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CONTEMPORARY SPATIAL PROBLEMS OF CAMPUS SPACES AND THE METHODS AND POTENTIAL OF THEIR ACTIVATION: BASED ON THE CASE OF THE CRACOW UNIVERSITY OF TECHNOLOGY CZYŻYNY CAMPUS

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Summary

As an academic city, Krakow has twenty-three tertiary education institutions located in different districts. The number of students living in Krakow can reach up to 130,000. Both of these statistics have varied over time, and the attempts to manage them in the past century do not meet current standards and cannot face upcoming challenges. The relationships with the external urban environment and other structures of the city are problematic since the areas between buildings are often neglected. There is an expectation that the universities will take the lead in formulating proposals for adaptation to climate change and at the same time will meet new social demands of the academic community. This paper presents a general overview of problems faced by university campuses on the example of the Czyżyny campus of the Cracow University of Technology. Using analytical methods associated with field research, the problems were identified and the potential of this area was outlined. Possible uses of the area were also proposed, based on the opportunities offered by the local heritage. Natural, social, and cultural aspects were considered. The analysis presented can be seen as a preliminary discussion of the potential of the areas directly adjacent to universities that set trends in proposed transitions, in accordance with, among others, the Green Deal. As well as seeking new solutions that combine strategic objectives, these areas are important from an educational point of view as they raise the environmental awareness of communities and younger generations, such as the students. Grassroots action that brings about real change is becoming increasingly urgent as it opens up the potential to harness the relationships between the city and campus, increasing their relevance as activation areas.

Keywords

climate change • campus • university • ecocampus • sustainable university campus

1. Introduction

Research indicates that urban areas and their inhabitants are exposed to several adverse effects of climate change.

The main role of decision-makers is to take care of ecosystems, reduce heat islands, preserve biodiversity, and provide access to green spaces as well as create human-friendly designs. A holistic design, taking into account both cultural and natural aspects, should be an overarching goal when implementing such transformations. The inclusivity of spaces and compositions that foster the creation of 'green' workplaces also deserves attention.

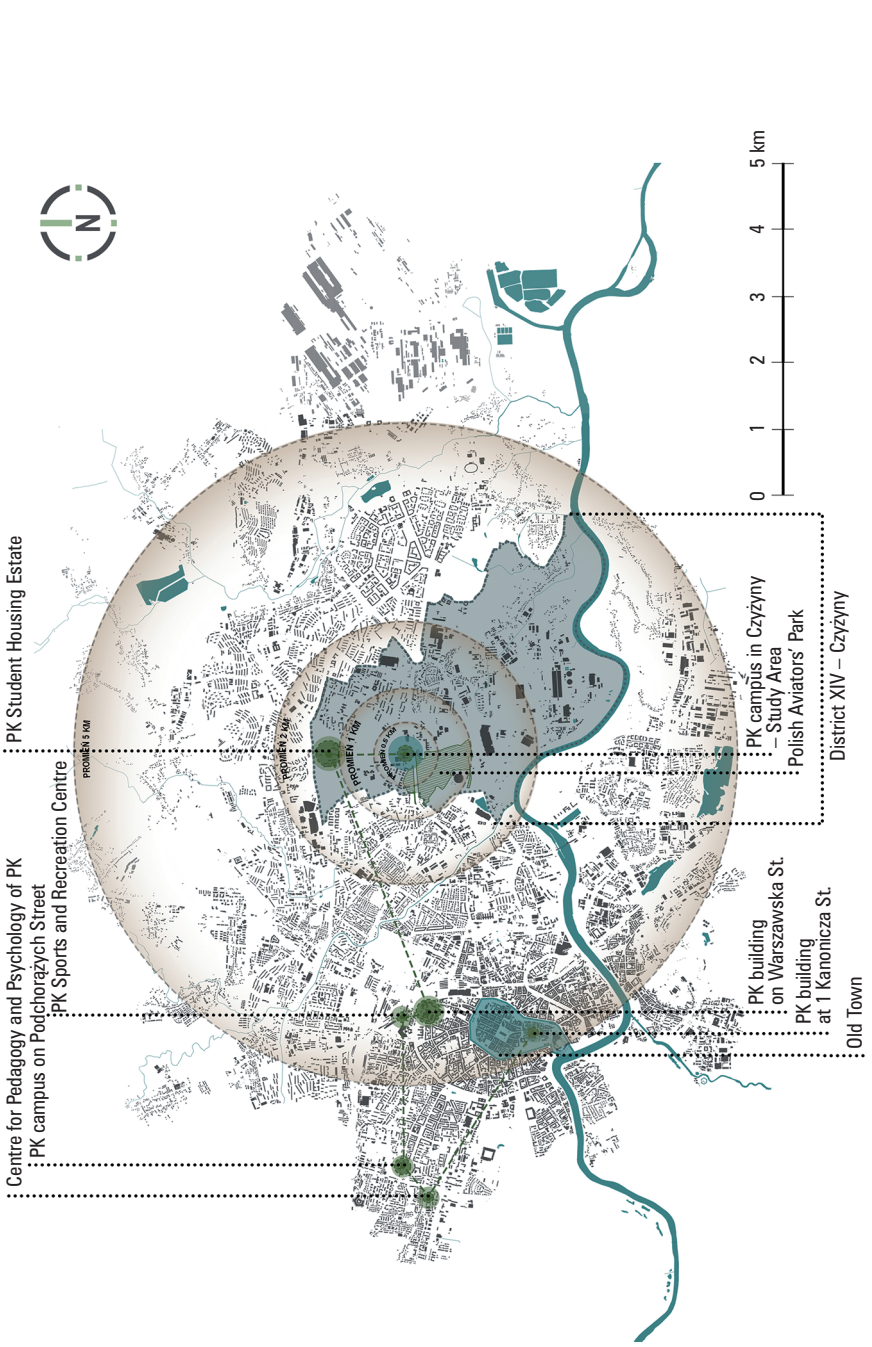
University campuses are strongly defined areas where a holistic approach to their design can bring back their social dimension. They can become generators of activity, testing grounds for implementing changes that follow new environmental solutions. There are 23 universities and colleges in Krakow that hold an important place in the life of the city. In addition to the obvious role of educating young people, they host research, facilitate the exchange of experiences, and serve as laboratory and experimental bases. Therefore, the main focus will be on identifying possible links between the university campus and urban and environmental activities, taking into account the multifunctionality of the space. The research will concentrate on the example of the Cracow University of Technology (PK) campus located in Czyżyny, which is one of the university's three primary locations.

