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OPTIMISATION OF SPACES DESIGNATED FOR LEARNING IN PUBLIC SECONDARY SCHOOLS WITH THE VIEW OF BEHAVIOURAL ASPECTS, ON THE EXAMPLE OF THE ACADEMIC SECONDARY SCHOOL OF THE SILESIAN UNIVERSITY OF TECHNOLOGY IN GLIWICE

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Abstract
The subject of this paper is an attempt to answer the question – how to properly shape learning spaces in public secondary schools from a behavioural perspective? The overarching aim of the study is to show the process of creating design guidelines related to shaping a built environment such as an educational space for young people. A process that should be carried out with the active participation of those using this space.
The aim of the work carried out was to analyse the quality of the built environment, which in this case is the space of a public secondary school – Academic High School in Gliwice, against the background of the actual, real needs and requirements of all user groups of this educational institution. The analyses carried out were primarily focused on the behavioural quality of the space of the school facility.
The expected end result of the analyses and research was the formulation of guidelines, suggestions, which will contribute to the optimisation of the quality of the space belonging to the student work and study zone of the Academic High School.

Keywords: **Behavioural quality; Quality of secondary school building space; Qualitative research; Secondary school user needs.**

1. INTRODUCTION AND STATE OF RESEARCH

Recent developments in sciences such as environmental sociology and psychology have proven that the physical environment is in close relation to human behaviour. How persons conduct themselves is determined by the surroundings of certain boundaries. One scientific theory is the actor-network theory ANT [1], which assumes the causality of non-human factors in social interactions. Environments, objects, cultural assumptions etc. act on each other and influence relationships and social interactions. Thus, by shaping the designed and built environment appropriately, we may influence the behaviour of its users [2]. When creating environmental conditions, the direct impact of their characteristics should be taken into consideration.

Therefore, we can assume that the quality of the built

environment and its various aspects directly impact the well-being of users. Not only does it affect well-being and mental health, but it also influences learning and work efficiency, a sense of security, and social interactions. A well-designed environment, its space, the way it is organised, shaped, and high-quality usability, significantly influence the comfort of work and learning and provide ample development opportunities. Properly organised space can promote a reduction in stress levels, enhancing creativity, and improving logical thinking [3].

Research on the relationship between the quality of the built environment and human needs was initiated in the second half of the 20th century by American researchers, carried out intensively at the beginning of the 21st century, particularly related to the streams of sociology and environmental psychology [3, 4, 5]. Research has developed in many directions, including neuroscience investigating the level of satisfaction of being in an appropriately decorated and aesthetically pleasing built environment. In Poland, this issue is being tackled by specialists from various scientific fields; authorities include Prof. Augustyn Bańka, a psychologist who is developing this topic in cooperation with architects [6], Prof. Maria Lewicka, also a psychologist, Prof. Lucyna Frąckiewicz, a specialist in social policy, and architects Prof. Krzysztof Lenartowicz, Prof. Elżbieta Niezabitowska [7] and Prof. Andrzej Niezabitowski.

While qualitative research initially focused only on identifying the technical quality of a building, over time the need to include other quality criteria related to occupant comfort, building management, economic issues, ecology was recognised. One of the first comprehensive, detailed methods of investigating the quality of a building, taking into account the behavioural needs of users, is the POE method developed and published by researchers: Preiser W., Rabinowitz H., White E.: P*ost-Occupancy Evaluation* (1988), and *Building Evaluation* (1989). Qualitative research has been conducted at the Faculty of Architecture at the Silesian University of Technology since the 1990s under the name "Silesian School of Qualitative Research" [8]. They concern the study of the quality of facilities with different functions, including educational buildings [9].

Educational objects are one of the most significant spaces, where the impact of the built environment on its users is particularly visible. Consequently, to properly define the built environment such as a school building, and to improve its functioning quality, suggestions for specific changes should be based on analyses and qualitative research. The results of these analyses and research will serve as a real source of information about the requirements set for school objects.

The presented study outlines the course of research and didactic activities conducted as part of the first edition of the PBL project (project-based learning) with students of secondary schools within *the Excellence Initiative Research University Project* at the Silesian University of Technology in Gliwice. This project was carried out in the summer semester of 2023 with the participation of students from the Academic Secondary School of the Silesian University of Technology, in collaboration with students from the Faculty of Architecture of the Silesian University of Technology. The topic addressed in this project was the optimisation of spaces designated for learning in public secondary schools with the view of behavioural aspects.

2. THE STUDY OBJECTIVE AND SCOPE

2.1. Aim of the study

The space of the public school – Academic Secondary School, located in Gliwice, at 10 Marcin Strzoda Street, was adopted as the research field for the analysis and research. The main objective of the project was to identify, investigate the behavioural quality of the built environment, which is the space of a public secondary school, against the actual, real needs and requirements of the different user groups of this facility, in order to improve its functioning. The expected end results of the research, in the form of guidelines, serve to increase the quality, improve the functioning of the spaces of this educational facility and are helpful in optimising the learning spaces, in behavioural terms.

Research on behavioural quality, i.e. on the personal, individual requirements of users in relation to a building, is challenging to carry out as they rely on elements based on subjective assessments. Evaluation of this quality encompasses aspects such as comfort, satisfaction, and enjoyment derived from being in a building, as well as matters related to the aesthetics of both interior and exterior spaces and their impact on the mood, psyche, and health of users [10]. Elements of behavioural quality also include privacy, territoriality, wayfinding [11], clear visual or auditory information, and a sense of security. Aspects of the internal environment, such as microclimate, are also considered, including:

– indoor air quality;

– temperature conditions inside the building;

– lighting with natural and artificial light;
– acoustic conditions (noise).

Issues related to behavioural quality can be considered from one perspective as the influence of the environment, individual zones, and spaces on the user's well-being; and from another perspective as the user's reactions to the conditions prevailing in the facility, such as microclimate (thermal changes, odours, varied auditory, audio, and tactile sensations).

Assessing this quality requires very close collaboration with users of a particular institution, as they are the ones best acquainted with the problems and deficiencies in their environment. They can provide valuable information and are experts in matters concerning the quality of the spaces they use. The most suitable research techniques applied in this case are surveys and direct contacts, conversations, and discussions conducted according to a previously prepared list of questions and issues.

The conducted analyses were focused on the behavioural quality of the facility's space and included [12]:

- Level of satisfaction regarding users' psychological needs, such as privacy, spatial gradation, "wayfinding" – finding the way to the destination – visual information.
- Aesthetics of the interior and exterior spaces.
- User's response to space (microclimate): thermal changes, odours, lighting, varied auditory, audio, and tactile sensations.
- The impact of the environment and individual spaces on the well-being, mood, psyche, and health of students.
- User's sense of comfort — ergonomic solutions.
- Sense of security, accessibility of individual spaces, and school zones.
- Contact with nature, greenery.

An important element of the conducted analyses was the assessment of the level of satisfaction of all users (pupils and staff) and the formulation of behavioural requirements for a built environment that is user-friendly for individual users (learner):

- Identification of all user groups within the educational institution.
- Clear determination of the needs and requirements of individual user groups regarding the school building.
- Formulation of the most appropriate and optimal working and learning conditions in the facility.
- Creation of a proper image and suitable aesthetics in various spaces for the users of the facility.
- Establishment of high comfort for using a particular space (privacy, territoriality, concentration, well-being).

2.2. Methods used in the research

When conducting the research, the following research methods were applied:

- Literature analysis of the subject and the problem.
- Analysis of available documents, architectural and construction documentation of the school.
- Photographic documentation of the building/ Building inventory (photogrammetric camera).
- Inspection and observation of the researched space.
- Inventory of equipment, devices, and furnishings in various zones of the facility.
- Focus interview with the first users of the building, after it was put into use following the renovation works.
- Survey research conducted among current users.
- Interviews and conversations with the school head teacher, teachers, students, and technical staff of the institution.

