D elements, called volumetric modules. This entails the use of spatial 3D modules made with built-in installations, fitted openings, complete surface finishing, necessary interior fittings, built-in furniture, and so on. Further studies [2-5] focusing on 3D volumetric modules emphasize many advantages of this approach to construction and provide specific examples of the system's utilization. Thai and col. [2] in 2020 termed modular construction a "revolutionary technology" and highlighted the main advantages of modularity in high-rise buildings, such as construction speed, safer production, reduced environmental impact, and better quality control. Besides the advantages, Subramanya and col. [4] also outline the limitations of such a construction system. The study summarizes the main limitations of the modular system and identifies five

* Corresponding author: ivana.halaszova@tuke.sk

main areas of challenges: transportation challenges, precision in planning, negative perception from the public and experts, establishment costs, and costs due to complexity and excessive coordination.

Another example from 2017 is a study introducing the concept of the "ClickHouse" module, designed for temporary emergency housing suitable for a 4 to 5-member family [6]. Another example is a project responding to climate change issues by creating floating modular hexagonal homes that adapt to rising water levels [7]. In response to the pandemic crisis from 2020 to 2021, the concept of a "green and portable modular building" emerged, capable of providing various configurations according to user needs [8]. Such a modular residential unit with zero energy consumption and a zero carbon footprint reflects an interest in a more sustainable approach to construction and mirrors the overall trend in construction aiming for minimal environmental impact.

The current approach to modularity primarily considers the use of modular constructions in the housing sector, but often lacks variability in constructions for potential application in other usage segments, such as public spaces. In response to this, a new concept of modular construction was developed at the Technical University of Košice (TUKE) – a remodular hexagonal unit characterized by high variability in floor plan solutions. One of the main advantages of remodular construction is the possibility of both constructional and material variability of wall panels, creating space for open (e.g., chillout zone, bus stop, etc.) or closed (social and hygienic facilities) modular constructions for use in both interiors and exteriors.

The article aims to analyze the potential of the newly created concept of the remodular unit, focused on a chill-out zone (CHoZ) located in the outdoor areas of the university campus. The analysis focuses on the perceptual experience of the CHoZ by respondents using the method of data zebra analysis through a questionnaire survey. The result of the analysis provides an overview of preferences for the use of the relaxation CHoZ located in the outdoor areas of the TUKE campus. The analysis results present material and volumetric preferences of users regarding the relaxation CHoZ, demonstrating the potential of the remodular unit for this purpose.

2 Methodology

The algorithm of the research methodology is presented in **Fig.1**. The entire process consisted of 5 main research steps, with a questionnaire survey used as the primary tool for data collection.

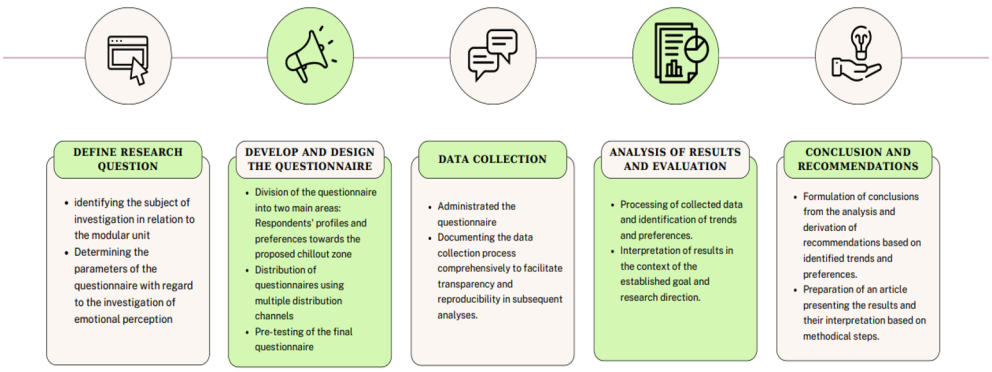

Fig. 1. Methodological steps of the research (Source: Authors).

The first step involved **defining research questions** to determine the goals and purposes of the analysis. The research aim was to gain an overview of respondents' preferences

regarding the design and placement of the remodular unit in the outdoor environment of the campus. The analysis focused on the remodular unit intended primarily as a relaxation CHoZ for students at the TUKE.

