CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

E-ISSN 2450-8594

CEER 2024; 34 (4): 0075-0093
DOI: 10.59440/ceer/194257

Original Research Article

THE APPLICATION OF SELECTED INVENTIVE METHODS IN THE DEVELOPMENT OF GUIDELINES FOR MODERNISATION CONCEPT OF THE BUS STATION IN POLANICA-ZDRÓJ (POLAND) - A CASE STUDY

Anna BOCHEŃSKA-SKAŁECKA[1]
Wrocław University Environmental and Life Sciences, Department of Landscape Architecture, Poland

A b s t r a c t

This paper outlines the outcomes of the deployment of selected heuristic methods in the initial stages of the design process for a modernised public space. The process was carried out in accordance with the objective of adapting the space to contemporary user needs and environmental conditions. The research is situated within the broader context of exploring solutions for shaping public spaces inspired by nature, with the aim of contributing to the enhancement of both the psychophysical condition of humans and the state of the environment. The Research through Design (RtD) methodology presented in this article is based on the use of two, different invention methods: 'brainstorming' (brainstorming) and the Theory of Inventive Problem Solving (TRIZ) (in Russian: Teoriya Resheniya Isobretatelskikh Zadatch). In addition, the Design Thinking (DT) method was employed at the stage of data collection regarding user preferences. The subject of this research is a specific building object, which simultaneously represents and exemplifies the city space.
In consideration of the project's assumptions, the principal objectives for the station's modernisation proved to be identical when employing both inventive techniques. An investigation into the potential for the modernisation of the bus station into a model public space through the utilisation of Nature based Solutions (NbS) and the advancement of a healthy lifestyle (wellbeing design) will facilitate the formulation of more comprehensive recommendations for the design of contemporary public spaces.

Keywords: public space, sustainable development, TRIZ, 'brainstorming'

1. INTRODUCTION

Crisis events frequently serve as a catalyst for the pursuit of novel solutions to existing challenges or the re-evaluation of established realities. It is evident that the recent pandemic has had a significant impact on our behaviour in public spaces and our expectations of shared spaces [4,10]. There is a growing recognition of the importance of functional-spatial elements in the creation of public spaces, with the

[1] Corresponding author: Wrocław University Environmental and Life Sciences, Department of Landscape Architecture, Wrocław, Poland, address, e-mail:anna.bochenska-skalecka@upwr.edu.pl, +48 71 3205562

aim of enhancing our wellbeing or, at the very least, avoiding any deterioration [10,14]. Recently, there has been a growing emphasis on the findings of the numerous studies conducted so far, which have demonstrated the significant correlation between the presence of green spaces and the enhancement of human well-being [4,14,20,30]. It is evident that the experience of 'lockdowns', particularly in urban areas, has underscored the necessity for incorporating nature-based solutions alongside measures aimed at enhancing the quality of life for residents in many urban strategies [20,29]. Recently, the outcomes of international design competitions for public spaces [38] have also demonstrated the potential of blue-green infrastructure (BGI) in fostering the integration of public spaces, including green spaces, which have been fragmented by urban development, thereby enhancing the quality of life for urban residents. The very definition of public space[2] indicates that one of the main design guidelines in its creation should be the incorporation of design solutions that enhance the quality of urban life. An innovative approach to construction is to seek solutions that improve the well-being of the environment. Competition-winning building projects with a public function, which are then promoted to a wider audience through social media, frequently become models not only of the functional or spatial solutions themselves, but also of lifestyles and thus of attitudes towards the use and 'exploitation' of the landscape, the environment and its resources. The implementation of healthy and intelligent solutions can be observed in the transformation of public spaces into 'indicators'. One exemplar of a model public space is the Polish Pavilion at EXPO 2020 in Dubai. The principal concept underlying the design of the modular wooden pavilion's exhibition space was inspired by the slogan 'creativity inspired by nature'. The exhibition elucidated the notion that a considerable number of scientific discoveries can be attributed to an understanding of the fundamental principles governing natural phenomena. This was exemplified by the perovskites discovered by Olga Malinkiewicz. In this space, visitors were to gain insight into how the principles of nature inform the construction industry's pursuit of sustainable solutions. However, inspiration alone is often insufficient, and the utilisation of innovative methodologies in the design process can facilitate the identification of non-obvious yet optimal solutions.

Heuristics is still underestimated in Poland, and can be a great help when searching for creative solutions to defined problems [1,5]. The Austrian economist and sociologist Joseph Alois Schumpeter (1883-1950) described what innovation [26] was more than a century ago. He defined it as the successful introduction to the market by an entrepreneur of a product or service that results from new combinations of existing means of production and generates economic growth and profit for businesses [20]. However, Schumpeter did not equate innovation with mere invention. Developing something new is a prerequisite for innovation, but only implementation, i.e. commercialisation and dissemination, can be regarded as innovation. Moreover, innovation is not only the outcome of new scientific knowledge generated by research and development activities. It is also often the result of using existing knowledge in a different way [8,33]. The Oslo Manual defines innovation as follows: an innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process) [22].

Inventive (heuristics) methods can be classified into several categories, each of which addresses a distinct aspect of creative thinking, problem-solving strategies, and innovation [5]. The application of heuristic methods leads to the generation of novel solutions [9], underscoring their role in fostering creativity. With regard to the nature of invention methods, we distinguish, inter alia [1,7,16]:

[2] The global definition of public space proposed by the UN defines it as follows: 'public space as all places that are publicly owned or of public use, accessible and enjoyable by all, for free and without a profit motive'. The essence of public space as a common good implies its accessibility to all with no direct cost to the user, and also its spirit of 'public service' without any purpose other than contributing to the overall quality of urban life

- methods based on free association (analogy method, brainstorming, Philips 66, Gordon's theory, reverse brainstorming, Peter's principle, "a new insight" method, syncretic method, situational approach, teratological approach, the Poka-Yoke method),
- analytical methods: Altszuller's method defectuology method, the method of 'voluntary constraints', the phenomenological method, the method of functional innovation, the list of features, the morphological method, the method of graphic presentation, the method of 'details').

The background to the research results presented in this article is the search for solutions for the shaping of public spaces inspired by nature. The objective is to develop a conceptual model of public spaces in a more crisis-resilient city. Given the intrinsic relationship between health and life sciences, a public space designed in accordance with the proposed model will serve as a pivotal spatial element in promoting healthy lifestyles among residents [2,10,20].

This article presents the findings of a case study investigating the development of initial concept guidelines for the modernisation of a bus station in the Lower Silesian spa town of Polanica-Zdrój. The study employed two research methods: 'brainstorming' [17,31] and the Theory of Inventive Problem (TRIZ), to generate design assumptions [21,25,28,33].

2. MATERIALS AND METHODS

2.1. Design assumptions

The main areas of strategic intervention, which are essential for developing the town Polanica-Zdrój, include spa and tourism, road and technical infrastructure, and air and natural resources protection [18,29].

The assumptions formulated for the project (Fig. 1.) included the objectives and directional activities for the development of the municipality of Polanica-Zdrój listed in the document Polanica-Zdrój Municipality Development Strategy for 2022-2027 [29].

