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Advances in Human Factors, Sustainable Urban Planning and Infrastructure

Proceedings of the AHFE 2017 International Conference on Human Factors, Sustainable Urban Planning and Infrastructure, July 17–21, 2017, The Westin Bonaventure Hotel, Los Angeles, California, USA

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8th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences

Proceedings of the AHFE 2017 International Conference on Human Factors, Sustainable Urban Planning and Infrastructure, July 17−21, 2017, The Westin Bonaventure Hotel, Los Angeles, California, USA

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Preface

The discipline of Human Factors and Sustainable Urban Planning and Infrastructure provides a platform for addressing challenges in human factors and engineering research with the focus on sustainability in the built environment, applications of sustainability assessment, demonstrations and applications that contribute to competitiveness and well-being, quantification and assessment of sustainable infrastructure projects, and the environmental, human, social, and economic dimensions of sustainable infrastructure. A thorough understanding of the characteristics of a wide range of people is essential in the development of sustainable infrastructure and systems and serves as valuable information to designers and helps ensure design will fit the targeted population of end users.

This book focuses on the advances in the Human Factors in Sustainable Urban Planning and Infrastructure, which are a critical aspect in the design of any human-centered technological system. The ideas and practical solutions described in the book are the outcome of dedicated research by academics and practitioners aiming to advance theory and practice in this dynamic and all-encompassing discipline.

A total of three main sections presented in this book:

I. Ergonomics in Building and Sustainable Architecture
II. Public Building and Urban Design
III. Infrastructure Planning and Learning for Sustainable Future

Each section contains research paper that has been reviewed by members of the International Editorial Board. Our sincere thanks and appreciation to the board members as listed below:

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We hope that this book, which is the international state of the art in Urban Planning and Sustainable Infrastructure domain of human factors and ergonomics, will be a valuable source of theoretical and applied knowledge enabling human-centered design for global markets.

July 2017 Jerzy Charytonowicz

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Ergonomics in Building and Sustainable Architecture

Parasitic Architecture: Theory and Practice of the Postmodern Era

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Abstract. Contemporary use of the term *parasitic architecture* refers to a wide scope of small scale architectonic “additions” to existing buildings. Legal and illegal, temporary and permanent, they all expand volumes of their hosts and sometimes develop their functions. The *parasitic* function, due to cities’ density, growing homelessness and immigration problems seems to divert the aim of the trend from artistic manifestations to social actions. Gradually the scope of the problems solved by *parasites* increases and discussion on the phenomena develops. The first developments distorting volumes of listed buildings were signed up by star-architects. Acceptation of sometimes outrageous changes seems to pave the way for architectural *parasites*. Applied methodology of the research focuses on finding historical justifications of the discussed phenomena and to investigate the forms of parasitic inclusions as well as possible influence of this trend. The methods involved included studies of literature, professional web pages, and research in situ.

Keywords: Parasitic architecture · Extensions · Modernizations · Social problems · Homelessness · Experiments · Artistic manifestations

1 Introduction

Researchers investigating architecture of the Age of Enlightenment and the nineteenth century, are unanimous in that the trail towards architectural stylistic diversity, the emergence of Eclecticism as an architectural style making use of architectural details originating from various periods, was broken by garden design. Buildings inspired by cultures of faraway lands, gradually becoming a part of the Empire, appeared in English gardens for the first time in the 18th century. These were the times when the aesthetic shock phenomenon entailed negative opinions from conservative circles appointed for that purpose. As recognised by researchers, Cristal Palace was an exception to this rule, erected in 1851 as a framework structure made out of cast iron, iron and glass. The new experiences afforded by it, an integration of the interior and the goings on of the exterior, were well received, if not applauded.