The research had the specific purpose of conducting the quality and behavioural assessment of the facility. Therefore, it was proceeded in a precise, systematic, and controlled manner. Moreover, it was carried out using well-defined organising tools that had been prepared in advance, including:

– targeted lists of the most important categories of the facility's functioning efficiency,
– original survey forms taking into account the needs of all user groups,
– a list of focus questions addressed to previous and current users – employees and pupils of the institution.

Under the supervision of staff from the Faculty of Architecture of the Silesian University of Technology, students from the school in question were involved in the research work. A specific range of research tasks was defined for them:

- Conducting analyses of scientific literature, design norms, and legal acts related to the designated research problem.
- Creating a list of quality categories for the Academic Secondary School of the Silesian University of Technology in Gliwice, focusing on

behavioural quality: systematically and effectively gathering data (list of the most important categories of functioning efficiency of the facility).
- Developing surveys considering the needs of all user groups.
- Preparing a list of questions addressed to the pupils and staff.
- Evaluating specific zones and spaces of the school.

The conducted activities allowed the students to become familiar with various aspects of analytical and research work, including:
- Identifying flaws and inadequacies that need to be addressed or compensated in the school space.
- Formulating suggestions for improving the quality of the facility's functioning.
- Identifying potential opportunities to enhance the behavioural quality of the school facility.

The participants took part in the research eagerly, utilising diversed research tools such as a photogrammetric camera and Virtual Reality (VR) goggles. They then analysed the results and described their outcomes. The students' activities were carried out in collaboration with students from the Faculty of Architecture of the Silesian University of Technology (consultations at the Faculty of Architecture), allowing young researchers to become familiar with the work environment, and the educational format at the university, and facilitating social networking. Such activities enabled pupils and students to acquire practical skills necessary for analytical and research work, as well as develop abilities for individual and teamwork. The comprehensive actions proposed in the project introduce secondary school pupils to the basics of planning and conducting scientific research, familiarise them with professional terminology, and enable them to present results during various scientific events (e.g., conferences as part of the ID-UB initiative, the Night of Scientists at the Silesian University of Technology).

2.3. Expected research results

- Anticipated results and benefits from the conducted research, which contribute to the optimisation of the quality of spaces within the student's working and learning areas, are as follow:
- Acquiring comprehensive information on the actual state of the school facility.
- Understanding the opinions of all user groups about the existing built environment, which is the school facility.
- Identifying flaws and inadequacies that need to be addressed or compensated.
- Creating an information base – guidelines for improving the standard of utilising the school facilities.
- Developing solutions helpful in adapting the facility to the real needs of users.

The conclusions contribute to defining modern standards of behavioural quality in learning and recreation spaces for students. Adapting the existing school-built environment to the needs of young people is to create a more friendly, safe, and aesthetic environment, providing conditions for efficient work and learning. The new, improved space shall promote a reduction in stress levels, enhance creativity, and logical thinking among the students.

3. ANALYSIS AND RESEARCH

3.1. Literature research

The initial actions involved conducting analyses of national and international publications, as well as information presented on various websites. To design school facilities well, knowledge from various scientific disciplines including environmental psychology, sociology, pedagogy, and ergonomics is required. Architects should be aware of the complexity of issues crucial in designing educational facilities. Such institutions should be built to the highest standards, from functional quality to technical quality, to highly significant behavioural quality. All behavioural quality elements must be considered when designing the built environment. The available literature on the subject, especially in the field of environmental psychology, items on qualitative architectural research and research on the quality of the built environment were therefore analysed. The standards and technical requirements to which educational facilities are subject were analysed. On the basis of this data, it was possible to formulate the characteristics of the educational space, to construct lists of expert evaluation criteria and survey forms.

Educational facilities are designed not only with consideration to the needs of the educational process itself but also to the needs and expectations of users of that space. It is crucial to recognise that humans are biological organisms with specific, diverse needs, not only physiological ones. Therefore, meeting expectations related to a sense of security and self-realisation must be factored in when designing an educational facility.

Educational institutions have long been associated with a closed architectural form, buildings with artificial lighting, and rigidly separated rooms. They are often believed not to engage students and not to encourage independent thinking. It is also challenging to speak about teachers' approaches to students. However, these trends are changing, both from an administrative perspective and in terms of modern thinking about educational spaces.

According to the research conducted jointly by the University of Salford in Manchester and architects from the Nightingale Associates design office [13], the performance of an average student in a well-designed school environment can increase by 25%. General attitudes toward learning and the ability to focus on assigned tasks are largely the result of analysed factors in the study, such as orientation, flexibility, layout, colour, access to light, noise, temperature, and air quality. The results of the above-mentioned study should be a compelling consideration as to the shape and functioning of modern schools.

3.2. Reference object research – case studies

For the purpose of this study, to acquire knowledge of the proper design of modern educational facilities, objects with similar functions and purposes were analysed. The research field for the analysis consisted of 5 educational facilities located and operating both in Poland and around the world:

- Akademia High School located in Warsaw;
- The School on Islands Brygge located in Copenhagen;
- Tran Duy Hung Secondary School located in Vietnam;
- Lyceum located in Chongzuo, China;
- Vocational and Technical School – CFA located in Mont-de-Marsan, France.

The analyses were conducted based on the following criteria:

- location,
- completion date,
- building area,
- ecological and energy-efficient solutions,
- unique technical and functional solutions.

The examples were presented in tabular form, which organises and facilitates the conducted analyses. The table below illustrates the approach to conducting a case study.

Table 1.
Examples of reference object analyses based on the complex of Akademeia High School in Warsaw

Object	Akademeia High School
Location	Polska, Warszawa
Designer	Medusa Group
Implementation	2017
Area	4 198 m^2
Description	A horseshoe-shaped building with a green courtyard and a large outdoor stand. The layout of the rooms allows for individual educational strategies and the learning process resembles that at universities. "Most of the classes are conducted according to the American Herakness method, whereby students do not sit in desks, but work together with the educator at an oval table". – words of deputy headmaster of the school Marcin Szala. Pupils work in an oval table system, teachers have no staff room, and permanently remain part of a compact educational ecosystem. This was the basis for the overall idea of creating a lifestyle atmosphere that encourages people to stay in school after school hours. The space in the middle of the school playground is ordered by a huge grandstand. A universal element, a meeting place to inspire students and teachers for unusual P.E., geography, biology or literature classes. The canteen is more like a restaurant than a traditional school canteen. It is a transfer of the modern living-room into the school. The venue is not only open at lunchtime, but is constantly changing its functions, from canteen to cafeteria with a reading room and live art studio. On the roof, there is a garden used for classes in biology, but also physics, astronomy or geography. During the summer season, beehives can be set up there or herbs can be grown for use in the school canteen. The hallway resembles no school corridors at all, but rather a scaly wooden hollow. The halls traditionally have chairs, but also multifunctional stands. When designing this venue, the architects were looking for ambiguous, multifunctional and inspiring spaces.
Source	https://www.archdaily.com/889061/akademeia-high-school-in-warsaw-medusagroup-studio

Own work

3.3. Own research

The second source of information gathered in the study was own research involving the analysis of available documents, architectural and construction documentation of the Academic Secondary School [ALO PS] facility, inspection, and observation of the researched space, building inventory (photogrammetric camera), as well as survey research and interviews conducted among the users of the facility.