The term 'modernisation' was removed from Article 3(7) of the Construction Law by Article 90(2)(a) of the Act of 24 July 1998 amending certain acts defining the powers of public administration bodies - as part of the state reform (Journal of Laws No. 106, item 668, as amended). This amendment entered into force on 1 January 1999. From that moment on, the following terms have been defined in the Act: construction, alteration, outward extension, installation, renovation. In this way, the legislator has unambiguously defined and organised the scope of terms appearing in the Construction Law, including a clear solution to the issue of classifying "modernisation". The term 'modernisation' falls within the conceptual scope of 'renovation', 'alteration' or 'outward extension'. Therefore, it has been established that the assumptions resulting from modernisation (technical process) are: restoration of the original state with the possibility of using construction products other than those originally used, it is possible to change the usable or technical parameters of an existing building, i.e. length, width, area of development (apart from cubic capacity, height or a number of storeys).

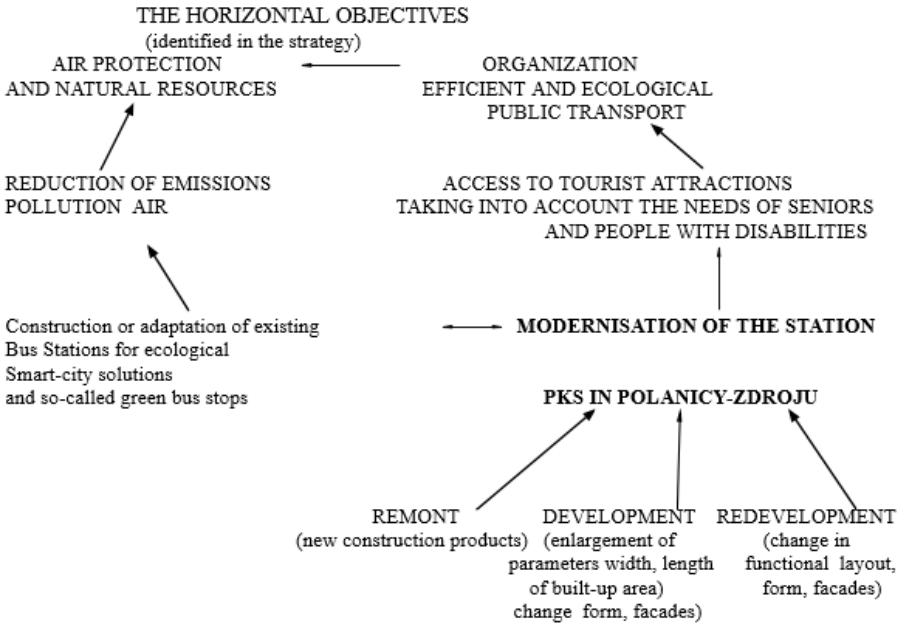

Fig. 1. Diagram of project intents on base [30,34,35] and the definition of modernisation set out in the current Construction Law (2023)

Additionally, the building of the bus station and its surroundings was assumed to have a new function to "fit in" with the projects included in the strategy. It is important, because of the funding possibilities for this technical process. The ideal vision of development is a resort in harmony between nature and modern technology, between the quality of life of all inhabitants and the satisfaction of tourists [3,30]. Polanica-Zdrój is located in a region with great tourist potential, which is not fully exploited due to insufficient accessibility. In a questionnaire survey carried out during the drafting of the strategy, residents also pointed out the need to improve public transport. One of the actions identified in the strategy (Strategic Objective 2, Action Line 2.4.) is the improvement of transport accessibility: measures to develop rail and bus transport in Kotlina Kłodzka. A horizontal objective is the protection of air and natural resources (OSI 5. Strategic Objective 5: Rational use of natural resources): organising efficient and ecological public transport, providing access to tourist attractions and addressing the needs of the elderly and people with disabilities. Other key actions include adapting to climate change and preventing risks: implementing a sustainable water management system, including small-scale retention programmes, and developing green-blue infrastructure. Examples of projects included in the strategy (Action Line 2.4). Improving transport accessibility) include promoting good practice in improving accessibility and raising the standard of rail services (renovating stations, creating transfer centres) within the town and co-designing a sub-regional programme to revitalise local rail services in the area of the municipality. The strategy does not estimate the costs of these projects, but the Polanica-Zdrój Bus Station could become an element of such revitalisation. All the more so as some of the measures are already being implemented (Action Line 5.1: Reduction of air pollutant emissions): Constructing or adapting currently existing bus stops to ecological solutions in the direction of a smart city and so-called green bus stops. The strategy also includes the purchase of low-emission vehicles (action to develop public transport and make it more attractive to residents).

2.2. Characteristics of the study object

Polanica-Zdrój is the youngest spa in Kotlina Kłodzka (Poland), dates to 1828 [2]. Its intensive development, associated with the discovery of new mineral water springs and the construction of a railway line from Kłodzko, started at the end of the 19th century and the beginning of the 20th century. It was during this period that most of the guest houses and villas were built around the spa house with the "Wielka Pieniawa" pump room, as well as other sanatorium facilities. Stary-Zdrój, the centre of Polanica-Zdrój, is an example of district designed according to the idea of a 'garden city' [2].

The subject of the study was a specific building object with a representative and typical character for the urban space and additionally located in a characteristic cultural and natural landscape of the spa town of Polanica-Zdrój [12]. The construction of the bus station in Polanica-Zdrój took ten years and was completed in 1988 (Fig.2.). It was the result of cooperation between several state institutions at that time. The opening of the bus station at Kłodzka Street meant that, after many years, the town had a place where all buses travelling to and through Polanica-Zdrój departed and arrived. As the local press reported (in 1988), this was a great logistical convenience for the residents, tourists and visitors of the time, who could wait for public transport under one roof after many years. Nowadays, despite ad hoc and recent renovations, the station, in the opinion of residents, tourists and visitors [30], is behind the times in terms of form and function.

Fig. 2. Bus station in Polanica-Zdrój a),b) Technical condition of the bus station in Polanica-Zdrój, (2023) c) station area on the side of the pedestrian zone of the city centre, Spa Park, (700-900m on foot),source: google map d) bus station plan

The main objective of the project is to modernise the structure of the existing bus station in Polanica-Zdrój. The building was constructed at the end of the 1970s, and it took ten years to build it (until 1988). It is a typical building of that time, as a so-called bus shelter: with a simple steel structure, often open (without filling the vertical partitions with building material or glazing), a system of canopies supported by steel columns, with small spans (3-6m), the canopy as a covering of corrugated sheet metal. In the later period, the divisions, vertical partitions, were often filled with hollow material in the form of bricks or hollow blocks. They were used to build walls separating individual sections (this was the case with the bus station in Polanica-Zdrój) (Fig.3).

a) b)

c) d)

Fig. 3. a) bird's-eye view of the centre of Polanica-Zdrój, source: https://x.com/ fot. Zbigniew Chojęta/ zdjecialotnicze.pl b) front area of the station, platforms, c) exit from the station towards the centre and the Spa Park, d) station equipment (2023)

The regulations set out in the Public Transport and Traffic Law of 16 December 2010, Art. 4(1)(2) of the a.p.t.z. defines a 'the station' as a place intended for the check-in of passengers, which includes in particular: transport stops, a ticket sales point and a travel information point. In addition, a station usually has a waiting room, a baggage room and catering facilities. The function to be fulfilled by a station is broader than that envisaged for a transport stop. Often part of the station space is rented out to shops and service points for travellers.