One hundred and fifty years later, in an epoch following modernism, aesthetic shock is an expected phenomenon, novelty in every field is received with an accepting inquisitiveness. These changes occurred gradually and encompassed all aspects of everyday life (fashion, cars) and culture. The Japanese Metabolism has had a presence

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in architecture since the 1960s and introduced new aesthetic dogma: modularity, combined with “randomness” of forms, and breaking down thereof. At the same time theoretical, re-scaled urban units and mega-structures, impossible to put into practice during those times were created. They were formed freely, organically.

The post-modernism of the 1970s reinstated symmetry of old, adding a plethora of colours and relying on shapes of well-known items and forms. Deconstructivism, which rattled structural rationality and entered into a discourse with the gravitational pull of the Earth emerged from that movement. High-Tech and gradually also other contemporary architectural trends appeared in different countries and for different reasons. High-Tech accustomed the average recipient to exposed technical elements of a building, constituting new, sometimes variable architectural detail.

In modern Europe, palace extensions were an often occurrence, executed in styles and shapes current at the time. The French castles of the Loire Valley are an example here, where subsequent epochs left their mark in the form of new wings, stairwells and details. Chateau Blois has seen development from a 13th century fortress, with successive additions of a Gothic, Renaissance and Classical wings. In those days, the concept of a stylistic subordination or inviolability of a form once considered to have been finished were unheard of. In the late 19th and early 20th centuries, when the foundations of architectural monuments conservation theory were being created in France, a doctrine permitting a large dose of freedom in interpreting forms of buildings restored in the spirit of stylistic uniformity.

At the same time, the randomness of style was a characteristic of architecture created during that period. In subsequent decades of the 20th century, driven by needs, feasibility and ardent modernism ideologists, this movement gained in prominence.

In the context of Oswald M. Ungers’ theory, a city’s urban plan yielded to a spatial definition imposed by structures which constitute further inclusion in the network of streets, injecting life into them. In his book “Großformen im Wohnungsbau” (O. M. Ungers, E Mühlthaler, 1966) he has used the term *parasitic architecture* in. He discussed urban scale of the *Großformen* which imposes a sense of order in the most spheres of the cities’ life. Architectural tissue was considered to be a parasite form within it: unpredictable and spontaneous fabric bringing life into the frame. Hence *parasitic*, thriving on urban network, was not a negative evaluation [1].

The intensity of contextual proliferation, plethora of forms, urban planning detail and infrastructure required by the residents to live gained momentum in the 20th century. A look at the vedutas of former masters and the staffages depicted thereupon, we realise how “empty” city spaces were. Road signs, information displays, adverts, radio and television antennas, fans, air conditioning units - the tale signs of an advanced infrastructure and symbols of a more comfortable lifestyle became an obvious part of urban space [2].

Citizens, artists, architects are used to experiencing and creating mobile urban space. Parametric design applied in architectural practice allows to adapt every form to changeable needs and situations entailed by a mutable urban environment.

2 Building Extensions – Needs, Emotions, Freedom

The middle of the 20th century is a period when Europe was shaking of the destruction of World War 2. The ever-present modernism was gradually overpowered by post-modernism and echoes of Japanese Metabolism seen since 1960s. The construction of Moshe Safdie's "Habitat 67" at Montreal's Expo was also significant. These were reinforced concrete structures, made up of repeatable blocks of typical dimensions, making up single family homes with terraces oriented towards Saint Lawrence River. The shapes were piled up in a seemingly random manner [3].

The concept of a function-driven building shape, resulting in breaking down of façade surfaces and silhouettes was developed in subsequent decades.

Form the sixties of the 20th century on, modernistic architecture was gradually infiltrated by the post-modern ideas. Symmetry, colour, references to the historical forms and details, humor – the new qualities were introduced [4]. Deconstructivism, high-tech, brutalism, established fertile ground for diversified formal, technical and structural solutions. Green terraces, balconies and roofs added a variability factor. Bosco Verticale, a pair of residential towers in the Porta Nuova in Milan (2015), designed by Boeri Studio (and gardening specialists), has achieved its changeability in this way (Fig. 1) [5].