2. Methodology and research area

The methods applied to analyse the area of campus in Czyżyny were supported by an analytical stage, which included in situ research, historical analysis, environmental analysis with site balance, valorisation, and SWOT analysis, as well as by a participatory stage with a survey of 136 respondents and an elaboration of the results. The final stage featured general design guidelines with concept elements. Stage one involved gathering data on the location, natural, topographical, climatic, and habitat conditions, as well as a greenery inventory with age stratigraphy, forest stand management, and communication analyses. The studies mentioned here were intended to bring the best possible understanding of the area's assigned function, resulting in the development of proposals for its adaptation while preserving historical, cultural, natural, and landscape values.

The focus was on the area surrounding the buildings of the Faculty of Mechanical Engineering on Jana Pawła II Avenue in Krakow. The total area of the surveyed site is 3.69 hectares. A large part of the area under study is occupied by a building – 0.75 hectares, located on parcels numbered 21/244; 21/275; 36/9, and 36/10 within the NH-6 precinct. Inside the study area, there is undeveloped greenery between the buildings. The area was analysed in the following categories:

- Study area = 3,69 ha
- Developed area = 0,75 ha
- Area of buildings' roofs = 8614,87 m^2
- Area of car parks and pavements = 1,4 ha
- Biologically active area = 1,5 ha
- Undeveloped area = 2,94 ha



Source: Authors' own study

Fig. 1. Diagram of the location of the site on the map of the city of Krakow

The site is located in the north-western part of Krakow's 14th district – Czyżyny. It is one of 5 locations of the Cracow University of Technology. The rest of the university's buildings are located to the west within a radius of over 5 km from the site. Close to the campus is the Polish Aviators' Park, which is connected with the history of the Rakowice Airport and the redoubt fort no. 15 'Pszorna'. The site is located in the southern part of Poland to the northeast of Krakow city centre.

The development of the analysed site was built in the 1980s. It is a landmark on the Krakow Route of Modernism [Wiśniewski 2020]. Previously, the area was a meadow. In the immediate vicinity is the Kraków – Rakowice – Czyżyny Airport, which was established in 1912 at the time when the aviation of the Austro-Hungarian Empire was growing. The current neighbouring complex with the aircraft hangars is listed in the register of historical monuments A-1106. In the inter-war period, Czyżyny was one of the poorest districts in Krakow. During World War II it was severely damaged, and after the war the so-called 'community housing' was built there. Since the 1970s, its development has been changing, with numerous new residential buildings, shops, and services [Kruszyńska and Wendel 2023].