In connection with the fact that Polanica-Zdrój received funding from Norwegian funds for the years 2021-2023 and the development of the Municipal Development Strategy for the years 2023-2027, the

issue of the further functioning of the Bus Station appeared as one of the problems to be solved by the Municipality. That was the reason for choosing the Bus Station as the subject of the study, i.e. a modernisation concept using inventive methods [12,24,30,32].

2.3. Selected inventive methods

There are many methods to help a person find an original (new) solution to a problem. They differ in complexity, effectiveness and difficulty, and in overall procedure. In general, the knowledge of the various techniques enhances our creativity, and the knowledge of their nature makes it easier to choose the best approach to the problem at hand. The 'creative block' often triggers the need to use an inventive method in the creative process [18,31]. This situation is described as a complete lack of new ideas and an inability to move beyond existing ways of thinking. In the study presented in this article, aimed at solving a design problem, two inventive methods with entirely different characteristics were used: 'brainstorming' and the Theory of Innovative Task Solving (TRIZ).

The brainstorming technique (Fig.4.) belongs to the group of inventive methods based on free association. Alex. F. Osborn, its creator, defined it in his book 'Applied Imagination' in 1953 [16]. Osborn presented a formula for working in teams to solve problems. Since then, the method has been modified in various ways [17]. However, its essence is to produce as many ideas as possible. In a meeting, people with different knowledge and experience propose, evaluate and select various solutions. Of course, its effectiveness depends on following some rules [16]. 'Brainstorming' is a popular method. However, it is important to note that it has its drawbacks [1,5]. A characteristic of this method is that it focuses on the quantity rather than the quality of ideas. Due to the large number of ideas, there is not enough time to analyse and test them all. This, in turn, leads to selecting the first solution (idea) that meets the criteria. As a result, the team is already focused on that idea and the other ideas are put aside without being examined in detail. Although this method often emphasises that no idea is definitively rejected but placed in a "parking lot" for later exploration. However, due to time constraints, this is where it often stops.

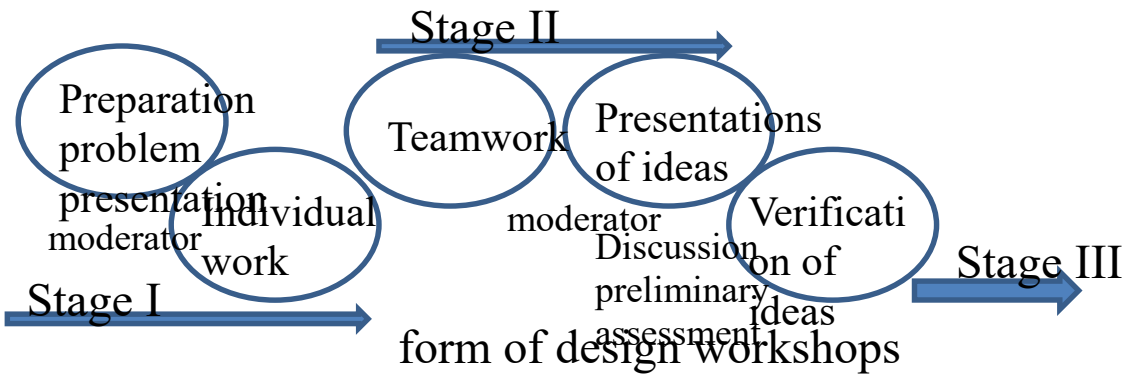

Fig. 4. Flow chart of 'brainstorming' method as design workshop form

'Brainstorming' is an essential step in a method that has been widely used in design for some time now, i.e. the Design Thinking (DT) [34]. The creators of this method emphasise that the starting point is the human being, for whom effective solutions are created, and his or her needs. The Design Thinking consists of 5 steps: empathize, define, ideate, prototype, test [34]. Nowadays, various participatory methods are applied more and more often, which, with the help of various tools, make it possible to

obtain information from users about their needs or vision of public space that meets their expectations [16]. Idea generation is the result of needs diagnosis in Design Thinking. It is an interesting 'method within a method' approach [34].

The Theory of Innovative Problem Solving (TRIZ) is an analytical method [6,21]. According to this method, the invention process is a system of algorithms leading to an optimal solution [28,33]. Gienrich Saułowicz (Henry) Altszuller, its creator, (1926-1998), formulated the thesis, based on the conclusions of an analysis of numerous patent documents, that all human creations, i.e. technical systems created to fulfil a specific function, develop according to objectively existing principles. These principles are cognisable, can be discovered and can be used to solve innovation tasks consciously [7,8,9]. The tools developed by Altszuller include: The Algorithm of Inventive Problem Solving, Principles for the Development of Technical Systems, Technical and Physical Contradictions, Invention Principles or the Invention Standards [20,27]. Over time, Altszuller's original TRIZ method has also developed into a technical system called modern TRIZ [33]. According to the idea of TRIZ, the world consists of two types of systems: natural (biological) and technical (a result of human activity). Modern TRIZ deals with technical systems and has been developed to solve innovation tasks. These tasks may involve generating new concepts or eliminating defects in existing technical systems [33]. TRIZ is a systematic method. Innovation is the result of a planned and iterative activity. It involves the creation of an algorithm consisting of three stages. The first stage, problem identification, involves eliminating the causes of defects in the technical system, not just their effects. TRIZ provides effective tools for finding solutions specific to the problem in the second stage of the algorithm. The third stage is the initial verification. It is essential to justify the adopted solution concept in terms of the practical consequences of creating or modifying a given technical system.

It was therefore decided to use one of the tools of the TRIZ method described by Altszuller: Technical Contradiction, which is used to describe innovation problems [6,33]. This is a situation where an action to improve one parameter of a technical system will result in the degradation of another (Fig.5.).