In terms of diversity of architecture and multiplicity of movements which are developing at the same time, the recent decades have no equivalent in history. A simultaneous saturation of city centres by listed buildings subject to heritage protection, resulted in the need to expand, convert and complete some of them.

Modernisations of post-industrial structures in city centres were the first important step in the theory and practice in handling non-typical, historic, architectural fabric. Due to the scale, character and used materials, post-industrial buildings constitute a specific group. Converted into lofts, shopping spaces and galleries, where both historic technological devices as well as systems were on show, they are important step in the theory and practice of buildings modernization[1] and gentrification of the districts process [6]. Today it is difficult to determine, by how much the coincidence in terms of dates explains the mutual inspirations between industrial architecture conversions and the High-Tech movement which has been growing since the 1960s.

An example of inspirations by technical ideas which go even further are the ecological movement and the sustainable development policy for cities and the construction industry. The Beddington Zero Energy Development (BedZED) in London's Hackbridge estate is a prime example. Designed in 2000 by architect Bill Dunster, aided by the industries and specific engineering firms. Both the shape of buildings as well as their details seen inside and outside are subject to technical requirements. These are: obtaining energy only from locally available renewable sources, significant energy efficiency, water efficiency, low environmental footprint and waste recycling. Eco-orientation of the development was

[1] Typical "hard loft" is a flat in abandoned postindustrial, historical, probably listed building. The first lofts were occupied by artistic bohema of the sixties, as a result of downtowns' expansion and evacuation of plants and warehouses seeking cheaper locations. Gradually lofts were converted into fashionable and expensive residences.

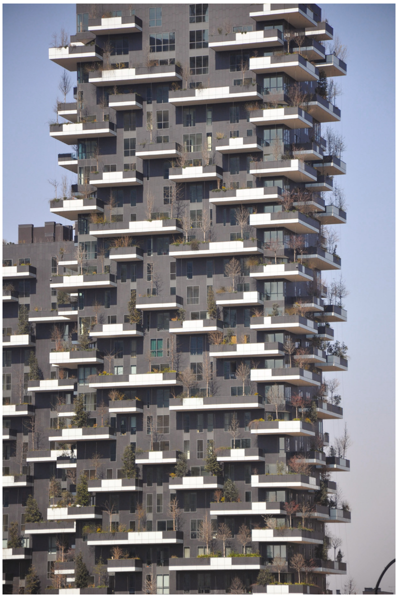

Fig. 1. Residential towers in the Porta Nuova in Milan, Boeri Studio, phot. T. Bardzinska-Bonenberg

Fig. 2. Zero Energy Development (BedZED) in London's Hackbridge, technical details in designer forms, phot. A. Bonenberg

accentuated by exposed, designed on purpose and colourful technical details of the buildings (Fig. 2).

Conversions following changing needs and creation of additional floorspace were also necessary in buildings such as town houses, palaces, churches, historic municipal and military buildings. They occupied plots within dense city centres and were enlarged in many ways.

The first project which prompted discussions amongst architects, as it broke away from the principles in use to date, was the expansion carried out for a law firm by Coop Himmelb(l)au between 1988 and 1989 (Fig. 3). The deconstructive interference in the structure of noble, historicizing, Viennese town house was an unexpected solution.

From that time, similar, contrasting designs could be seen in the projects of numerous architectural firms. Their scale gradually grew: some tear the existing building apart, through an element alien in terms of shape and texture, purposely deconstructing the whole. With major architectural personas behind them, they were received by the architectural circles with acclaim. Critical opinions were far and few between. That's how it was in 1996 when it came to the expansion of the Victoria & Albert Museum designed by Daniel Libeskind, an architect rather unknown in that time. It was to occupy the site of the Museum former boiler house [7]. Examples of successfully completed museum extensions include The Royal Ontario Museum in Toronto, known as The Crystal, piercing stone-clad edifice, completed in 2007 [8], and

Fig. 3. Coop Himmelblau, 1998, Schuppich, Sporn, Winischhofer, law firm office extension, Vienna, phot. M. Baczkowska.