3. Analytical research

Natural settings are important in the design of urban spaces as they have a direct impact on the quality of life of residents. Design should use natural resources in a sustainable way. The analysis of the campus area included: soil, climate, air and water quality, and the local ecosystem.

Data indicate that the analysed area is located on loess from the Quaternary period [Gardziński and Gardziński 2010]. A significant part of the district is covered by loess and alluvium – thanks to the close location of the Vistula River, which caused the accumulation of alluvial deposits. The relief of the study area is flat. The total difference in terrain ranges between 212.50 and 211.50 m above sea level – that is 1 m.

In Krakow, predominant are soils typical for oak-hornbeam habitats, which pass into water meadows in areas of depression. The study area belongs to the zone of anthropogenic soils, which are subject to transformation caused by frequent human activities. The area was once covered by sub-continental oak-hornbeam (*Tilio-Carpinetum*) [Matuszkiewicz 2008], whose typical soils are eutrophic, fresh and fertile. Before the 1970s the area was overgrown by meadows with arable fields. Today, the area is largely covered with bituminous paving, and the soil between the buildings is mixed with debris left over from the construction of buildings in the late 1970s and early 1980s. There is no surface water on or near the project site. The nearest reservoir, an ecological utility (the Dąbski Pond) [Gryboś 2023], is 1.2 km to the southwest, and the nearest watercourse (the Vistula River) is 1.5 km away. The site lies outside the flood risk area.

Both Krakow and the study area lie in the warm temperate climate zone [HVACR 2012]. The highest temperature recorded in the city was 38.8 degrees C and the lowest was –26.8 degrees C. The highest rainfall totals were recorded in June and May, and the lowest in December. Krakow's climate is one of the warmest in Poland, especially when

considering maximum temperatures. The average annual amount of actual sunshine is 1523.4 hours [Matuszko and Piotrowicz 2015]. Despite the increased emissions of dust and gases, Krakow ranks as an area of high air regeneration due to the abundance of greenery that exists within the analysed area and its surroundings. The location of the site in an area surrounded by greenery such as the Polish Aviators' Park is conducive to the creation of a local microclimate. It is characterised by slightly lower air temperature and less ventilation. The large area of greenery and natural overgrowth in the park has a positive influence on the local air movement, caused by the difference in temperature between planes covered with greenery and concrete, and on the degree of air humidity.

The study area is one of the areas where forest communities classified as sub-continental oak-hornbeam (*Tilio-Carpinetum*) once grew, which have high natural values. The forest stands in these habitats often consisted of lindens and hornbeams with some oaks [Matuszkiewicz 2008]. On the basis of data from the Local Spatial Information System, it was demonstrated that a significant amount of actual greenery that is located near the development are historic parks and gardens. One of these is the Polish Aviators' Park, which is a large enclave of vegetation – including fortress greenery. A large part of the area is also covered by natural scrub dominated by blackthorn.

Soil reaction tests

Soil pH measurement surveys were carried out throughout the study area. Their scope included the collection of three soil samples at different depths from each sector. The exception were sectors A and B, which combined two smaller sections due to the large surface area of the car park. The results clearly showed that the mean of each measurement was:

- Sector A and B (Parking): pH = 7,0 – neutral reaction,
- Sector C (Interior): pH = 7,5 – neutral reaction,
- Sector D (Interior): pH = 7,0 – neutral reaction,
- Sector E (Interior): pH=7,0 – neutral reaction.

When calculating the mean of all the results from the sectors, it is noticeable that the soil inside the study area is equal to pH = 7.0 indicating a neutral reaction. The reason for this result could be that the soil was mixed with rubble (probably after the construction of a nearby building). The entire study was carried out using helliga fluid. With the results, it is possible to select suitable plant species for the local habitat conditions.

Dendrological inventory

A dendrological inventory was carried out in August 2022. Its aim was to update the land survey and height map with existing trees and shrubs. Species were identified in detail, dendrometric parameters were determined (height, crown diameter, spatial arrangement of elliptical crowns, trunk circumference at 5 and 130 cm, shrub area), the

condition of the vegetation described, and comments and proposed recommendations for further maintenance management were added.