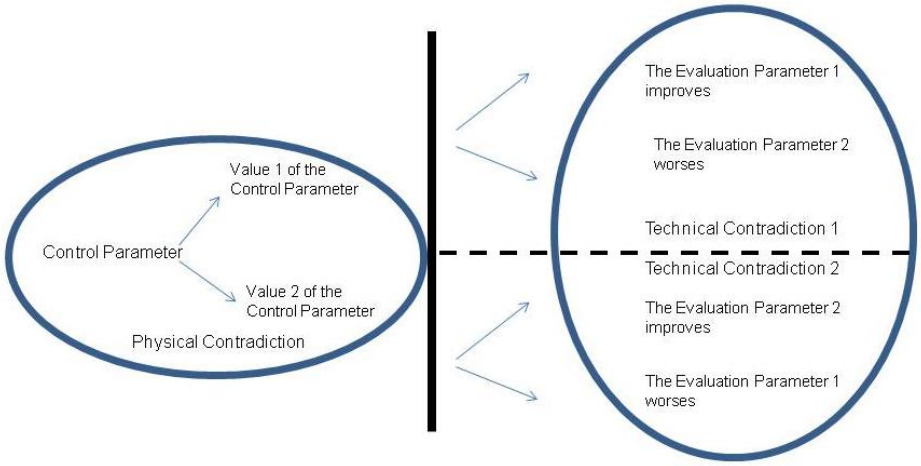

Fig. 5. Model of technical contradiction in according to TRIZ theory.Source:authors' own work on base Donnici, G et al.(2018)

3. COURSE OF THE RESEARCH

3.1. The 'brainstorming' method in the concept for the modernisation of the Polanica-Zdrój bus station

The design workshop on 'Tourism development' was attended by twenty-seven participants (students of landscape architecture, first year of Master's degree) and led by two academic teachers: an architect and an environmental engineer. The workshop was conducted in three 2-hour sessions over three weeks (1 session per week). During the first session, the students worked individually, while during the other two meetings, the students worked in teams: two 2-person teams, two 4-person teams and five 3-person teams. During the second meeting, the teams exchanged ideas with the teachers, while during the third meeting, they presented their concepts and each presentation was followed by a general discussion (Fig.2). Prior to the workshop, the teachers emailed an article on 'brainstorming' to the participants to read, but the workshop leaders did not check the participants' knowledge of the material sent. During the first meeting of the design workshop, the teachers presented the design problem, the design intents (in the form of a multimedia presentation showing the object and the site through internet images and a Google map; the participants were not on site) and the basic information about the 'brainstorming' method. Each participant was to generate as many ideas as possible for the problem and its objectives. They were allowed to use the Internet while working. The ideas had to be written down on paper (any graphical form was acceptable). At the beginning of the second workshop session, the participants were divided into teams, which summed up the ideas of all team members in the form of a list of ideas, crossing out those that were repetitive. Each team had more than twenty ideas on their list. The team of two had the largest number of ideas, 36. The teachers then discussed the compiled list of ideas with each team. The next step was that the team jointly selected five ideas to take forward and analyse them in the context of the project objectives. In the final workshop session, the teams selected 1 or 2 ideas and developed a preliminary concept for the modernisation of the station. At the third meeting, the concepts were presented in a multimedia format consisting of the team members' drawings, diagrams, sketches, photos and materials from the Internet, so-called 'good practices'. Any form of presentation was allowed, but it was limited by time (7-10 minutes) and number of slides (up to 7), and it was stressed that the form could correspond to poster boards (electronic version).

3.2. The TRIZ method in the concept for the modernisation of the Polanica-Zdrój bus station

The bus station in Polanica-Zdrój is a small bus station (Fig.1,3) and does not function in accordance with the definition of a bus station, but as a transport stop. For this reason alone it requires modernisation. Due to the fact that the modernisation of the PKS station in Polanica-Zdrój will result in certain things improving in the use of the station itself (in the technical system) or more broadly in the city (larger technical system), but certain parameters of these technical systems may deteriorate, e.g. increase of expenses in the city budget in the following year. It was therefore decided to use one of the tools of the TRIZ method described by Altszuller: Technical Contradiction, which is used to describe innovation problems [6,33].

Based on the project assumptions, the previously defined criteria (Fig.5) were formulated as Technical Contradictions as follows. The Technical Contradiction can be formulated by using the scheme [6,28,33]: IF-THIS-BUT. The IF-THIS-BUT scheme gives us two parameters: the parameter from the THIS-line-that which must be improved or changed according to the key problem; the IF-line-a known technique that improves the parameter from the THIS-line; the BUT-line-a parameter that will be made worse by the technique described in the IF-line. In order to solve the formulated Technical

Contradiction (TC), we use another tool developed by Altszuller, the so-called Contradiction Matrix (Altszuller Matrix), which allows us to derive a general solution model by recommending a set of Derivation Principles (40 general, postulated solution models) for typical Technical Contradictions [6,28].

The Contradiction Matrix (also known as the Altszuller Matrix) is a problem-solving tool that produces a generic solution model by recommending a set of Invention Principles for typical Technical Contradictions. In order to be able to apply the Contradiction Matrix to the created Technical Contradiction, it is necessary to generalise its parameters. Task-specific parameters will be exchanged for those selected from a list of 39 typical (generalised) technical parameters [6,33]. The selection of a typical parameter depends only on the judgement of the project team. When creating the 39 parameters, Altszuller's aim was to create as general a set as possible that can be applied to any technical field To obtain the recommendations of the Invention Principles, it is necessary to read them from the Contradiction Matrix. The matrix consists of 39 rows and columns. The rows list all (from 1 to 39), identified by Altszuller, typical parameters to be improved and the columns similarly list parameters that are deteriorating. In both rows and columns, the overall parameters are listed in the same order. After selecting the relevant row and column, the numbers of the recommended Invention Principles are written in the cell at their intersection. The Contradiction Matrix is not symmetrical (Fig.8.). Therefore, care should be taken to select from among the original and inverted contradictions the one that better represents the pursuit of the project goal rather than the one that focuses on avoiding negative consequences. When searching the matrix for a suitable recommendation cell, the improving parameter should be found in the rows of the matrix and the worsening parameter in the columns.