Fig. 4. Daniel Libeskind, 2011, Bundeswehr Military History Museum Dresden, phot. M. Nowosad

2011 extension of the Bundeswehr Military History Museum in Dresden, by the same architect where the eclectic building was similarly deformed (Fig. 4) [9].

In many cases, in designs and projects Dutch MVRDV develops the concept of free façade structure which reflects the internal functions. This holds true for both multi-functional buildings as well blocks of flats. WOZOCO complex for elderly people, known as hanging houses of Amsterdam, was built in 1997. Characteristic cantilevered volumes resulted from too small plot and adhering to the daylight regulations [10]. Recently MVRDV developes its project of modernization of mix-use complex Vandamme Nord in Gaîté-Montparnasse in Paris. The complex was built in the early seventies by French architect Pierre Dufau [11, 12]. The reconstruction includes a collection of glass "boxes" inserted into the existing reinforced concrete frame and penetrated by greenery. The volumes vary in size, programme, colour, and materials. Set against the background of rythmically cadenced facades of high rise office buildings, they create outstanding informal composition.

Vitra Haus by Herzog and de Meuron in Weil am Rhein is a manifestation of structural freedom. The space for arranging furniture and other home fixtures in a manifestational manner assumed the shape of stacked, simple, archetypical pitched roof houses [13].

The freedom to shape architecture remains in accordance with the way in which they are used. Conversions, adaptations, temporality, stem from growing impact of everyday mobility. Purchases in "pop-up" shops: temporary, operating out of rented spaces, advertising over the internet and attracting customers via that channel, co-working offices which rely on a turnover of "employees" where each one is a freelancer in their profession, became a sign of the times [14].

Residents have increasingly more to say when it comes to the shape of existing buildings and the form of their façades: pipe aerials were replaced by plate-like satellite installations that constitute a detail in their own right in the landscape of estates and large city streets. ICT system elements are part of building façades and silhouettes. They constitute a spontaneous and variable composition, driven by the needs of users and media providers.

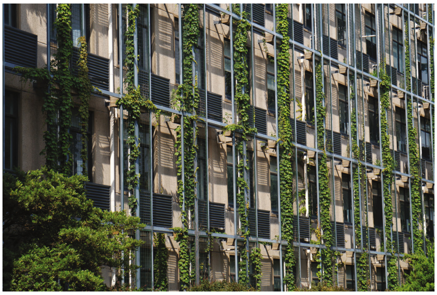

Fig. 5. Shanghai, balconies an office building with a frame added to provide space for air conditioning units for every room separately, phot. T. Bardzinska-Bonenberg

Fig. 6. Poznan, an office building from 2010 is dominated by industrial “roofscape” of the ventilation and air conditioning equipment, phot. T. Bardzinska-Bonenberg

The facility to individually adjust the temperature and exposure to sunlight of residential and office interiors constitutes a basis for further interventions into the external form of buildings. Air conditioning units have appeared by windows and on balconies in accordance with the uninhibited will of the residents. External shutters and awnings amend wall colour, structure and articulation, which is taken into account by architects when it comes to new buildings (Fig. 5).

Roof areas are evading attempts to control them in modernised buildings and in new structures. Intelligent air conditioning systems and air ventilation systems change the silhouettes and building dimensions through numerous box-like additions together with ducts. Unpredictability, stemming from technological progress and changing standards is, in this case, significant (Fig. 6) [15].

3 Parasitic Architecture – Manifestations, Solutions and Jokes

Theoretitians of architecture, visioners, such as Archigram group and AA circle in London, the Metabolists in Japan, Lebbeus Woods in the USA anticipated these phenomena in the sixties of the 20th century. Their followers Zaha Hadid, Rem Koolhas and Peter Eisenman introduced the new qualities into architecture. Variability in architecture gained professionals, users and onlookers appreciation.