In order to make a detailed dendrological inventory, the study area was divided into 5 field sectors (A–E). A total of 269 specimens of trees, shrubs or groups of shrubs were inventoried.

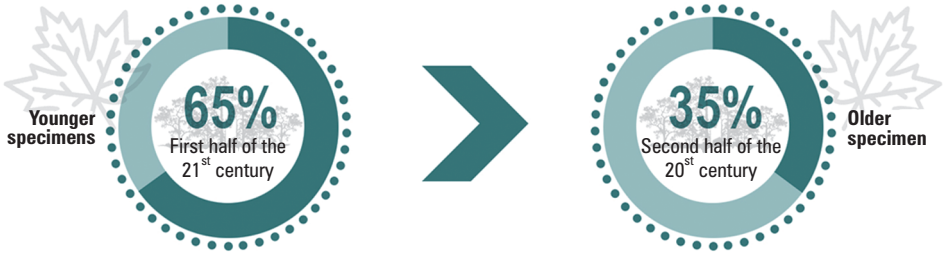
Stand stratigraphy

Stand stratigraphy is a method of studying changes in a tree stand. This involves carrying out surveys to determine the age and height of the trees in a particular location, as well as their structure, species composition, perimeter, and phytosanitary condition. Stand stratigraphy is particularly useful in the field of nature conservation and the design of public spaces, as it allows the assessment of the condition of greenery and the influence of environmental factors on its physical appearance. These studies help in planning and assessing the effects of climate change, as well as allow the prevention of damaging changes to the tree stand or avoid making poor decisions on greenery design.

Age stratigraphy was carried out based on the information compiled in the dendrological inventory table. Each item was carefully examined for age based on archival orthophotomaps. All greenery was divided into two categories:

1. Plants from the second half of the 20th century – 94 specimens.
2. Plants from the first half of the 21st century – 175 specimens.

The surveyed photographs clearly showed that the vast majority of the greenery belonged to the second category, i.e. it came from the first half of the 21st century.



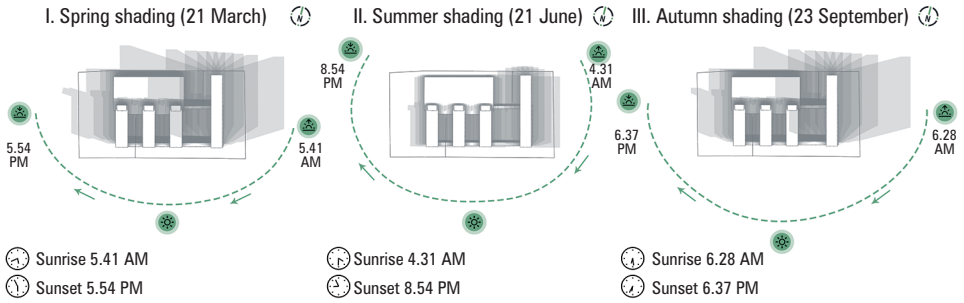
Source: Authors' own study

Fig. 2. Percentage age distribution of trees and shrubs

Shading analysis

Three shading analyses were made for three seasons based on the 3D model of the building: spring, summer, and autumn. Each was shown in the timeslot from 8 a.m. to 6 p.m. A significant difference was observed between spring and summer. It was found

that in spring the shaded position belongs to the north side of the building facade. In contrast, twilight affects the areas between the sectors of the pavilions. In the summer season, the shading remains in the same places, but is reduced. The shaded position on the north side is halved and much more light reaches the sectors. The analysis of autumn shading is in 90% similar to that of spring shading. The first two models are very important from the point of view of vegetation selection, as this is the time of an increased and vital growing season.



Source: Authors' own study

Fig. 3. Scheme of the shading analysis of the study area

Communication situation of the study area

The study site is located near one of the main roads, which are important for communication in the city. It is surrounded by Professor Michał Życzkowski Street and Jana Pawła II Avenue. The Avenue is a major transport route, connecting the city centre with the western parts of Krakow. The campus is not fenced.