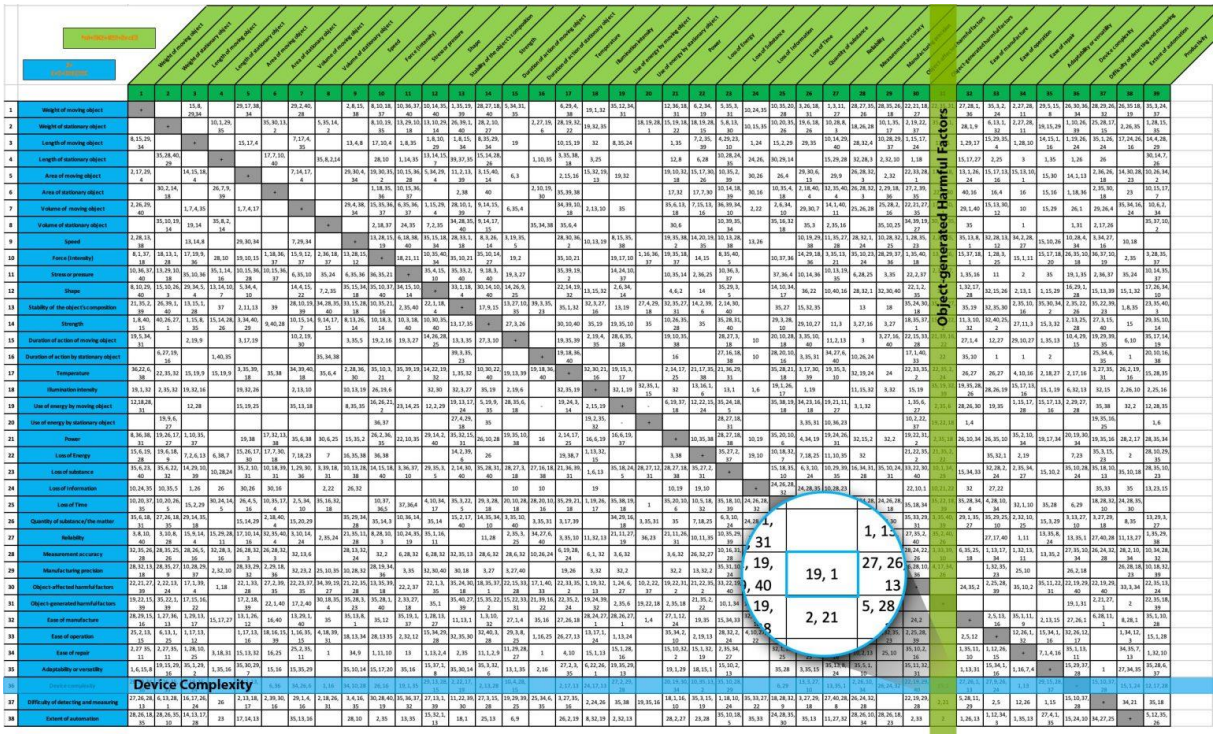

Fig. 8. Example of Contradiction Matrix. Finding the TRIZ contradiction in the TRIZ template (click the figure to maximize). Download TRIZ free template Source:

https://www.designorate.com/practice-guide-to-solve-problems-with-triz/

The list of 39 typical (generalised) technical parameters and 40 Invention Principles has remained constant since Henry Altszuller formulated them [6,8,33].

This study used the above-mentioned website and the matrix posted there [33,37].

4. RESULTS

During the workshop, it became clear that not all participants had read the ‘brainstorming’ publication. It was found that the workshop participants did not all have the same understanding of the solutions to the design problem. Some wrote down the characteristics of the space, the users' needs, and the emotional states associated with being in a space. The level of detail in the 'lists of ideas' presented by the Design Teams also varied (Fig.9.). Therefore, it was difficult to interpret the results of the design workshops based on this method and to compare the results between the Teams.

Fig. 9. A “tag cloud” of ideas – ‘Brainstorming’ on base program WordClouds.com

It can be seen that the first ideas mainly concerned the introduction of new functions and greenery, both 'within the building itself' of the station and within its surroundings (Fig.10.). The notion of inclusiveness, understood by the Teams as a space accessible to all, without restrictions, but also comfortable and equipped with facilities, i.e. additional elements of architectural elements, reconstruction of the ramp or construction of a new one, also resonated strongly. All the teams emphasised in their selected ideas to be taken forward as design concepts the location of the bus station in Polanica-Zdrój. It was the trigger for several teams to show already at this stage that the station would be only one of many points on the map for modernising the public transport in the town and the municipality. Three Teams strongly emphasised the possibility of implementing blue-green

infrastructure (BGI) by upgrading the station into the town's public transport system. Four Teams treated the station building as a volume for additional greenery ('living walls and roofs'). All the teams' ideas involved upgrading the station to a multifunctional space.

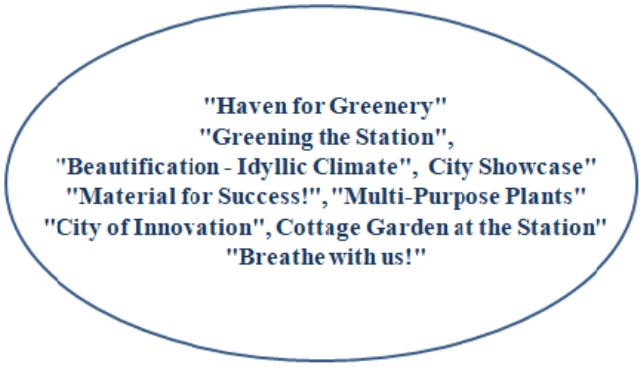

Fig.10. Keywords of the design ideas

Using the basic tools of the TRIZ method: Technical Contradiction and Contradiction Matrix, five Technical Contradictions were created based on the assumptions of the station upgrade project: TC1-TC5 and the following procedure was used to solve them (Fig.11.).

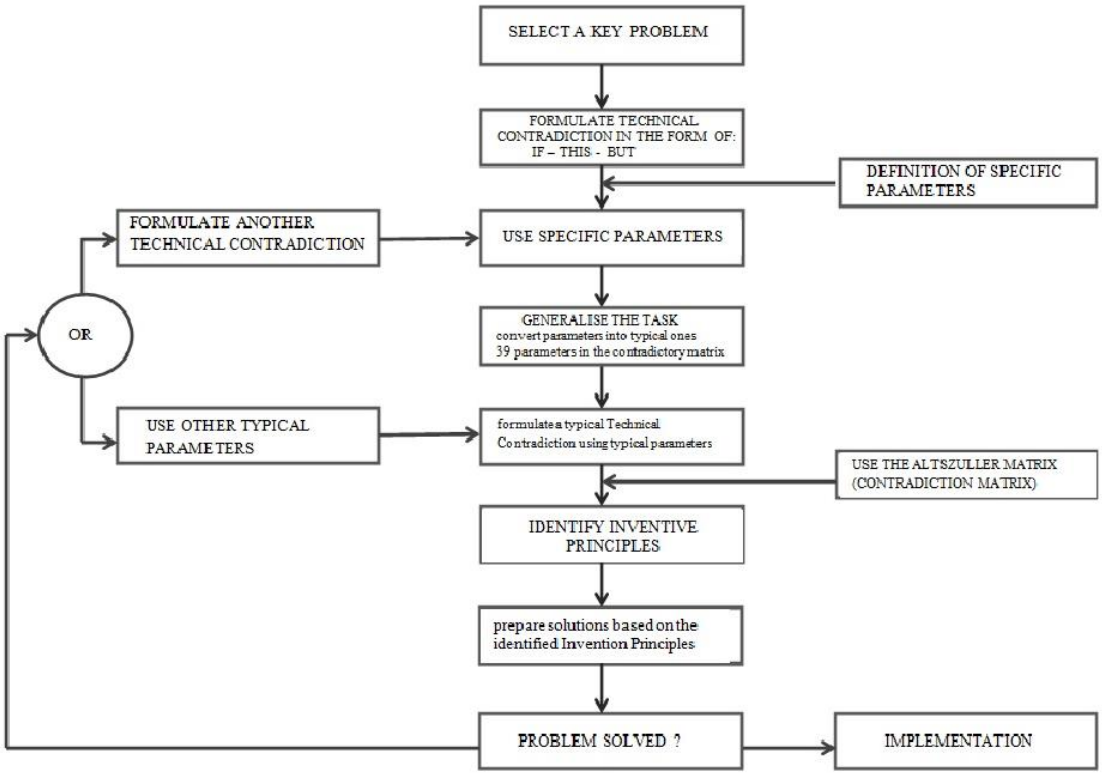

Fig. 11. Technical Contradiction (TC1-TC5) resolution scheme own work on base www.novisimo.com (2023)

The Technical Contradictions (TC1-TC5) formulated for the bus station upgrade project are:

TC1: Modernisation to reduce emissions/improve microclimate (air) quality at the Bus Station:
Specific parameter: air quality – Typical parameters 26: quantity of substance,
Specific parameter: roof weight – Typical parameters 02: weight of stationary object.
For the combination of these typical parameters the matrix suggests the use of the following Invention Principles: 27: Cheap, short life; 26: Copying; 18: Use of vibration/mechanical oscillation; 35: Change of the physical and chemical properties of the object.