Spontaneous activities of owners and inhabitants result in “personalised” additions to the elevations, roofs and volumes of buildings. Although they melt into contemporary townscape, the sense of susceptibility to deformations of buildings and urban spaces remains. This concerns laymen, artists and architects, and contradicts former constancy of architecture [16].

Probably the facts mentioned above contribute to perceiving buildings and urban space as adaptable structures.

Fig. 7. Chinese street poster warning against illegal developments on the rooftops of the blocks, Shanghai 2015, phot. T. Bardzinska-Bonenberg

Fig. 8. Restaurant “Priceles Milano” on the top of Banca Commerziale Italiana building in Piazza della Scala during the Expo 2015, phot. A. Bonenberg

However the first attempts of placing parasitic extensions on existing buildings were implemented in the seventies of the last century. In 1971 architect Jean-Louis Chanéac and Pascal Haüsermann installed a “parasite” bedroom for a baby on the façade of a modernist residential apartment block in Geneva for a family struggling with no success for a bigger flat. “La Bulle Pirate” had organic shape and was made of laminates, resins, glass fiber, reinforced polyester and foam [17]. In that time actions like this were considered artistic manifestations. Clip-on extension of the director’s office in Centraal Museum in Utrecht, by Atelier Van Lieshout was mounted in 1997, and now constitutes a part of the Museum exposition [18].

Recent social problems in Europe gave a new sense to such interventions. Movement in favour of reclaiming locations for a minimum standard living spaces for homeless, immigrants and fugitives is developing. Young generation of architects and artists puts forward propositions of the different locations and develops appropriate projects. They follow citizen-led initiatives and temporary projects by people hoping to make their lives better. In some situations such ideas get clearance and are carried out; if not approved they remain illegal building works (Fig. 7).

In a crisis situation city authorities allow to organize temporary living spaces in forms that were unthinkable several years before. Architect Stephane Malka is an author of such shelters as A-Kamp 47. One of them is located between a cultural centre and a railroad network at La Friche de La Belle de Mai in Marseille. Its construction employs scaffolding mounted to a blind wall and separated from the street by vertically spread army tents [19]. Similar idea was employed in constructing a shelter in Herleen in Holland. A scaffolding mounted on a blind wall is divided into separate cubicles and protected from the outside by a patchwork of reused windows and doors [20]. Converting billboards of different types into habitable structures is one of the most interesting ideas. Supplied with energy, these big structures are distributed across cities as well as in the open, they cover blind walls, offering a challenge to architects and designers. In Belgium architect Karl Philips uses billboards to arrange different types of houses and shelters depending on the kind of a billboard structure [21].

Manifestations aimed at awareness of the problem of homelessness are also undertaken. Project of situating the structure of habitable containers under the cover of the Great Arch in Defense in Paris by Stephane Malka was published in 2009 [22]. Repetitive habitable structures can be mounted on the walls as the Rucksack House by Stefan Eberstadt. A cube of 9 m^2 offers a variety of activities: an extra bedroom, studio space or a living area. The box is mobile and in 2004 it was in Leipzig, in 2005 in Cologne and then in 2011 – in Bamberg [23]. Lara Calder Architects designed an advanced, parametric Parasite Prefab flat construction, aimed at mounting at walls, pillars of bridges and viaducts [24].

More realistic (and built) are living units occupying roofs of the existing buildings, using their staircases and installation ducts. Among the examples the Las Palmas Parasite in Roterdam, by Korteknie Stuhlmacher Architecten is the best known [25]. In Paris small flats in the “boxes” were overhung above the abandoned houses. This development by Stephane Malka, named 3BOX, is placed on and over their existing rooftops. It was made possible with a new legislation acts from 2012 on, that allow urban heightening in French cities [26].

Large scale propositions are also put forward. On Salerno - Reggio Calabria unused highway viaduct, Ja Studio Inc. designed “Slow up-rising” structure, a network of solar villages set in a picturesque landscape [27].