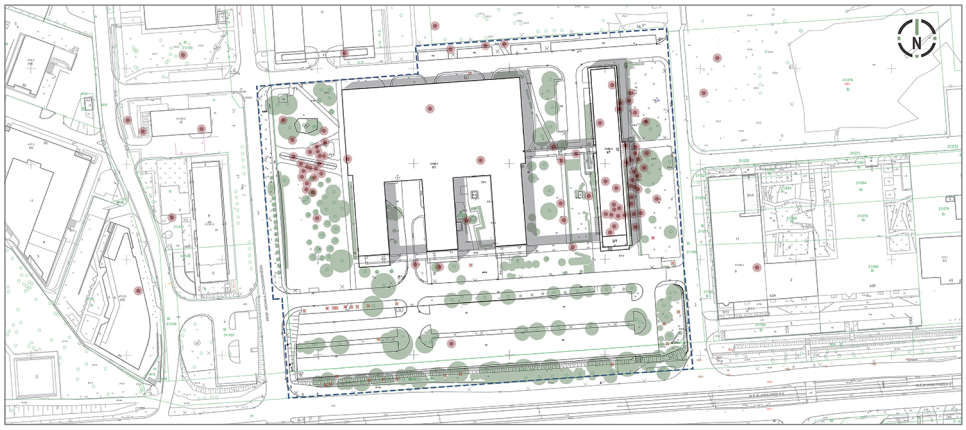
We can distinguish numerous paths and cycle routes in its vicinity. Their routes involve many shortcuts, which facilitate mobility and save time by, among others, students trying to get to the university. There are tram and bus routes along the Avenue with stops and 250 m and 500 m access isochrones. The closest are located just off the entrance road to the study area.

The nearby Polish Aviators' Park, adjacent to the Faculty of Mechanical Engineering, plays a very important role. The vast majority of people surveyed spend their time there among the greenery. One of the most important elements in the entire survey is the opinion on safety. Two places in particular were singled out as being the most dangerous. One is the road without a pedestrian crossing on the west side. It is inconvenient for people to access the campus from the west side. The second place is the green area on the north side outside the study site. Due to its great neglect, it is a gathering place for various social groups both during the day and at night. There is no lighting or walkways there.

Analysis and interpretation of key findings from social surveys

The identification of problems related to the shaping of the spatial structure of universities is understood as, among other things, an analysis of the challenges of making optimal use of the available educational space, planning the infrastructure, providing adequate conditions for learning and research, and creating a space that is conducive to social interaction and academic development [Wehle-Strzelecka 1985]. In social surveys, the focus was mainly on the function and appearance of the site. Questions were also asked about the safety of the surroundings and the lack of certain elements in their development. Respondents were asked where they stay during breaks and after classes, how often they visit the campus, how they rate its space, and what spaces are missing or too many. They were also asked to mark places where they meet and relax that need to be changed or new features added, and where they like to spend time surrounded by greenery both on and beyond the campus plan [Staniewska and Działek 2022].

The results clearly indicate that during the break between classes, students usually stay on campus or sometimes go home if there is a possibility. When classes are over, the vast majority go to their places of residence. If they stay at the university, they are most likely to spend their free time in the corridor, in the cafeteria or outside around the faculty.

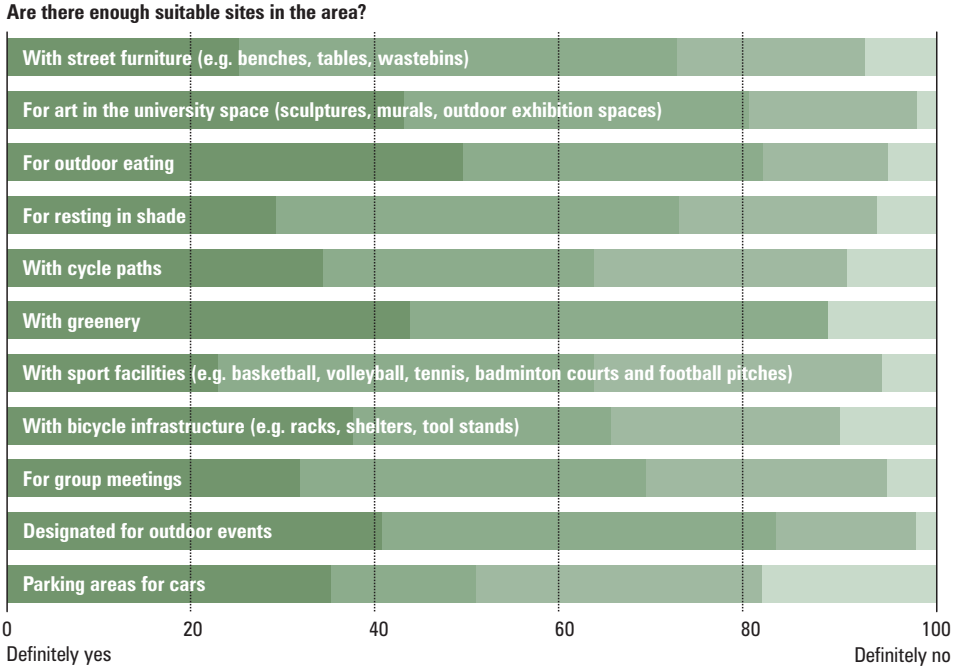


Source: Authors' own study

Fig. 4. Places where respondents are most likely to relax and seek peace and quiet