TC2: Modernisation to add a new function to the Bus Station in Polanica-Zdrój by extending it.
Specific parameter: usable area – Typical parameters 36: complexity of the system,
Specific parameter: biologically active area – Typical parameters 06: area of the stationary object.,
For the combination of these typical parameters the matrix suggests the use of the following Invention Principles: 6: Multifunctionality; 36:Use of phase transitions.

TC3: Modernisation aimed at aesthetics of the bus station building in Polanica-Zdrój.
Specific parameter: facade aesthetics - Typical parameters 36: complexity of the system,
Specific parameter: renovation cost - Typical parameters 34: ease of repair.
For the combination of these typical parameters the matrix suggests the use of the following Invention Principles: 1: Fragmentation; 13: Vice versa.

TC4: Modernisation of the bus station to improve the efficiency of the use of public transport in the city and the municipality.
Specific parameter: efficiency of the station – Typical parameters 39: productivity,
Specific parameter: biologically active area– Typical parameters 06: area of the stationary object.
For the combination of these typical parameters the matrix suggests the use of the following Invention Principles: 10: Pre-action / pre-arrangement; 35: Change in the physical and chemical properties of the object; 17:Transition to another dimension; 7: One in the other (‘matrioszka’).

TC5: Modernisation of the bus station to improve its accessibility, especially for seniors and people with disabilities.
Specific parameter: availability of the station – Typical parameters 27: reliability,
Specific parameter: Aesthetics of the station – Typical parameters 12: shape.
For the combination of these typical parameters the matrix suggests the use of the following Invention Principles: 35: Change in the physicochemical properties of the object; 1: Fragmentation; 16: Partial or over-activity; 11: Temporarily supported cushion.

For example, shown below is the Conflict Matrix for Technical Conflict TC1 (typical parameters: 2,26) with selected Invention Principles: 27,26,18,35 (Fig.12.).

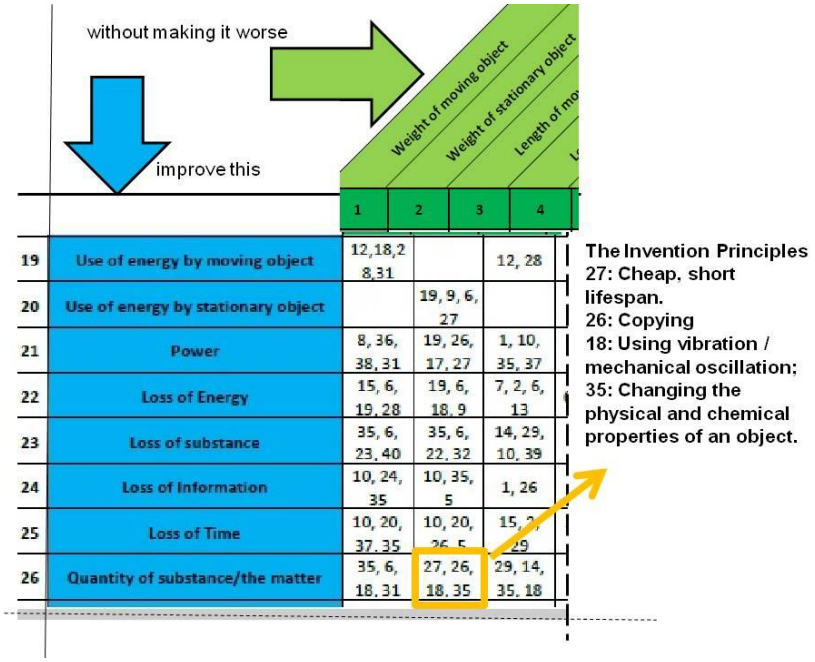

Fig. 12. Example of Contradiction Matrix for TC1 on base www.designorate.com

The generalisation of the problem is to find the intersection of requirements - to improve air quality without worsening the weight of an immovable object. The result is a general solution, i.e. homing in on a small group of principles, out of 40 principles.

Apart from Principle 18, each is usable , as a guideline for the design concept. Introducing an additional form of greenery to a station facility does not have to be just a 'green roof' and additional roof loading can be avoided. Solutions can be sought by introducing, for example, 'living walls' with self-supporting structures that can create additional station space, or by using some kind of 'copy' of a green roof such as sedum mats. Or analyse the types of green roofs in correlation with the reinforcement of the building structure.

After analysing the project assumptions, the following Invention Principles were selected for further design work on the modernisation of the bus station in Polanica-Zdrój: 1,6,13,17, 26,27 (Tab.1.).

Table 1. List of Invention Principles resulting from the solution of Technical Contradictions (TC1-TC5), selected for continuation in the concept of modernisation of the bus station in Polanica-Zdrój with sample design guidelines formulated on their basis, Source: own elaboration

1	Segmentation: Divide the object into independent parts. Make the object easy to disassemble. Increase the degree of fragmentation or segmentation of the object. Design guideline: dividing the bus station with its surroundings into functional zones.	6	Universality/ Multifunctionality: Make a part of the object, or the entire object perform multiple functions; eliminate the need for other parts. Design guideline: introduction of tourism-related functions. Shaping the station as an urban public space with greenery (waiting room - rest, relaxation).	13	The other way around: Invert the action(s) taken to solve the problem (e.g. instead of cooling the object, heat it). Make movable parts (or the external environment) stationary, and stationary parts movable. Turn the object (or process) "upside down". Design guideline: introduction of sensory spatial temporary and mobile elements.
17	Transition to another dimension: Move the object in two- or three-dimensional space. Use a multistory arrangement for the objects instead of a single-story arrangement. Tilt or re-orient the object, put it on its side. Use a different side of the given area. Design guideline: redevelopment: green, usable roof.	26	Copying: Instead of an unavailable, expensive, fragile object, use simpler, inexpensive copies. Replace the object or process with optical copies. If visible optical copies are already used, move to infrared or ultraviolet copies. Design guideline: introduction of sedum mats to the roof. Introduce diverse, energy-efficient lighting.	27	Cheap short-living objects: Replace an expensive object with a multitude of inexpensive objects that compromise certain qualities (service life, for instance). Design guideline: use of trellises with plants as self-supporting 'living walls'. The introduction of multifunctional elements such as a pot-sitting-table with seasonal plants.