“Parasitic” conventions in developments occur recently in the housing areas as an architectural gag. Astonishing colours, forms and textures contrasting with the host-building adhere to the idea of comforting yet distinctive additions. Among them the extension by MVRDV (2007) of a house in Rotterdam is an outstanding example. Blue “one-room-houses” situated atop of the old structure, create private micro-townscape on the roof of the building. The bedrooms and atelier are conceived as separate volumes, providing needed space and privacy of every member of the family [28]. In Cologne, Germany, a red, irregular mixed-use building was constructed over a large historical entrance gate to the former factory warehouse area. Built by Manuel Herz Architects and named ‘Legal/Illegal’ by its designer. It follows all the building codes but also breaks conventions of a suburb house. It engages the core of the existing building acting as a true “parasite” and forming one cohesive unit with it. The extra effect factor was vital in this project, as the environment was not attractive, nor the district booming [29].

Many of the interventions mentioned above exploit the same aesthetic idea as the discussed before modernizations and adaptations built in compliance with the building codes and carried out by recognized architectural companies and star architects. They all contradict unity, rigidity and grid of architectonic composition.

4 Conclusions - from Avant-Garde Achievements to Institutionalized Developments

Parasitic volumes use construction, media, communication spaces from their mother-structures. Acceptance of this trend and its attractiveness is confirmed by the examples of ephemerical and exclusive structures built in locations offering unforgettable views and experiences. They come into being in the great cities of contemporary Europe. Temporary, transportable restaurant on the roof of the Palais de Tokyo Museum in Paris was designed in 2009 by architect Pascal Grasso. It offered a panoramic view over the Seine and the Eiffel tower as well as the top *quisine* [30].

Restaurant The Cube was designed by Park Associati Design Studio in Milan, as a pop-up restaurant and was sponsored by Electrolux Co. Since 2011, two versions of the restaurant have been located in different cities in Europe. During 2011 they visited Milan and Brussels, while in 2012 they were in London and Stockholm. In each city, the restaurants were placed on top of a monument; in Stockholm atop of the Royal Swedish Opera House, in Brussels on the triumphal arch at the Parc du Cinquantenaire, in London it was located on top of the Southbank Centre [31].

During the Expo 2015 this idea was revived, and restaurant "Priceles Milano" on the top of Banca Commerziale Italiana building, offered a view of the Piazza della Scala and silhouette of cupolas and towers of the city centre, along with the cultural events in its flexible, adaptable interior. It was designed in 2015 also by Park Associati Design Studio and supported by the Master Card investor (Fig. 8) [32].

There was a number of unaccomplished designs of additional commercial "parasitic" spaces throughout Europe; most of them were abandoned for financial reasons and some frightened away decisive bodies. Project by Claudio Silvestrin (2007), proposing a cafeteria on the rooftop of the National Museum in Poznan and postponed for a time being, inscribes itself within this trend [33].

The fact of emergence of the *parasitic extension* trend in architecture is confirmed by the A.I.R. prefab system by Canard Development Group [34]. The system consists of ready-to-mount elements that can be added to any building and multiplied to achieve expected size of the interior. These "parasites" also thrive on the media delivered by the main building.

It can be assumed that the gates to free structuring of a building volume are slowly opening.

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Guidelines for Managing Complex Scenarios for Optimization of Infrastructure Transformations

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Abstract. Infrastructure transformation strategies in rural areas are influenced by a lot of diverse aspects such as climatic or demographic changes. The optimization of these strategies is based on scenarios, which are basically containers holding input data. This paper presents recommendations for the design of a scenario assistant system to generate complex, but complete, valid and consistent scenarios in an intuitive and simple way for experts and non-experts in the water supply and waste water disposal domain. Requirements were collected in several workshops with domain experts and end users. The concept recommendations have been derived to improve and speed up the development process of future scenario management assistants.