Description of the Facility

The building of the Academic Secondary School is located in Gliwice, on the corner of Wrocławska and M. Strzoda streets. The history of this building dates back to the 19th century when it served as an inn with accommodation and a stable, due to the close proximity of the square known as the horse market. In 1900, the building underwent reconstruction, being transformed into an entertainment hall, a restaurant, and a gallery. The hotel and its cultural function continued uninterrupted until the 1940s. After the war, the building was handed over to the newly established Silesian University of Technology. The Student Cultural House operated here, and in 1958, the

Figure 1.
View of the building from the intersection of Wrocławska Street and M. Strzoda Street

Figure 2.
View of the building from the Wrocławska Street

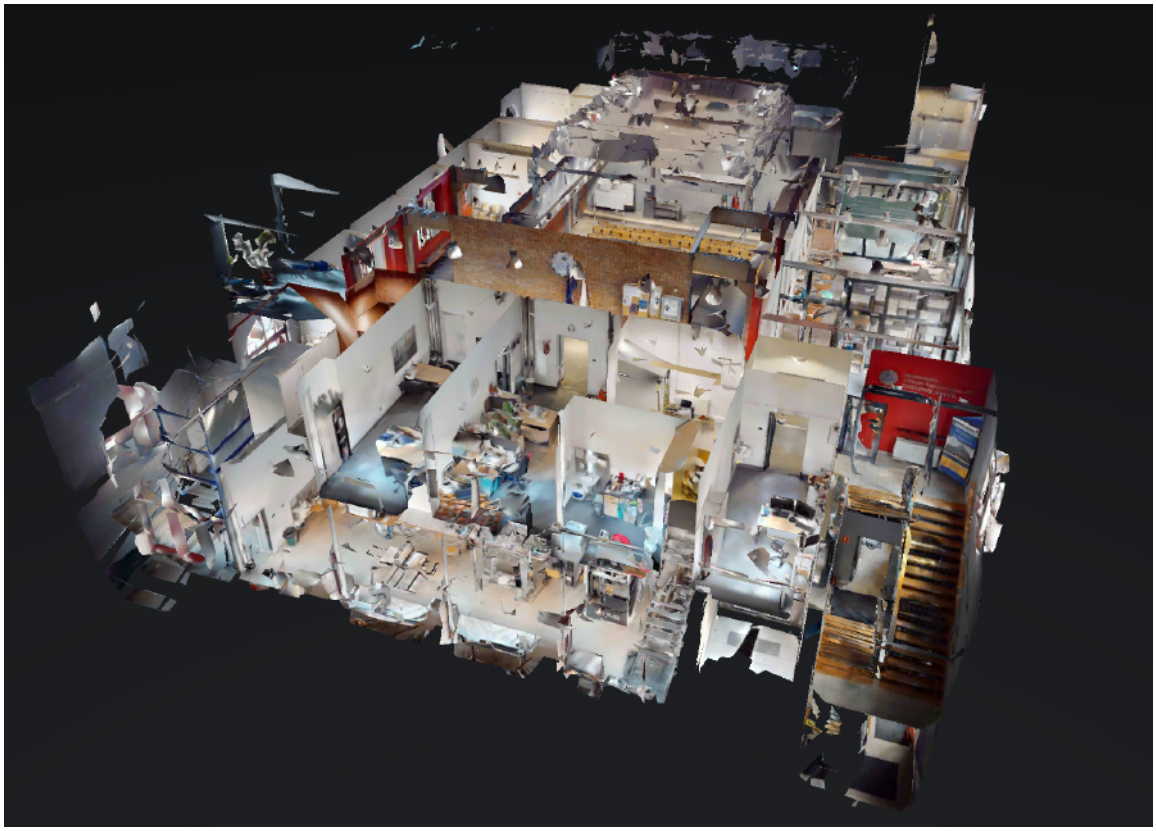


Figure 3.
3D model of the school building in Gliwice – view from M. Strzoda Street (Own work)

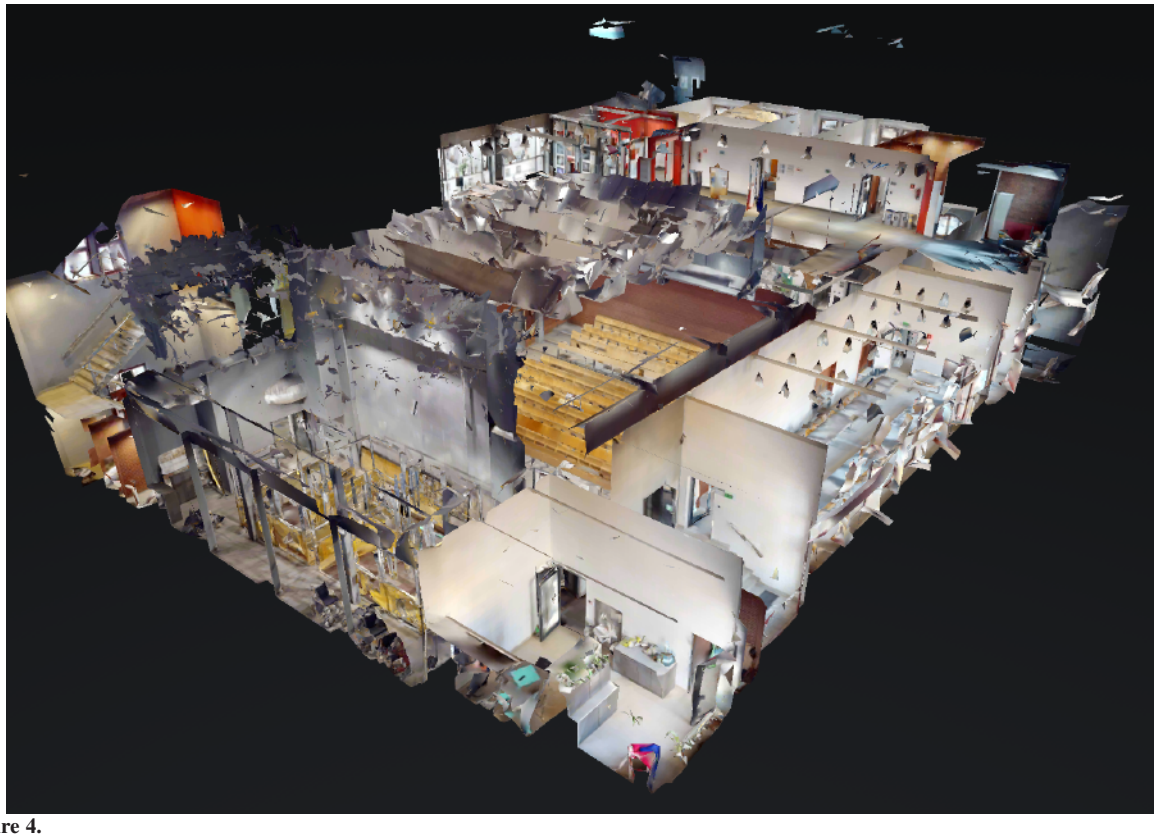


Figure 4.
3D model of the school building in Gliwice – view from Wrocławska Street (Own work)

Cinema-Theater X designed by professor Tadeusz Teodorowicz Todorowski, was opened. The cinema hall could accommodate 400 viewers, and a small technical backstage and dressing rooms were also established for a theatrical stage. The Discussion Film Club had its seat here, and various cultural events, concerts, and theatrical premieres were held, bringing together the student cultural movement [14].

In 2009, the Cinema-Theater building was decommissioned due to its very poor technical condition. In 2010-2011, the building was renovated and partially superstructed with a change of use. The building was adapted for use as lecture theatres, art studios and offices and was handed over to the Faculty of Architecture at the Silesian University of Technology for teaching students of Architecture and Interior Design. In 2018, a part of the facility was transferred into Academic Secondary School. There are currently two units operating in the building: the Faculty of Architecture (on part of the basement and ground floor) and the Academic Secondary School (upper floors).

Research of the existing state – inventory

To obtain actual parameters and dimensions of the school facility and compare them with existing technical documentation, measurements were conducted using modern surveying techniques with the aid of an advanced research tool – the photogrammetric camera (Matterport PRO2). The measurement standard employed allowed the project participants to capture a 3D space and transform it into a digital twin model (Fig. 3, 4).