4. ANALYSIS OF THE RESULTS AND DISCUSSION

4.1 "Brainstorming" method

Based on the results obtained and the conclusions drawn from the discussion during the third session, an important point can be drawn about the design process itself [17].The use of the brainstorming method in the first phase of the design work led the workshop participants to look for analogies to solutions in areas of life that were completely different from the solutions that functioned in the station buildings and their surroundings [18]. This was most evident in the keywords the Teams formulated for the main design idea (Fig.10.). Some Teams linked the slogans for the modernisation or the "new station" itself with the slogan of the development strategy of the Polanica-Zdrój Municipality [30] or referred to the character of the place: a spa and the historical context of the "garden city"[2]. The multimedia presentations, which included the initial ideas for modernising the bus station in Polanica-Zdrój, varied in their approach to the problem. Some Teams focused on linking the users' needs with modernisation of the station, while others focused primarily on its aesthetics. This seems to be very valuable for further activities, i.e. the preparation of an exhibition of preliminary design concepts with the results of this design workshop using the brainstorming method. Reviewing with users, site managers or potential investors the impact of such an activity is an integral part of the process. To some extent, the ideas were verified and evaluated (following the general steps of the brainstorming method) during the third meeting and the discussion following the Teams' presentations. The purpose of the evaluation was to check the extent to which the resulting ideas were in line with the project objectives. It was decided that all ideas generated during the workshops would be presented at an exhibition held in the station building

in cooperation with the Polanica-Zdrój Municipality. The brainstorming method has both supporters and opponents [17,31]. Some studies show that people working individually on a topic are often more creative than a group of people working as a team [31]. Despite these findings, brainstorming is still widely used. One reason for this is that it often has a positive effect on the group of people who have to work together, or it serves as an "interlude" to defuse tense situations in the team, or as a kind of bonding between people involved in the same event. Of course, the results obtained by using this method also depend on the manner and quality of its implementation and on favourable or unfavourable external circumstances, which are often beyond the control of the facilitator or the participants in the process [5,16].

The decision to use this method in this situation was based on the fact that it provides a simple way of involving current and potential users in the design and investment process [17,31,32]. Public participation in the design of public space is mandatory under the Spatial Planning Act and has been further strengthened by the latest amendment (Spatial Planning Act, Journal of Law .2023.977, Chapter 1.a Art.8e.) The ideas presented during the planned exhibition at the Polanica-Zdrój bus station, which are the result of a brainstorming workshop, will enable not only the local residents, but also tourists and visitors to the city to discuss the future of the bus station and the development and shape of public transport in the city. It will also provide material for further work and modifications to the municipality development strategy, which will be a mandatory strategic document for every city and town in Poland from 2026 [36].

4.2 TRIZ method

As a invention method belonging to the group of analytical methods, TRIZ was designed to serve as a counterbalance to brainstorming from the group of freely associative methods. The use of these two contrasting invention methods in a single study: the Research through Design (RtD) represents a non-standard approach [18]. The juxtaposition of the results obtained from two different methods allows for a broader spectrum of potential solutions and may have an innovative impact on the final design and implementation of modernisation [1,16].

TRIZ offers the possibility of solving problems by means of a fixed algorithm, which allows for faster solutions to repetitive problems. Its versatility and the combination of knowledge from different fields contribute to its high effectiveness [8,9]. Moreover, it provides a comprehensive interdisciplinary approach, which, on the one hand, allows us to regard it as an expert method, but on the other hand, enables its application in a general manner. It should be noted, however, that in contrast to brainstorming, TRIZ necessitates the formulation of precise assumptions regarding the project, which in turn imposes certain limitations on brainstorming that have a detrimental impact on the efficacy of the method. The utilisation of TRIZ tools must be aligned with the assumptions made. This necessitates preparation and experience in employing TRIZ as an expert method [21].

4.3. „Tool kit” case study for the modernisation of a bus station in Polanica Zdrój

The main directions for the modernisation of the station proved to be the same when using both invention methods. These were: the addition of a new function to the station building and its surroundings, the introduction of additional greenery into the space of the building, diversified in terms of form and type, including the so-called alternative ‘living walls and roofs’, and the use of new (in the sense of different from existing) building materials and technologies. It became evident that the modernisation of the station and its surrounding area should be oriented towards the creation of a multifunctional, inclusive and sensory space. The bus station modernisation case study was carried out using two different heuristic methods: ‘brainstorming’ and TRIZ, as well as user needs data obtained

through the Design Thinking (DT) method. These were visualised in order to identify solutions based on nature and blue and green infrastructure (BGI) [23].The experiment thus corroborates the findings of other studies on the design of urban public spaces as locations for mitigating the adverse effects of climate change and enhancing the human psycho-physical condition [14,15,20]. The combination of these two distinct heuristic methods at the initial stage of the design process proved to be an enlightening experience, yielding insights that can inform further research in the area of urban public space design, with the aim of enhancing resilience to emergencies [5,27,32,38]. The methodology presented is a combination of methods: Design Thinking (DT), 'brainstorming' and TRIZ in a single type study the Research through Design (RtD). This methodology will be further tested in other case studies of the modernisation of urban public spaces.

5. CONCLUSIONS

The use of two different methods in research through design (RtD) and the incorporation of data obtained through the Design Thinking (DT) method represents a novel approach that expands the scope for identifying optimal solutions for utilisation in the modernisation process.

The employment of brainstorming in the initial phase of the design process enables designers to transcend the conventional solutions that have been previously established, thereby facilitating an alternative analytical approach to the problem at hand. Furthermore, this method allows designers to leverage insights gained from other realms of life, thereby facilitating the discovery of optimal solutions. This is of particular importance in the context of modernisation and redevelopment of existing buildings.

The brainstorming method is particularly suited to the participatory design process, due to its methodology which makes it straightforward to involve users. At the same time, it provides material for public consultation in the development and updating of the municipal development strategy.

The practical result of applying the selected methods is to obtain preliminary concepts for the modernisation of the bus station and specific technical solutions to be applied. These will be presented during an exhibition organised in cooperation with the Polanica-Zdrój Municipality at the bus station in Polanica-Zdrój. This will allow a discussion to take place on the future of the station building, the directions for its modernisation, but will also contribute to a broader public discussion on the development and shape of public transport in the city.

It will also provide material for further work and modification of the municipal development strategy, which will be a mandatory strategic document for every city in Poland from 2026.

The application of TRIZ, which employs algorithms, enables the attainment of results (principles) that can be utilised to develop a conceptual model of a public facility/space that meets general, universal objectives, namely the enhancement of the human psycho-physical condition and the condition of the environment.

Using different methods and tools to identify solutions to complex problems fosters the development of creativity, which serves as the foundation for the creation and implementation of innovations.

ADDITIONAL INFORMATION

The study was carried out as part of an internal research and development project No. POMOST N110/0004/22. The author has received training in methods over the past year: Design Thinking and 1sth Level MA TRIZ.