Keywords: Scenario generation · Usability · Design guidelines

1 Introduction

In many rural areas, the population and settlement structure will drastically change over the next decades. Not only the natural mortality rate combined with the low birth rate has led to a population decrease, but more and more people will move from the rural areas to the cities. Among other aspects such as climate change, changes in law and individual water demands, this will lead to many problems concerning functionality of the water and waste water infrastructure in most rural regions.

To tackle the questions of how to transform the infrastructure in rural areas, the German Federal Ministry of Education and Research (BMBF) funded the project SinOptiKom where a transformation optimization and decision support system has been developed based on a stakeholder analysis [5] across multiple sectors (sanitary environmental engineering, spatial and environmental planning, computer science, and mathematical optimization). Complex relations and a high number of parameters define different scenarios, the system then provides optimized transformation strategies and an analysis tool [3]. Defining and generation as well as managing these scenarios is challenging. Therefore, a scenario generation assistant has been developed. Depending on the target group, different basic design decisions influence the usability of the scenario generation tool. Therefore, a meaningful application of design principles can improve the efficiency, effectiveness and the user satisfaction.

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In the paper at hand, we describe the requirements on the design of the developed scenario generation assistant. Our contribution are the concept design recommendations for complex scenario management applications based on various design and simplicity guidelines.

2 Related Work

2.1 Design Guidelines

The user work flow in a tool is heavily influenced by its design [20]. Maeda defines ten laws of simplicity in 2006 [9] which serve as guidelines for the development and evaluation of tools since their publication [11]. Lemberger and Morel [10] describe the value of simplicity in information systems and propose best practices for designing those systems. However, there are limits of simplicity. At some point of simplification, there is not enough content left for the users to understand labels, title, charts, etc. in the same way as the creator intended to express [12]. Therefore, an appropriate balance of simplicity and complexity is needed, as also stated by Maeda's 5th law "Differences" [9]. This balance becomes an important challenge in the management of complex scenarios.

Further, following the Gestalt principles by Wertheimer [17, 18], the organization of elements has a large impact on the user's perception. The perception directly influences the performance as well as the size of and distance between interactive objects which is defined by Fitt's law [15]. MacKenzie and Ware extended Fitt's law to include lag in interactive systems [16].

Different devices such as desktop PCs or tablets have different display sizes and resolutions. Therefore, design guidelines for responsive design [13, 14] have been developed. Particularly, the use of touch-based devices needs special adaptations [19].

2.2 Scenario Definition

Following Heinecke and Schwager [1], scenarios describe alternative, plausible and consistent images of the future which consist of logical and internally correct assumptions or descriptions of development paths of possible future situations based on present structures leading to these images of the future. In contrast to simple forecasts, a scenario does not provide any information about probabilities. Therefore, it is important to develop scenarios systematically and comprehensible.

In this paper, we apply the following definition: a scenario defines a collection of assumptions for different drivers and a set of basic parameters. It includes the complete description of all aspects and information that are necessary to start potentially following processes: in our case, the optimization and the visualization of the results and the water infrastructure as well.

2.3 Transformation Support

The planning of infrastructure transformations and its supporting is a big challenge. Different approaches already exist, from integrated dynamic visualization in geographical information systems (GIS) [6] to combination of GIS and cellular automata theory [7] to model urban growth. The tool described by Kulawiak et al. [8] aims to support in different domains, infrastructure vulnerability assessment, diminish risks and strategic planning of city development. These approaches are focusing on cities where many aspects significantly differ from conditions in rural areas which has been focused in our project. Furthermore, the preparation of scenarios and the analysis part is integrated and cannot be used independently.

In the paper at hand, we present requirements, concept design recommendations and a use case of a scenario generation assistant.

3 Requirements

In the following section, basic requirements based on expert feedback are presented. Scenario generation and management tools in technical domains (e.g. environmental engineering) have to deal with various requirements. Most of the time, complex scenarios cover different domains, hence, multiple experts and stakeholders exist. To gather the requirements of a scenario generation tool, multiple workshops with many stakeholders from the waste water domain, including experts and end users, were conducted. Based on their feedback, we concluded the following needs which can be transferred to other domains.