The questionnaire design focused on dividing questions regarding respondents' profiles and their preferences regarding the proposed CHoZ in relation to technical parameters and material preferences. Multiple distribution channels were used for **questionnaire developing** (QR code and hyperlink to the webpage, poster with a link to the printed questionnaire, direct engagement of respondents), through which the questionnaire was distributed among respondents in public spaces of the TUKE (university library, spaces of the Faculty of Civil Engineering, university café), as well as in the virtual space (social networks, official website of the Faculty of Civil Engineering, email). The Click4Survey internet platform [9] was utilized for questionnaire creation, offering simple and efficient online questionnaire and survey creation with various distribution options and the possibility of summary analysis after the questionnaire closure.

Data collection process involved administering the questionnaire by obtaining direct responses from respondents and also managing responses from distribution networks. It was also essential to ensure consistency and accuracy in the collected response data (eliminating the number of partially completed and unsent responses) throughout the real-time data collection process until its completion.

Data collection is completed followed by **data analysis and interpretation of results**. In depth analysis was conducted, including the identification of preferences regarding the constructional and material design of the modular CHoZ in the outdoor spaces of the university campus.

The conclusions and recommendations interpret the results of the analysis of respondents' perceptual preferences regarding the CHoZ based on spatial module perception. Based on the analysis results, recommendations and practical guidelines were formulated for further steps in the development of the remodular unit design and its implementation in practice.

The questionnaire was structured into 14 questions thematically divided into two sections, namely:

- Questions focused on respondent profiles (**Fig. 2**)
- Questions focused on material preferences, as well as preferences regarding the size and location of the CHoZ (**Fig. 3**)

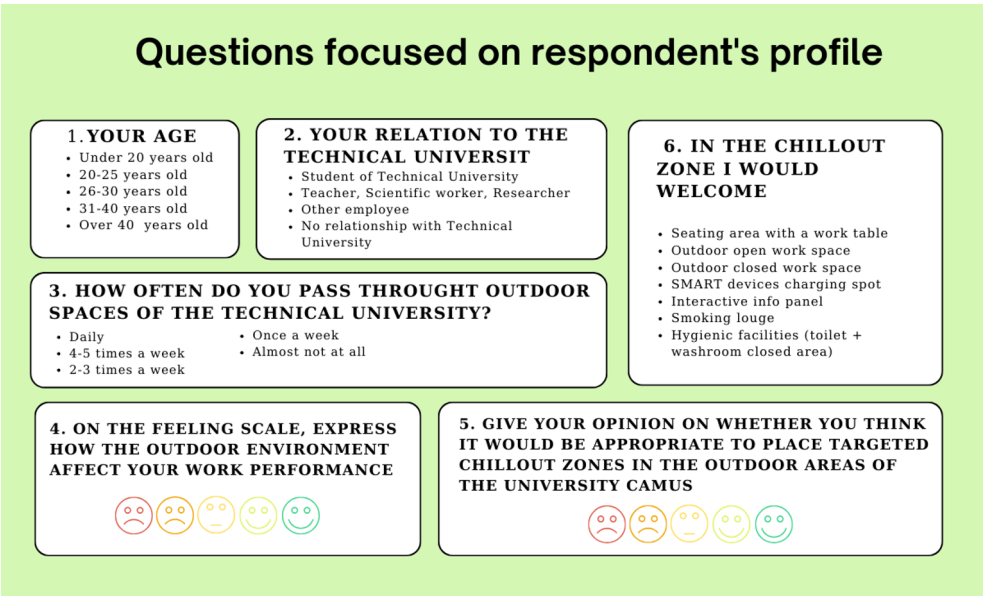

Fig. 2. Overview of questions aimed at respondents (Source: Authors).

The first part of the questionnaire consisted of five questions focused on respondents' profiles, specifically their age, affiliation with the TUKE, frequency of outdoor campus visits, as well as questions aimed at perceptual understanding of the need for establishing CHoZ in outdoor spaces and the impact of the outdoor environment on respondents' work performance. Gathering this data was a crucial step for subsequent analysis of interest in space utilization, as it provided important information about the preferences of the target group (especially students actively engaged in university environments).