The interactive model facilitated the creation of a virtual walkthrough, enabling a digital analysis of the building structure and the spaces of selected functional zones of the building (Fig. 9, 10). Based on the captured images, precise measurements of the object's geometry were taken (reality was reflected with an accuracy of 1%). The digital inventory facilitated the selection of areas with adaptive and design potential, particularly in shared areas such as corridors, the entrance hall, and wall niches, as shown below.

Functional layout in existence

The existing functional layout of the school building

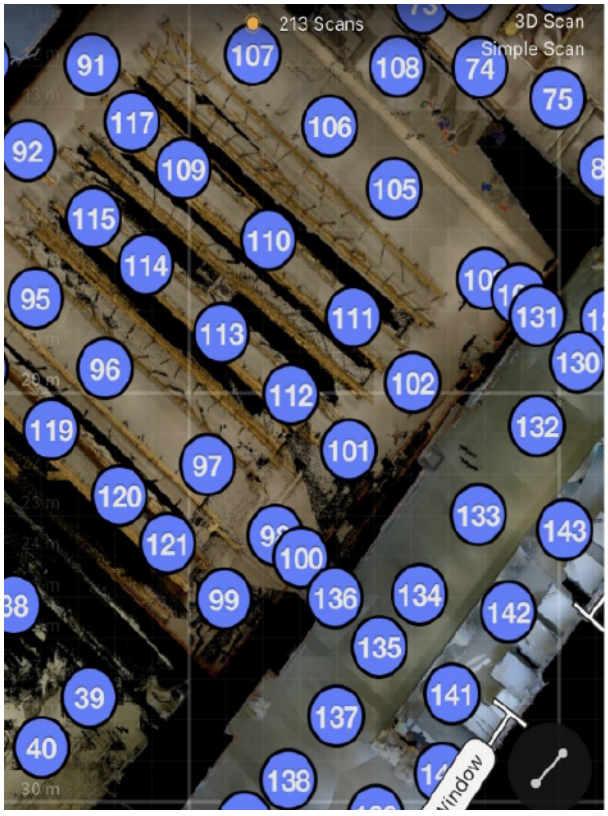


Figure 5.
Map of photogrammetric scan positions of selected functional zones on the ground floor of the school building in Gliwice. (Own work)
Figure 6.
Example measurement photo taken at station No. 147, depicting the shared area – main hall. (Own work)

Table 2.
Measurement data from photogrametric Matterport camera

MEASUREMENT DATA Research instrument: Matterport PRO2 camera			
Number of measurement sites	Measurement time per one site	Overall measurement time	Number of points in the cloud
525	20 seconds	175 minutes	785 000 000

Own work

under study is the result of the functional adaptation of spaces originally used for the former theater facility (Cinema-Theatre X). The change in the building's use was carried out following building policies, bills, and regulations applicable at that time. However, the technical adaptation of the building for cultural purposes resulted in several deviations from the contemporary design standards for secondary school functions. This includes disruptions in the relationship between functional elements, an unclear layout of passageways, and the mismatch of natural lighting distribution for teaching purposes. In its current function, the facility does not include essential user (student) areas such as green recreation zones and individual spaces.

The internal functional layout of the building was designed symmetrically relative to the central axis, which is parallel to the longitudinal axis of the building. The central route, originally serving as the foyer in the theater, was redesigned and adapted for educational spaces (auditorium, lecture halls), recreational areas, and exhibition spaces.

The main entrance to the building is located on the east side. On the ground floor, there is a porter's lodge, exhibition space, a small lecture hall, a large lecture hall (formerly the theater audience with a stage), sanitary facilities, and educational rooms. The ground floor is exclusively available to students of the Faculty of Architecture at the Silesian University of

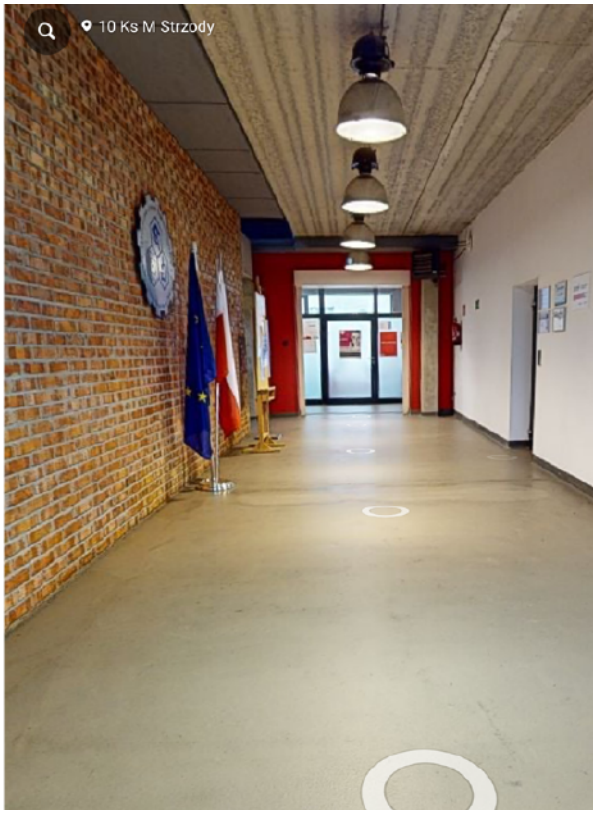


Figure 7.
Map of photogrammetric scan positions of selected functional zones on the first floor of the school building in Gliwice. (own work)
Figure 8.
Example measurement photo taken at station No. 209 depicting the shared area – corridor. (Own work)

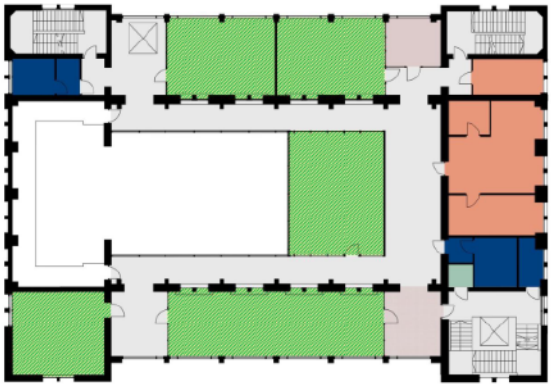


Figure 9.
Functional layout of the 1st Floor of the Academic Secondary School, in Gliwice (Own work)

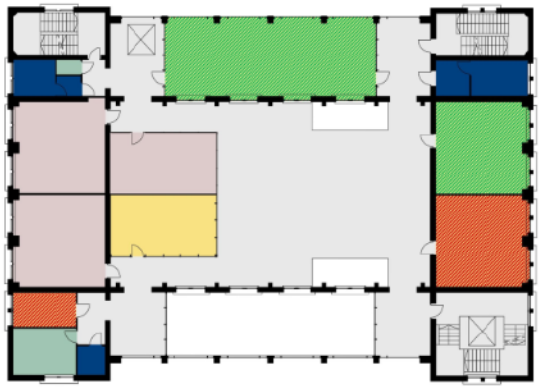


Figure 10.
Functional layout of the 2nd Floor of the Academic Secondary School, in Gliwice (Own work)

Technology, as a result, the changing rooms for school students were relocated to the 3rd floor of the building. This design solution creates a functional collision in the passageways.

The space on the first floor was organised with adaptability in mind, creating areas with good natural lighting conditions and more shaded areas, taking into account user accessibility (for teachers and students). However, the organisation of the space omitted silence and noise zones.