Assessing the quality of the space is an extremely important point in the study. When asking respondents about the appearance, the majority found the area unsightly. Overwhelmingly, respondents stressed that the area discussed is dull and monotonous. A very important and surprising fact is the information regarding the acoustics of the interior. A large proportion of students and staff stated that the area is optimally quiet. However, the other opinions should not be dismissed, as many people also responded that street noise is perceptible inside. With regard to the functioning of the space, respondents

considered it to be dead and not conducive to creativity. Despite the negative opinions, the majority of respondents find the space easy to navigate and are familiar with it. This fact underlines the connection between users and the study area. Respondents made it clear that they expressed a wish for changes in the surrounding space.



Source: Authors' own study

Fig. 5. Graphical overview of survey results

The social surveys revealed that there is a need to develop the space with the introduction of activation features that will let people make better use of the surrounding area. Respondents to the survey suggested adding facilities that allow eating in open spaces. Such measures will make the area more welcoming and provide opportunities for students to enjoy their time. The results also suggested that the introduction of new features will increase social integration among the academic community. In addition, the new spaces will serve as a platform for event management, meetings, and a variety of activities. All of these elements will help meet the needs of the local community and ensure that the public spaces are used in the right way.

Respondents were mostly highlighting leisure, outdoor recreation, and places to eat. The main objective would be to improve the quality of use and aesthetics of the site. An analysis of strengths, weaknesses, opportunities, and threats was carried out during the research. The most important factors influencing the state of the area were taken into

account. These made it possible to define a strategy for action, on the basis of which the site development plan was designed.