The second set of questions consisted of nine questions (**Fig. 3**) focusing on:

- general perceptual understanding of the design of the remodular unit,
- preferred size of the CHoZ, ranging from single to triple-module designs,
- material preferences for individual building elements and structural solutions, and preferred placement of the CHoZ in campus spaces.

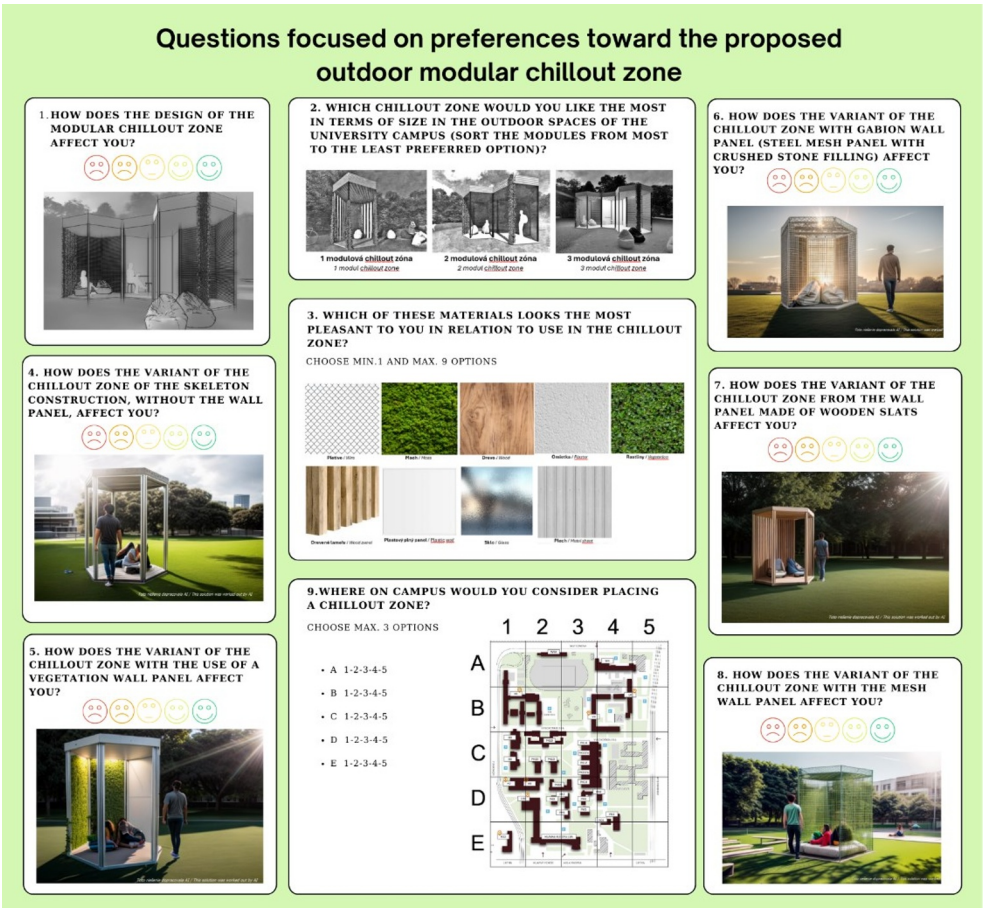

Fig. 3. Questions focused on the structural and material solution of the chillout zone in the campus premises (Source: Authors).

3 Results and discussion

Data collection was conducted over a period of two weeks during the ongoing semester of the academic year 2023/2024, when a high concentration of students was expected in the spaces of TUKE. A total of 209 respondents completed the questionnaire.

The platform used for creating the questionnaire survey also offered the possibility of final analysis of response collection. The analytical report from the platform reflected that the highest number of responses was recorded through the use of QR codes (this distribution channel was utilized by 78.4% of respondents). The average time spent by respondents completing the questionnaire was just under 5 minutes. The final analysis identified 19 responses that were irrelevant (started but unfinished) and therefore were not included in the final results analysis. In the next step, the analysis of relevant results, which comprised 190 responses, was conducted.