According to the conducted research, the predominant usable area on the first floor of the school consists of shared spaces: hallways and stairs, and recreation space. Along the passageways, classrooms were

planned with wide doors to the corridor, partly eliminating the lack of access to natural light and improving the comfort of individuals in the corridor. The hallways and stairs, and recreation spaces were directly linked by arranging existing wall niches.

Summarising the conducted functional-space analyses, it should be noted that the predominant passageway area of the facility indicates a disproportional, inappropriate functional layout of the school (excessive passageway area over educational one), which indirectly results from the inflexible form of the adapted building. Therefore, a significant issue is the lack of educational space, which is partially compensated by sharing the space designated for university students (ground floor). However, this solution is an example of disrupting relationships between functional and user zones. In terms of the functional layout of the building, the gastronomic and sports zones were not considered – these needs are addressed outside the facility.

User groups and their needs – 2011-2018

After the building was put into use following the change of use, the building started to be occupied by students of the Faculty of Architecture, research and teaching staff and administrative staff (gatehouse staff, housekeeping staff etc.).

The building has a full basement and this is where the sculpture workshop, the modelling room and the storage rooms were planned to be located – this is still the case today. The location of the sculpture workshop (where these classes are also held at present) is not suitable due to the lack of natural light in this room (no windows) and the lack of a permanent finish on the concrete floor (no possibility of cleaning the floor, dusting of the floor). Two lecture theatres and two teaching rooms are located on the ground floor level with elevations along busy streets, resulting in increased noise levels in these rooms. The remaining ground floor area consists of communication space and ancillary rooms (toilets, welfare facilities, auditorium facilities). The first floor of the building is designated as office and educational space, with five teaching rooms, including one two-storey high, and one without direct access to natural light (a computer lab with indirect lighting through glass walls). On the second floor, three teaching rooms have been designed – two large drawing studios and one indoor room, fully glazed with indirect natural light. The remaining rooms have been designated for the teaching staff – offices, toilets and social areas. A large hall, above which a large non-opening skylight has been made, occupies a large part of the floor. Due to the fully glazed facades on this floor and the large skylight, this part of the building quickly becomes overheated. No operable windows were made in the glass façades or in the skylight, which resulted in a lack of ventilation of the rooms (windows in the glass façades were added later). On the third floor (usable attic) there were two large painting studios with technical facilities. Due to the small windows of this part of the building, which used to be a non-utilitarian attic, the natural light illumination of these spacious rooms was inadequate.

Former residents of the building made the following comments on the functional and behavioural quality of the building:

- The overgrowth of communication space was observed during use, as compared to the usable space directly related to the primary function, which resulted in difficulties in teaching and the need to combine several groups in one room,
- Lack of leisure facilities for students,
- Lack of catering function in the building (lack of space, lack of plumbing facilities),
- Lack of adequately separated rooms for academic staff, resulting in 8-10 people working in the same room, which was not equipped with opening windows,
- Overheating of office and teaching rooms,
- Inefficient heating system in the building (fan heater system) causing difficulties in heating the attic rooms and the rooms located at the glass facades,
- Inefficient ventilation system in the building,
- Excessive glazing of all rooms in the building combined with the inability to cover the windows caused glare to the users, as well as sunlight penetrating the screen into the auditorium.

The essential comments of the former users of the upper floors of the building coincide with the observed and researched problems faced by current users.

User groups and their needs – 2018-2023

Current users of the school space were divided into external and internal users. External users include visitors such as the Faculty of Architecture students (entrance area, ground floor), and parents.

When considering the users' needs regarding the Academic Secondary School [ALO] building, first of all the internal user group was taken into account, as

Figure 11.
Diagram of user groups of the school. (Own work)

the space of the building may hinder or facilitate their learning and work. The internal user group is comprised of students and staff, including teachers, administrative personnel, and maintenance and technical staff.

There are four defined user groups in this category:

– Students – 209 individuals,
– Teachers – 31 individuals,
– Administrative staff – 4 individuals,
– Maintenance and technical staff – 4 individuals.

The following diagram illustrates the internal user groups of the school facility.

For a proper determination of the needs and expectations of the secondary school users, surveys, interviews, and discussions regarding the functioning of the facility were conducted.

Survey research

The conducted surveys, interviews, and discussions with users of the Academic Secondary School were focused on the functioning of the school facility and quality levels affecting users' comfort. Their indirect task was to assess users' awareness of their expectations and needs regarding the school environment, and the school building (whether these needs and expectations exist and to what extent they are met), and to determine the level of behavioural quality affecting the comfort of space utilisation.

1. The survey aimed at students of the Academic Secondary School in Gliwice.
2. The survey directed to the staff of the Academic Secondary School in Gliwice.
3. The interview with the staff of the Academic Secondary School in Gliwice.

The respondents comprised four user groups of the facility:

- Students – 209 individuals,
- Teachers – 31 individuals,
- Administrative staff – management, school office – 4 individuals,
- Cleaning and technical staff – 4 individuals.

The research conducted has allowed to identify specific problems and needs of the users, providing guidelines for improving the quality of the educational space. Based on these findings, valid conclusions have emerged regarding the functioning of the facility and the level of quality affecting users' comfort. Valuable information collected from students and teachers helps determine areas that require attention and further action. Primarily, there is a need to consider these conclusions in a future project aimed at improving the conditions in the school.

The conducted survey research, discussions, and interviews with users of the secondary school facility can be summarised as follows – there can be observed:

- insufficient seating and tables in shared spaces,
- inadequate number of sockets in classrooms,
- furniture in shared areas arranged in a way that hinders movement during breaks,
- poor air circulation leads to stuffiness on warm days,

- poor acoustics, audible sounds from the street, and other rooms,
- noise and poor acoustics in classrooms when chairs are moved,
- classrooms and shared spaces well-lit (some rooms excessively so),
- lack of separate rooms for individual sessions with students (they are conducted after classes in classrooms),
- the facility is adapted for people with disabilities.

Respondents also proposed their ideas to enhance users' comfort. These included:

- Purchasing and installing blinds to limit sunlight.
- Introducing greenery indoors and increasing greenery in the outdoor recreational area.
- Providing a designated area for meals in shared areas.
- Relocating the changing rooms from the 3rd floor to the ground floor, near the entrance area.
- Redesigning and rearranging Room 07 (inadequate ventilation and space).
- Improving air circulation throughout the building.

Microclimate research

The quality of the microclimate of a school facility is influenced by a number of factors, such as temperature, humidity, room acoustics and the carbon dioxide content of the air. If any of these factors exceeds the standards, the comfort and cognitive abilities of the staff and pupils in the school are impaired. In accordance with current legislation, the minimum temperature in the teaching rooms of public secondary schools has been clearly defined. According to these standards:

- Classrooms and teaching areas – minimum temperature: 18°C.
- School corridors – minimum temperature: 16°C (for pupils only during breaks).
- Cloakrooms and stairwells – minimum temperature: 16°C.
- Changing rooms (e.g. for P.E. classes) and shower rooms – minimum temperature: 21°C. [15]

However, the concept of minimum temperature should not be confused with the optimum, comfortable temperature for the user.

Another microclimate factor is air humidity. According to research conducted by Elżbieta Słodczyk and Dariusz Suszanowicz [16] it should be 30–50% in summer and 45–60% in winter. However, a frequent problem is its increase when a group of people stays in a room for a longer period of time, e.g. during lessons, when it starts to exceed the norm. Too low a level of humidity leads to unpleasant symptoms such as a scratchy throat and dry eyes. It also has the effect of reducing resistance to viruses. Too high humidity promotes the growth of harmful moulds, fungi or bacteria.

Selected microclimate factors were measured in classrooms, corridors, and other usable spaces using specialised measuring tools. A 1 SVAN 979 sound and vibration level meter from SVANTEK was used to measure noise levels and vibrations in classrooms. Other values were measured with a Testo 400 multifunction meter equipped with a temperature, humidity and carbon dioxide probe and a windmill probe.