REFERENCES

1. Antoszkiewicz, J 1990. *Metody heurystyczne*.[Heuristic methods]. Warszawa: PWE.
2. Balińska, G 1991. *Uzdrowiska dolnośląskie. Problemy rozwoju i ochrony wartości kulturowych po II wojnie światowej*. [Lower Silesian spas. Problems of development and protection of cultural values after World War II].Wrocław: Wydawnictwo Politechniki Wrocławskiej.
3. Bocheńska-Skałecka, A 2011. *Model solution-an essential, initial designing tool for shaping energy-efficient building development and land development.* Procedia Engineering **21,**International Conference on Green Buildings and Sustainable Cities, Bolonia, Italy, 805-810.
4. Crossley, AJ and Russo, A 2022. Has the Pandemic Altered Public Perception of How Local Green Spaces Affect Quality of Life in the United Kingdom? *Sustainability* **14 (13),** 7946.
5. Derlukiewicz, D et al. 2018. *Projektowanie Innowacyjne. Podręcznik*. [Innovative Design. Handbook]. Wrocław: Politechnika Wrocławska.
6. Donnici, G et al. 2018. TRIZ method for innovation applied to an hoverboard. *Cogent Engineering*, ***5*(1).**
7. Dostatni, E et al. 2015. Projektowanie wyrobów AGD z wykorzystaniem metod inwentycznych [Design of white goods using inventive methods]. *Zarządzanie Przedsiębiorstwem*, **Nr 2,** 9-17.
8. Feniser, C et al. 2017. The Evaluation and Application of the TRIZ Method for Increasing Eco-Innovative Levels in SMEs. *Sustainability,* **13,** 1125.
9. Ikovenko, S et al. 2023. *Współczesna Teoria Rozwiązywania Innowacyjnych Zadań Podręcznik na 1 stopień certyfikacji Międzynarodowego Stowarzyszenia TRIZ (MA TRIZ)*. [Contemporary Theory of Innovative Task Solving Handbook for Level 1 of the International TRIZ Association Certification (MA TRIZ).]. Warszawa: Novismo sp. z o.o.
10. Kaczyńska, M 2022. Present security of the neighbourhood urban parks considering SARS-CoV-2 potential spreading – A case study in Ursynów district in Warsaw. *Acta Scientiarum Polonorum Administratio Locorum*, **21(3)**, 355–377.
11. Kamińska, P and Michalak, H 2023. Multi-criteria analysis and design ideas of green façade system as eco-friendly architectural solutions. *Civil and Environmental Engineering Report. CEER.***33 (4)**, 0023-0041.
12. Kiniorska, I and Brambert, P 2022. Przemiany dworców w miejskiej przestrzeni publicznej. Przykład Kielc. [Transformation of stations in urban public spaces. The example of Kielce.]. *Prace Komisji Geografii Komunikacji PTG*, **25(3),** 24-40.
13. Kubicki, P 2021. Odporność miast i nowe polityki miejskie. [Urban resilience and new urban Policie.]. *Politeja*, **nr 5 (74)**, 225-239.
14. Liu, H et al. 2021. The Role of Nature-Based Solutions for Improving Environmental Quality, Health and Well-Being. *Sustainability*, **13**, 10950.
15. Madureira, H and Monteiro, A 2021. Going Green and Going Dense: A Systematic Review of Compatibilities and Conflicts in Urban Research. *Sustainability*, **9**, 10643.
16. Martyniak, Z 1997. *Wstęp do inwentyki.* [Introduction to invention]. Kraków: Akademia Ekonomiczna w Krakowie.
17. Mo, H et al. 2022. Neurocognitive feedback: a prospective approach to sustain idea generation during design brainstorming. *International Journal of Design Creativity and Innovation*. **10:1**, 31-50.
18. Niedziela-Wawrzyniak, S and Wawrzyniak, C 2021. Architektura – badania poprzez projektowanie. [Architecture - research through design.]. *Builder*. **8**, (289).
19. Nieścioruk, K 2013. Cartographic source materials and cartographic method of research in the past environmental analyses. *Bulletin of Geography. Socio–economic Series,* **No. 22**, 81–95.

20. Noszczyk, T et al. 2022. The impact of the COVID-19 pandemic on the importance of urban green spaces to the public. *Land Use Policy* **113**, 105925.
21. Obora, H 2008. Metoda twórczego rozwiązywania problemów TRIZ. [TRIZ creative problem solving metod.]. *Zeszyty Naukowe*, **nr 75,** Uniwersytetu Ekonomicznego w Krakowie, 117-130.
22. *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, The Measurment of Scientifiy, Technological and Innovation Activities,* by OECD/Eurostart/EU,2018.
23. Pancewicz, A 2021. *Climate-Friendly Cities – Blue-Green Infrastructure Activities*. IOP Conf. Ser.: Mater. Sci. Eng. 1203 022049. WMCAUS 2021.
24. Pancewicz, A 2022. Urban nature as an active means of adapting public spaces to climate conditions: case studies from Copenhagen and selected polish cities. *Civil and Environmental Engineering Report. CEER.***32 (4),** 0123-0146.
25. Rejmaniak, R 2021. Autonomiczność systemów sztucznej inteligencji jako wyzwanie dla prawa karnego. [Autonomy of ai systems as a challenge for criminal law.]. *R O C Z N I K I N A U K P R A W N Y C H Tom XXXI*, **numer 3**,95-113.
26. Schumpeter, J A 1960. Teoria rozwoju gospodarczego. [Theory of economic development.]. Warszawa: PWN.
27. Shabb, K et al. 2022. Launching the Mission for 100 Climate Neutral Cities in Europe: Characteristics, Critiques, and Challenges. *Front. Sustain. Cities*, **Volume 3**, 817804.
28. Skoryna, A and Cempel, Cz 2010. Możliwości zastosowań metody TRIZ w diagnostyce maszyn. [Application possibilities of the TRIZ method in machine diagnostics.]. *Diagnostyka*, **3(55),** 69-77.
29. Stålhammar,S and Pedersen, E 2017. Recreational cultural ecosystem services: How do people describe the value? *Ecosystem Services* 26, 1–9.
30. Strategia Rozwoju Gminy Polanica-Zdrój na lata 2022-2027. Załącznik do uchwały nr IV/28/2022 Rady Miejskiej w Polanicy-Zdroju. [Development Strategy of Polanica-Zdrój Muncipality for 2022-2027. Appendix to Resolution No.IV/28/2022 of the Municipal Council in Polanica-Zdrój].75-79.
31. Świątek, M 2017. Kreatywność w zarządzaniu projektami – Burza mózgów jako metoda heurystyczna (ujęcie syntetyczne). [Creativity in project management - Brainstorming as a heuristic method (synthetic approach).]. *ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ. Seria: Organizacja i zarządzanie z.***105**, 495-503.
32. Wysocki, M 2015. *Przestrzeń Publiczna Przyjazna Seniorom. Poradnik RPO. [Senior Friendly Public Spaces. RPO Guid.]*. Warszawa: Biuro Rzecznika Praw Obywatelskich.

WEBSITIES

33. www.novismo.com access: 12.12.2023 – 29.07.2024.
34. www.dt-institute.pl/ access: 15.02.2024 – 25.03.2024.
35. www.mpoia.pl/index.php/dzialalnosc/zespol-rzeczoznawcow/39-p-zespol-rzeczoznawcow-mpoia-rp/2227-opinia-nr-248-doste-pnos-c-obiektu-dla-oso-b-niepelnosprawnych access: 25.02.2024.
36. https://izbaarchitektow.wroc.pl/wp-content/uploads/2023/09/OPINIA-ZR-2_2023.pdf access: 25.03.2024.
37. www.designorate.com access: 25.02.2024 - 29.07.2024.
38. https://www.publicspace.org/the-prize access: 25.07.2024.