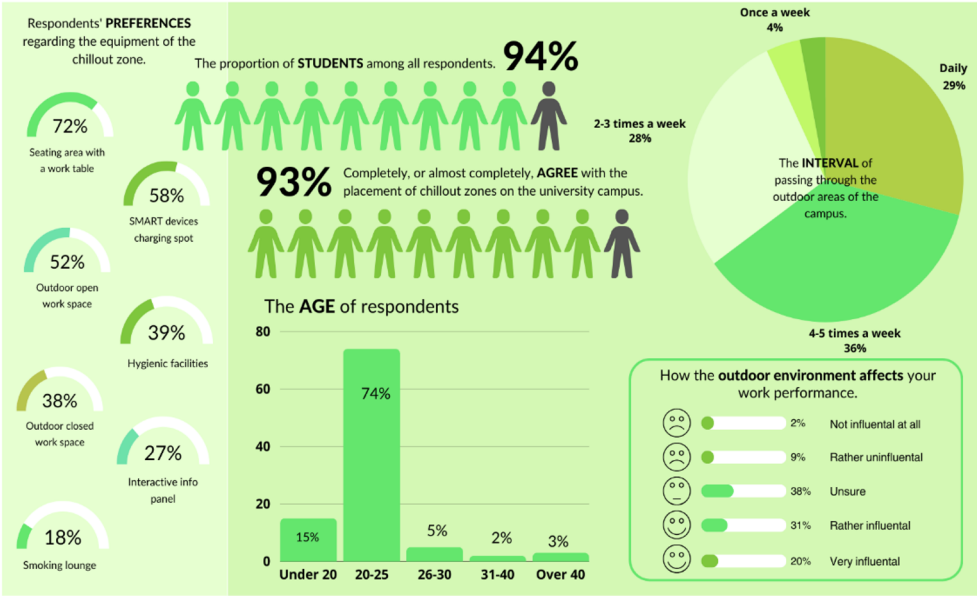

Fig. 4. Alanysis of data collection results focused on the profile of respondents (Source: Autors).

Results of the first set of questions (**Fig.4**) focused on the profile of respondents showed that the largest proportion of respondents were aged up to 25 years old (a total of 89.5% of respondents), while 10.5% of respondents were over 26 years old. It can be inferred that a significant number of respondents are assumed to be students affiliated with TUKE; only 5% of respondents indicated an age over 30 years old, suggesting a more professional relationship with TUKE for these individuals. The data revealed that the highest proportion of respondents were students of TUKE, as much as 94%, confirming the assumption about the number of students deduced based on the age profile of respondents. Since the questionnaire was also addressed to other academic personnel of TUKE, 4% of respondents were teachers and researchers, 1% represented other university staff, and the remaining 2% were respondents not affiliated with TUKE. Data on the number of students at TUKE from 2023 [10] indicate that the number of students participating in the survey (94%), 178 students, represents only 1.8% of the total of 9 714 current students studying at all nine faculties of the university.

Regarding the interval of usage of outdoor spaces of the university campus, it was found that 29% of respondents pass through the spaces daily, with the majority, up to 36%, traversing the campus 4-5 times a week. Additionally, 28% of respondents pass through the spaces 2-3 times a week, 4% pass through once a week, and 3% of respondents stated that they almost never traverse the outdoor spaces. The data indicate that more than half of the respondents (65%) traverse the outdoor spaces of TUKE at least 4 times a week, reflecting the length of the work week as well as the presence of students and staff at the university.

Regarding the question of how the outdoor environment affects their performance, only 20% of respondents expressed complete agreement, but 31% of respondents lean towards this agreement, together representing more than half of the respondents. However, there is a large group of respondents (up to 38%) who have a neutral stance on this question. Altogether, only 11% of respondents stated that the outdoor environment has little to no influence on their performance.

Concerning the question of whether it would be suitable to place targeted CHoZ in the outdoor spaces of the university campus, almost three-quarters (74%) of respondents fully agreed, to which an additional 19% of respondents also almost fully agreed. Only 7% of respondents remained neutral, and the remaining 1% indicated a preference against.