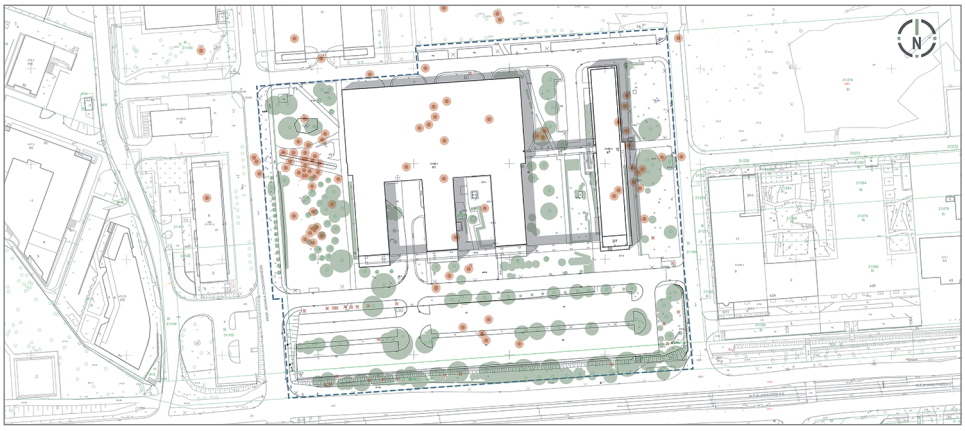


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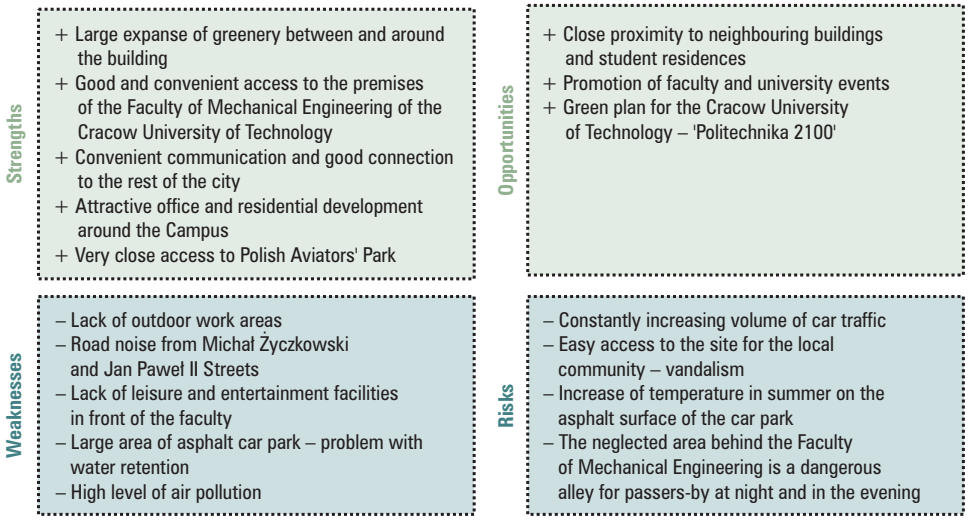
Fig. 6. Places that need to be changed/improved/added new functions



Source: Authors' own study

Fig. 7. SWOT analysis of the project area

Design guidelines are a set of principles and recommendations for the planning, design, and management of public spaces. They cover a range of issues such as conservation guidelines, ideational directions, standards of use, and methods of adaptation.

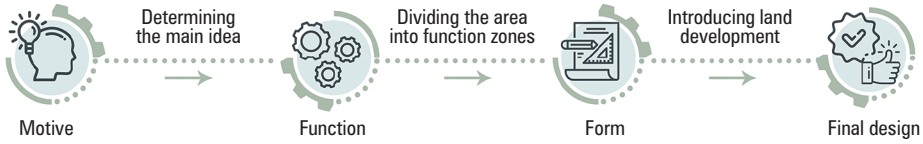
The designed space in question focuses on environmental qualities, function, exposure, and aesthetics.

In summary of the results, it was observed that in most cases the adaptation of the site allows it to be exposed and adapted to different purposes. In addition, the daily use is predominantly a walkway, which takes a few minutes or more, and users stay for a short time, usually no more than an hour. The conservation guidelines have considered creation, removal, conservation, and recomposition. In turn, the ideological orientations are set by subjectivism, utilitarianism, verismo, and didacticism.

4. Project propositions

The project aims to create a welcoming, safe, and comfortable environment for all users who access the area around the Mechanical Engineering Department. The project will cover various aspects, including the introduction of new infrastructure elements such as pavements, paths, and parking spaces. There are also plants to landscape the area with greenery, introduce new elements of street furniture and provide safe and friendly places for all users to rest and relax. All these designed elements will be installed in accordance with current standards and guidelines to ensure safety and convenience for all users. The design puts particular emphasis on harmony with the surrounding environment and optimal use of available resources.

The proposed lines of activation will involve describing the motif, and the function of the form and undertaking the development of the final design.



Source: Authors' own study

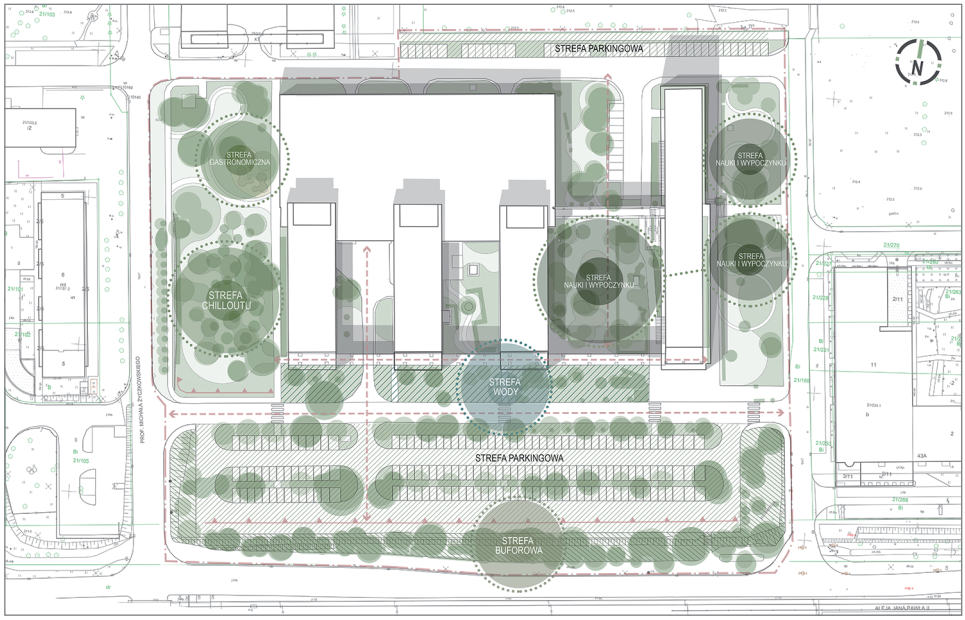
Fig. 8. Diagram showing the project development process