Tabela 3.
Overview of room temperature and humidity. (Own work)

ROOM	temperature [°C]	air humidity [%]	CO_2 concentration [ppm]
Corridor (1st floor)	22.15	35.5	771
Corridor (2nd floor)	22.10	34.4	710
Corridor (3rd floor)	20.35	42.1	849
Concierge	21.80	32.3	553
Assembly hall	21.20	38.1	631
Bathroom (ground floor)	21.45	41.3	722
Library	21.60	38.2	761
Teachers' room	22.20	39.6	844
Quiet work room	22.85	34.7	771
Cloakroom	21.25	37.4	715
Room no 304	20.75	39.8	482
CLASSROOMS			
IT room	23.30	34.6	989
Room no 07	20.06	32.8	517
Room no 107	21.20	28	507
Room no 202	22.35	39.4	806
Room no 202A	24.60	41.5	1296
Room no 206A	24.40	47.9	2972
Room no 210	22.20	34.9	812
Room no 305	20.85	40.2	585

The temperature of all rooms stays within the norm. The lowest – as expected – was recorded in the rooms with the largest area of windows and those directly connected to them. Students point out the reduced temperature there in winter, and the risk of falling below the acceptable threshold of 18°C is highest.

Humidity is insufficient in almost all rooms. The lowest result was obtained in the two-storey room on the first floor and the highest in the room on the second floor. It is probably elevated by the air exhaled by many pupils, which is also directly correlated to the concentration of carbon dioxide in that room.

The CO_2 concentration stays within the norm for all rooms except for the small rooms on the second

floor. One of them is characterised by an outstandingly too high result, almost 2–3 times higher than the other: almost 3000 ppm. Comparing this with the values shown in Tab. 3, it can be seen that this is a value that strongly reduces the cognitive abilities of students and teachers.

Low airflow velocities were recorded with ventilation, e.g. only 0.15 m/s. This poor circulation may be a factor leading to the accumulation of large amounts of exhaled carbon dioxide within the room.

The noise level is mostly dependent on the nature of the activities rather than the characteristics of the room. Low results were obtained in rooms intended for individual use: library – 40db, staff room – 45db, cloakroom – 51db, gatehouse – 54db. During an ongoing lesson, the volume was 62db. In the corridors during break time, approximately 69db was recorded. The worst acoustic conditions can be seen when using the classroom located on the ground floor along Wrocławska Street. The measurement was taken when no classes were taking place, nevertheless, normal conversation led to a level of 73db.

Research conclusions:

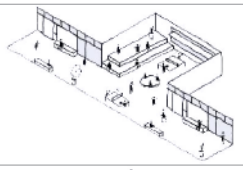
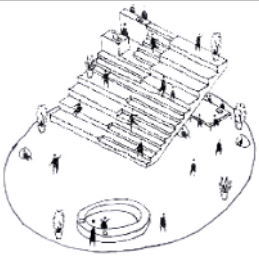
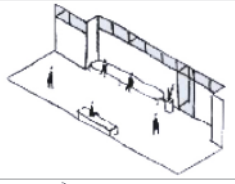
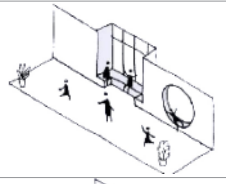
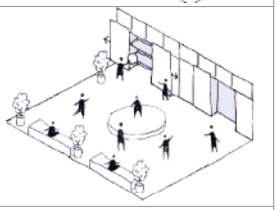
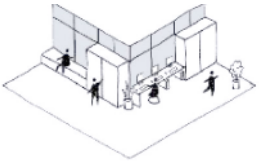
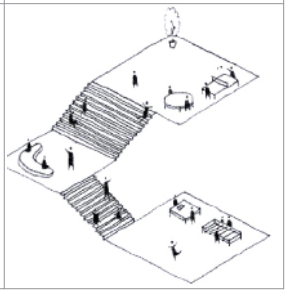
- poor ventilation is a problem in the building,
- in small rooms the CO_2 content in the air is too high,
- due to overheating in some rooms the humidity is low,
- in rooms with a large window area the temperature is too low in winter,
- in some rooms (mainly the ground floor room) there is poor acoustics which makes it difficult to conduct lessons.

Functional-spatial arrangement – as-designed status

In the scope of the research project, during the inspection and observation of the examined space, analyses were conducted regarding shared and recreational areas. These areas represent the greatest surface potential of the building and influence the perception of the entire facility. Due to the poor organisation of the shared space, the passageways dominated the area and limited adaptability for recreational functions and informal learning, significantly reducing behavioural quality. The needs of teachers and students for various forms of relaxation were taken into consideration when proposing functional solutions regarding dynamic (movement) and static (reading, concentration, conversation, quietening) form [17].

An important aspect considered when examining educational spaces is the quality of the environment, as it significantly influences the well-being and effectiveness of its users. To provide students and teachers with the best conditions for acquiring knowledge, developing passions, and interests, a classroom is simply not

Table 4.
Types of organized recreational spaces in an educational facility

Wall niches serving as common rooms – This larger open space allows for the organisation of workstations or reading areas.	
Schoolyards – usually the most popular places visited by students. Typically organised outdoors, they allow students to engage in conversations, play games, and participate in dynamic relaxation activities such as table tennis.	
Games area – It is a small space organised for plays and various games for a small number of students.	
Area in a wall niche – It is a small space designed for relaxation. Usually organised in a well-sunlit area and surrounded by greenery.	
Island – a large space (e.g., main hall or wide corridor) where furniture is arranged to facilitate larger gatherings.	
Windowsills – these are places often used by students for individual work, equipped with power points allowing for laptop work and studying.	
Stairs – a popular choice among students for organising conversation spots and other activities.	

Own work

sufficient. It is important to address the shared areas properly by introducing diverse greenery into the school environment, creating spaces for individual work, and areas facilitating integration and socialising, and ensuring an appropriate microclimate, including favorable temperature, access to fresh air, and proper lighting with both natural and artificial light.

The synthesis of the conducted research resulted in proposals presented in the form of architectural arrangement projects for selected spaces, created by students of the Academic Secondary School. The optimal areas selected for this purpose include passageways, relaxation zones, and the entrance to the building (external stairs).

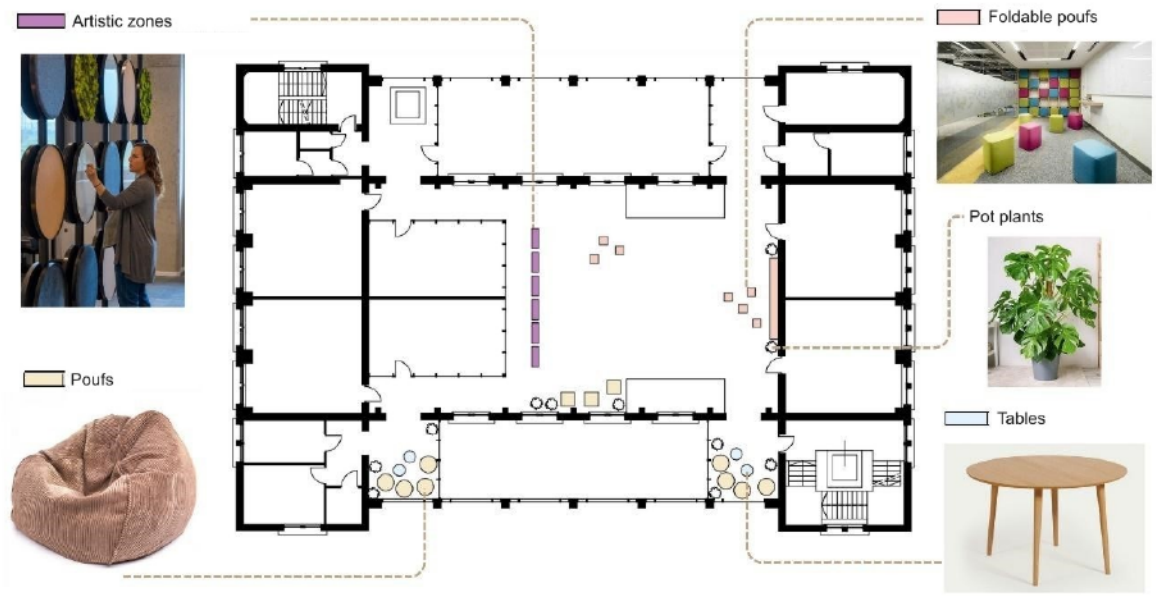


Figure 12.
Conceptual design of the common room area (lobby on the second floor) in the existing space designed as an artistic area, game corners and places for larger meetings for integration, conversation and other forms of relaxation. (Own work)