Regarding preferences for equipping the outdoor CHoZ, respondents had the option to choose from seven possibilities, and they could select multiple answers. Among the most preferred options, seating with a work desk (72%) was marked as the most favored. Options with over 50% preference included charging stations for SMART devices (58%) and an outdoor open workspace (52%). This was followed by the option of hygiene facilities (39%), an outdoor enclosed workspace (38%), and an interactive info panel (27%). Equipping the CHoZ with a smoking area was shown to be the least preferred option (18%), which, however, declares a relatively high percentage of smokers among students. From this, it can be inferred that, in terms of the purpose of the CHoZ, an open space equipped with a work desk and charging stations for SMART devices is preferred.

The second set of questions focused on gathering data regarding the perceptual perception of specific material and volumetric solutions, including determining preferences for the placement of the CHoZ in the outdoor spaces of the TUKE campus (**Fig. 5**).

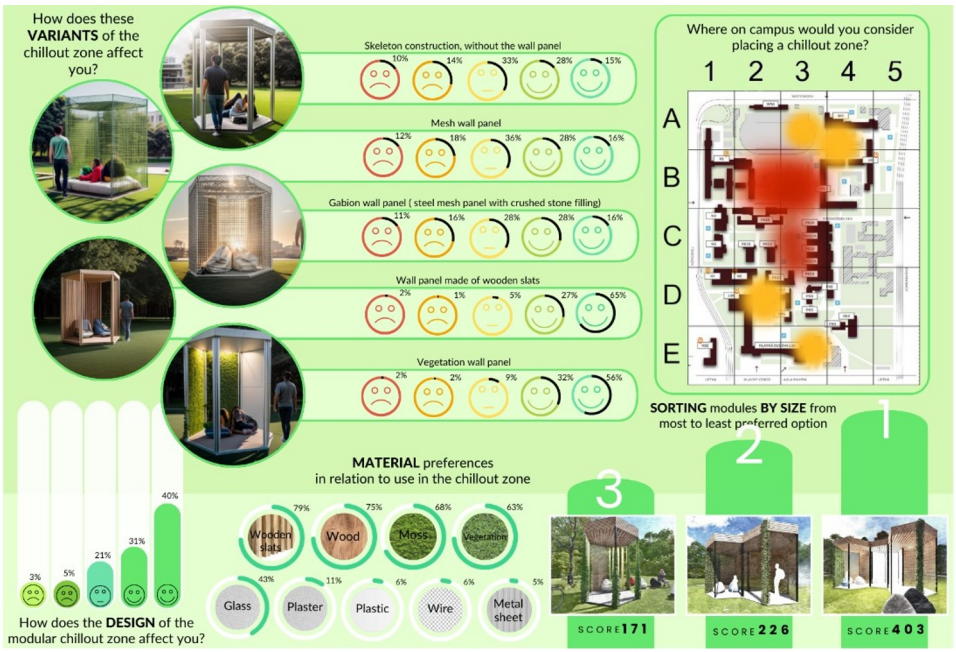

Fig. 5. Analysis of data collection results focused on respondents material and volume preferences, and preferences regarding the location of the chillout zone (Source: Authors).

The first question was aimed at assessing the perceptual perception of the unit's construction solution. Respondents were presented with a three-module unit with an exposed skeleton, and they rated on a perceptual scale how they perceived the design of the modular unit. 40% of respondents found the presented solution very appealing, and 31% of respondents approached this expression, constituting a large majority of those who liked this design. In contrast, only 8% of respondents belonged to the group that either did not like the solution at all or only slightly liked it. 21% expressed a neutral opinion, which is a relatively large group, but they may change their opinion if presented with a real prototype.

The questionnaire also analyzed preferences regarding the size of the CHoZ. In the questionnaire question, respondents were presented with 3 variations of the unit (single-module, double-module, and triple-module CHoZ). Respondents were tasked with ranking the various options from most to least preferred. According to the ranking, the triple-module CHoZ scored the highest with a score of 403, followed by the double-module CHoZ variant

(226), and the single-module CHoZ was least favored by respondents (171). It is evident that the largest CHoZ is clearly preferred, where multiple students could meet and work together on tasks.