Functional zoning

By dividing the area into the car park zone and the zone between the buildings, the whole site is distinct and has different functions. The subdivision attempted to combine the two elements so that they form an integral whole by functioning realistically and interacting with the other zones. The following zones have been specified in the study site: catering, chillout, learning and leisure, water, parking, and buffer.

Several environmentally friendly solutions have been adopted in the design: an attempt has been made to solve the problem of excess rainwater, 80% of the pavement has been replaced with permeable surfaces, native species have been selected, the north wall has been covered with ivy and biodiversity-friendly elements have been intro-

duced into the space. Several new tree plantings have also been proposed to offset the urban heat islands.



Source: Authors' own study

Fig. 9. Functional diagram

Source: Authors' own study

Fig. 10. Green solutions scheme

Summary of aspects

The project addresses water-related aspects such as drought prevention, biodiversity enhancement, water storage, controlled nutrient accumulation, and efficient plant irrigation. These measures support sustainable water management, environmental protection, and resilience to climate change, promoting sustainable development.

Many key aspects were prioritised within the proposed site development elements. Safety, both for users and the environment, was a key focus, with an emphasis on minimising the risk of accidents and hazards. Functionality was achieved through the

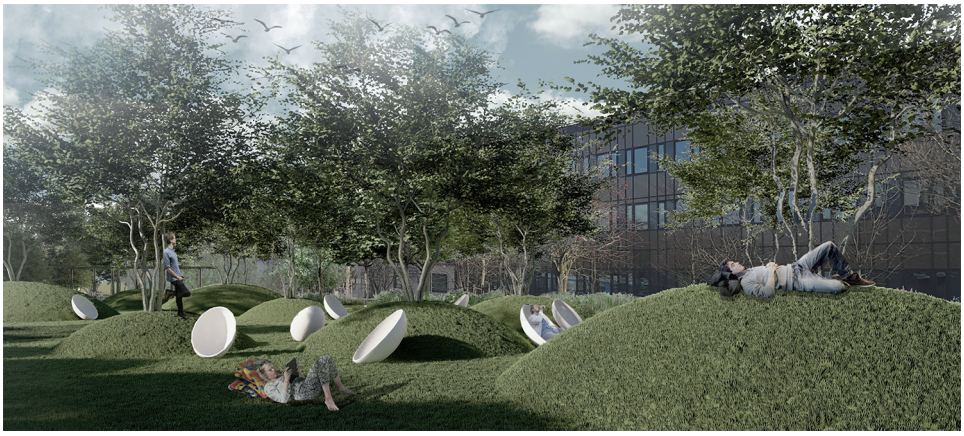
strategic positioning of the space, facilitating its use by different user groups. Design quality refers to the materials and techniques employed in the process, aiming for durability and aesthetics. The ecological approach takes into account the protection of the environment, including the optimal use of resources, the reduction of CO_2 emissions, and the preservation of the natural balance. Ultimately, the comfort associated with ergonomics provides convenience and facilitates the use of the space. These elements create a coherent and sustainable solution for users and the environment.

Source: Authors' own study

Fig. 11. Aspects of the proposed rain garden

Source: Authors' own study

Fig. 12. Aspects of the proposed parking canopy



Source: Authors' own study

Fig. 13. Visualisation of the chillout zone

Source: Authors' own study

Fig. 14. Visualization of a rain garden next to the main building of the Faculty of Mechanical Engineering at PK in Czyżyny

5. Conclusions

The grounds of the Faculty of Mechanical Engineering of the Cracow University of Technology are an extremely important place for the academic community that is open to residents. At present, it is neglected, without function and unadapted to modern user needs. The untapped potential is greenery, which has a positive impact on quality, aesthetics, and the environment. Recommendations include the use of different types of materials, and native species, taking measures to offset the problems of modern cities, e.g. water storage. They make the space more environmentally relevant. The introduction of pro-ecological solutions is appearing more and more frequently not only in university strategies, but also in implementations. This is the right direction to position universities as leaders in environmental solutions.

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