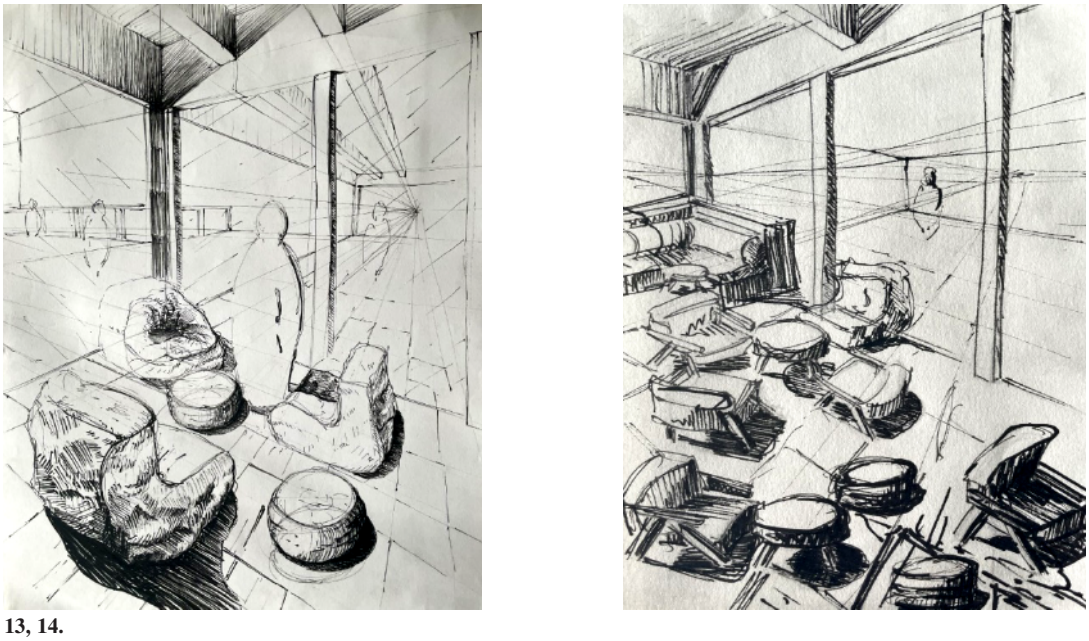


Figure 13, 14.
Conceptual design of an integration zone in the common space. The corner in the common room niche for conversation and integration (Own work)

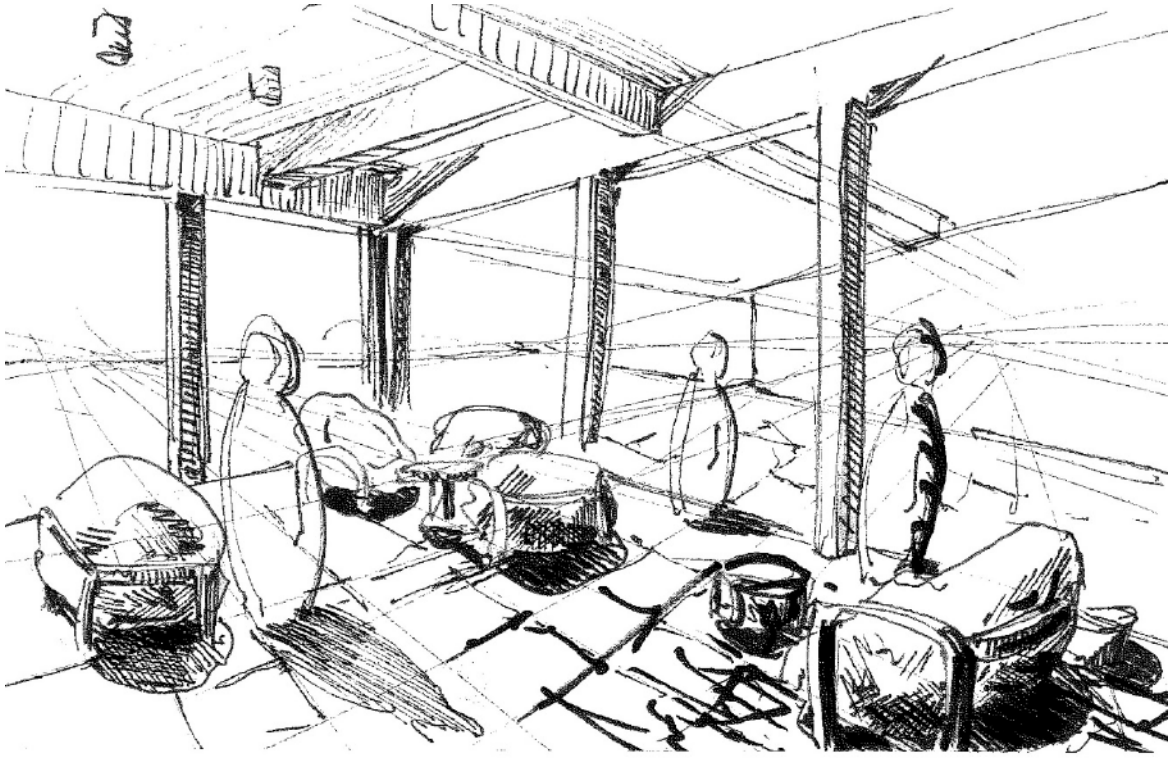


Figure 15.
Conceptual design of the integration zone in the common room space. The islands in the common room niche promote group work (Own work)