Regarding material perception, respondents were offered 9 material solutions. Respondents expressed which of the given materials they found most pleasant for use in the CHoZ, with the option to choose a minimum of 1 and a maximum of 9 from the options provided. Respondents leaned towards natural materials, such as wood (75%), wooden lath wall paneling (79%), vegetation panels using sterilized moss (68%), and vegetation panels using plants (63%). Among the non-natural materials, glass (43%) was the most preferred, while materials like plaster (11%), wire mesh (6%), solid plastic panels (6%), and metal sheeting (5%) were significantly less preferred. The results clearly indicate that natural materials are preferred, confirming the previously mentioned preference for visually open CHoZ construction.

Part of the material perception was also a series of questions displaying variations of a single-module outdoor CHoZ using different wall panel material designs. The unit variations were created with the support of artificial intelligence, and respondents evaluated them on a perceptual scale. The results showed that as many as 92% of respondents clearly preferred CHoZ using wooden wall panels (65% and 27%) and vegetation wall panels up to 88% (56% and 32%). For the other variations, such as CHoZ using gabion wire mesh panels with stone filling, wire mesh wall panels, or empty skeletal constructions without wall cladding, respondents provided neutral to positive responses. Again, the dominance of natural materials was confirmed in this question.

The last question aimed to determine preferences regarding the placement of the relaxation zone on the university campus. Respondents were given the opportunity to mark locations on the attached map of the university campus divided into sections in rows (A-E) and columns (1-5). Respondents marked the most preferred locations as cell B3 (81%), representing the university baseball field, C2 (64%) and C3 (64%), with the same number of responses, representing public spaces on the university campus primarily used for student transit between university buildings. Another frequently marked location was cell D2 (57%), representing the space behind the main TUKE building, or cell E3 (50%), representing the vicinity of the central lecture hall building, Aula Maxima. The remaining cells received ratings from respondents below 50%, with the least marked cells being positions B2 (2%) and C5 (2%). Valuable insights were gained from this data, usable for placing CHoZ in campus spaces.

4 Conclusion

The aim of the article was to analyze the concept of a remodular construction created at the Faculty of Civil Engineering of the Technical University in Košice, utilized for the specific use. One of the possible variations offered by the hexagonal-shaped modular unit is its use for creating targeted chill-out zones (CHoZ) in the outdoor areas of the university campus. The goal of the analysis was to obtain information about preferences of its potential users regarding the use of the modular unit to analyze preferences in creating outdoor CHoZ in the university campus spaces.

The main tool for data collection was a questionnaire survey, created using the Click4Survey online platform. The questionnaire consisted of fourteen questions divided into two thematic sections. The first set of questions focused on the respondent's profile. The second section was focused on material and volumetric preferences, as well as preferences regarding the placement of the CHoZ. A total of 209 participants took part in the survey, of which 19 responses were incomplete. 190 responses were included in the final analysis, of

which the majority, up to 94%, were students of the Technical University of Košice (TUKE), representing 1.8% of all current TUKE students studying at the university's nine faculties.

From the results, it can be concluded that the majority of respondents were TUKE students aged up to 30 years, who use the outdoor spaces of the TUKE campus for transit at least 4 times a week. Up to 65% of respondents stated that they strongly agree or somewhat agree with the creation of CHoZ on the campus premises. In terms of CHoZ amenities, respondents predominantly favored seating area with a work table, outdoor open spaces for work, and places for charging SMART devices.

The results of the analysis of material and size preferences showed that respondents most liked the three-module CHoZ whichshows an interest that multiple students could meet and work together on tasks.

Respondents preferred natural materials such as wood and vegetation elements like plants and moss. Glass was also highly rated, confirming the demand for open space from previous questions. From the analysis of the placement of the CHoZ, it emerged that respondents prefer public spaces on the university campus, which they use daily to transit between university buildings, or places near the main building of TUKE.

The insights gained provide an important input for shaping the design and subsequent implementation of the modular unit in the event of using the module for the purpose of an outdoor relaxation zone on the university campus. The results presented in this publication will be utilized in the implementation of the modular construction, which will be the subject of upcoming activities.

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