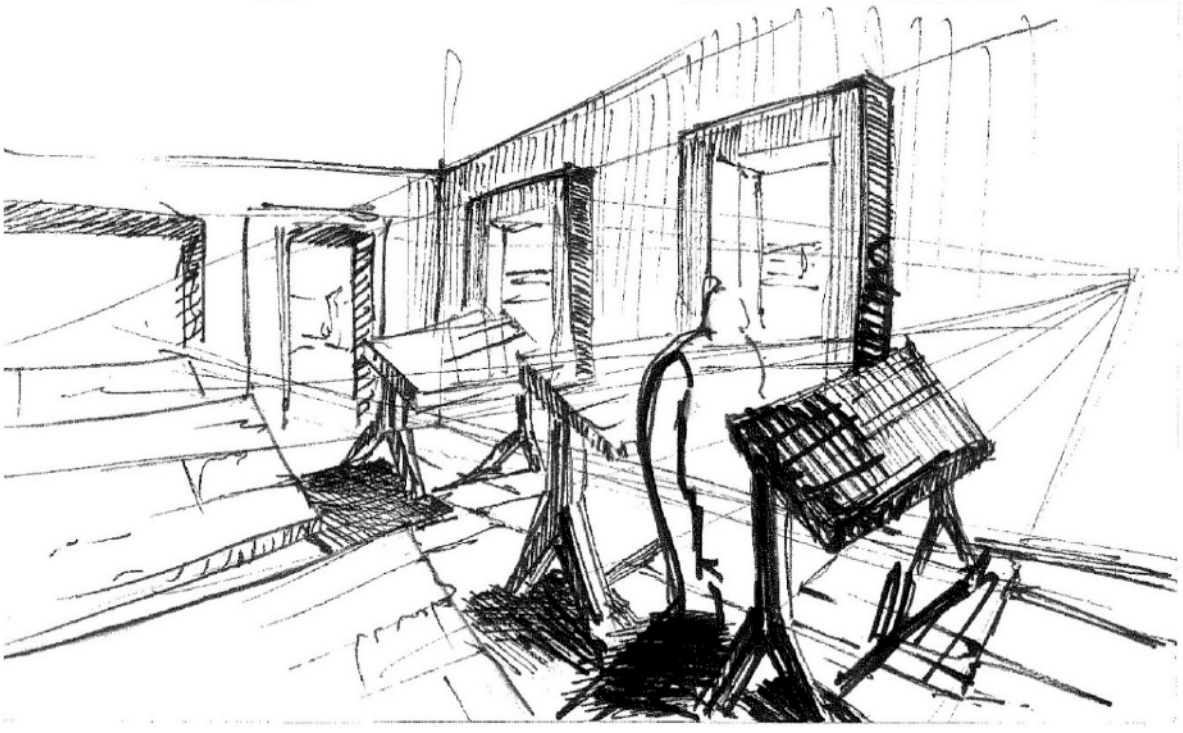


Figure 16.
Conceptual design of the art zone in the common room alcove space. The artistic zone in the common room niche is conducive to individual work, tranquillity and the development of manual skills (Own work)

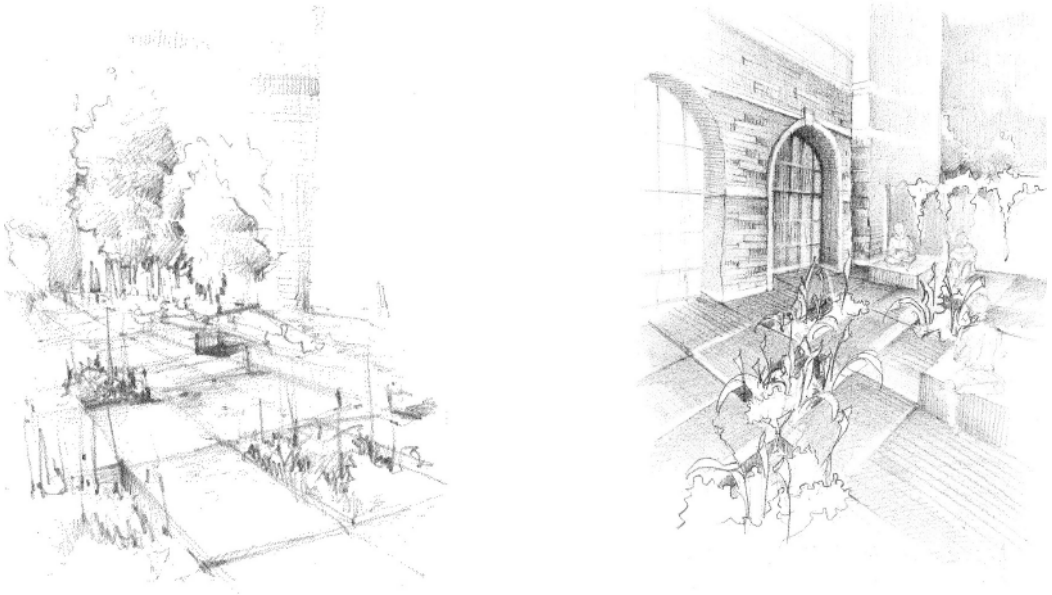


Figure 17, 18.
Conceptual design of ornamental greenery on the outdoor terrace. Conceptual sketch of the planting design (e.g. decorative grasses) in the areas where the paving slabs have been removed in the existing outdoor terrace (Own work)

4. CONCLUSIONS AND GUIDELINES

The information gathered during the conducted analyses and research on the behavioural quality of the facility helped formulate a strategy for the school building. They indicated optimal solutions that the institution's management may implement. The issues presented in connection with the conducted analyses will directly contribute to improving the quality of the environment in the secondary school building in several cases.

The final conclusions can be presented in three categories:

– Efficiency of space and passageways utilisation.

– Indoor environment and microclimate.

– Aesthetics of external and internal spaces.

In order to use space and communication efficiently, it is recommended:

- compliance of spatial solutions with building standards and regulations,
- adaptation of individual spaces to the needs of the educational and social processes taking place in them,
- the design of the functional layout and communication making efficient use of space, without non-use areas,
- introduction of visual information on the layout and function of the building; the direction of movement and communication should be clear,
- enabling comfortable movement in classrooms and communal spaces,
- creation of aesthetically pleasing, well-organised seating areas for meetings, (along circulation routes),
- corridors illuminated, bright and open to other parts of the building.

To ensure a favourable indoor environment and microclimate, it is recommended:

- ensuring the ability to adjust air temperature and humidity to users' needs,
- providing proper room ventilation and air humidification, eliminating drafts,
- ensuring optimal sunlight levels in different zones throughout the day and sufficient artificial lighting,
- using healthy, non-toxic materials with high aesthetic quality,
- implementing materials and architectural solutions contributing to effective noise reduction,
- introducing natural greenery into both interior and exterior spaces.

In order to ensure that the external and internal space is aesthetically pleasing, it is recommended:

- ensuring visual information – ease of reading functions of a given space with the use of appropriate architectural means

- harmoniously shaping surroundings and interior of the building (spatial order).
- providing contact with nature by introducing natural greenery to different floors of the building (well-incorporated groups of suitable plants without obstructing passageways).
- aesthetically arranging space around the building, with resting places featuring small architecture and high-quality organised greenery (conservatory, winter garden).
- classroom and shared area furnishings to be ergonomic, tailored to students' needs, easy to use, and made of natural, healthy, non-toxic materials.

Short-Term Solutions

1. Installing automatic sunshades on the glass façade (educational zone) and the skylight (public zone).
2. Installing automatically opening windows in existing skylights to improve air circulation and building ventilation.
3. Developing greenery and small architectural arrangement projects in the external recreational space.
4. Planting greenery in the external recreational space and installing small architecture.

Long-Term Solutions

1. Developing interior design projects for shared, educational, administrative, and utility spaces.
2. Developing a building permit design for the reconstruction and expansion of internal sanitary installations: mechanical ventilation, air conditioning and heating.
3. Developing a building permit design for the reconstruction and expansion of internal electrical installations: low-current systems, internal and external lighting, and monitoring.
4. Developing a project for implementing energy-efficient solutions: photovoltaic panels, heat pumps with exchangers, etc.

SUMMARY

In summary, the above conclusions and solutions provide a solid foundation for determining the directions of actions and project work for the Academic Secondary School. Their implementation can significantly impact the educational space, raising its behavioural quality, operational standards, and users' comfort.

Improving gastronomic infrastructure, optimising classroom space, enhancing internal passageways, providing space for teachers, and individual rooms for classes, and introducing greenery into interiors are priorities in the context of a project aimed at meeting the needs and expectations of users. Implementing the above suggestions will have a significant impact on the school's space, promoting the creation of a friendly, safe, and functional environment for learning and work, contributing to the improvement of the entire education process.

It is worth emphasising that a crucial aspect during the research on the behavioural quality of such places was the close cooperation with participants in the educational process, who best understand the needs related to a given space; they are experts in matters of quality and the standard of the built environment they use. Elements of behavioural quality include not only comfort but also aesthetics, privacy, clarity, and a sense of security. Essential factors influencing the correct functioning in a given space are also microclimate elements, such as air quality, lighting, and acoustics, which impact users' overall satisfaction.

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