Scalability: Obviously, different stakeholders belong to different user groups: e.g. starting from a local village major who wants to have an overview, mostly cares about costs and acceptance to the experts who are interested in and focused on technical details such as diameter of sewers or flow rates. Designing a tool which has to fulfill the needs of all user groups is very challenging. Therefore, the scalability across different user groups is crucial.

Another basic requirement that results from different user groups is the platform and device independence. The users use different systems (Windows, Linux, MacOS) and different devices(stationary desktop environment vs. mobile devices) at work. The use of tablets was rated as an important aspect which requires an adapted graphical user interface (GUI) design to provide scalability across devices.

Simplification: The complexity of the scenarios cannot be managed in its entirety at once. Instead, a separation in multiple smaller parts is needed where each part deals with a few aspects of the whole scenario. This multi-part management should lead the user through the scenario generation and management process.

Further, some kind of additional help functionality should always be available to guide the user in his current task. This is essential since most of the time the user is not an expert in all necessary domains.

Background Activity: In complex scenario definitions, and it is not unusual that many aspects influence each other, resulting in many internal data links and dependencies.

Hence, some configurations that are made by the user in the one part of the scenario may restrict options and configurations of other parts. This basically requires internal decision trees in the background so that an option is not selectable anymore. Otherwise, incorrect combinations might occur in the final scenario definition and further steps are more complicated or impossible.

File Management: Depending on its complexity, it might be very time consuming to define and generate a complete scenario. Thus, users might pause their work and continue later. To simplify and secure this process, one need a possibility to save the current state of the generation process and load it later to continue working. This should also enable a duplication of already defined scenarios to create similar and comparable scenarios by manipulating only a few configurations instead of starting from scratch.

Further feedback and requirements were directly related to environmental engineering domain. However, the presented requirements can similarly occur in other domains.

4 Concept

The following section focuses on the derived concept based on the above-mentioned requirements and taking into account related design guidelines and principles.

Platform and Device: Concerning the platform and device independence, important aspects have to be considered. While the platform independence is given by an adequate selection of development environment and programming language, the device independence leads to other challenges. Example: small hyperlinks in text passages can be clicked quite well in desktop environments using mouse and laptops with touchpad. However, in touch screen-based settings such as tablets, these links are hard to get. Here, at least larger text or alternative UI-elements like buttons are usually used nowadays to provide easier, more comfortable and mobile-device-adapted input possibilities. Furthermore, guidelines of responsive design propose grid based layouts amongst others. Structuring the contents that way, the display space can be efficiently used across different display sizes and resolutions.

Step-by-step: Based on the requirements for simplification, the scenario generation is split in multiple parts. To fully define a scenario, the user has to configure parameters and give inputs, a step-by-step workflow supports the user to not forget any part. To visualize the workflow, we recommend a progress bar consisting of single elements (one for each part) which can be enriched with additional details providing information, e.g. categorical names. Color-coding the progress bar elements assists the user to identify finished parts or parts that require input. Furthermore, the progress bar elements can directly be linked to the corresponding parts which simplifies the navigation.

Appearance of Options: Each part of the scenario is presented in one view. For the design within one view, Maeda's second law "Organize" [9] and the Gestalt laws [18] lead to a similar appearance which should be consistent across the application based on the above-mentioned grid layout. This is true as well for the presentation of options (settings which the user can select). Grid layout based and large UI-elements for the available options makes the system appear simpler. Large elements and short distances between the elements have another advantage: following Fitt's law [15], these two aspects positively influence the usability.

Following Maeda's first law "Reduce", the presented options should not be completely filled with information. Although more information about various options is available, it is recommended to reduce the content to few meaningful components such as short significant title, short description, and potentially a meaningful icon, image, or a chart.

In addition, so called "quick-access-options", i.e. predefined configurations, usually save a lot of time. These quick-access-options have to be prepared and defined by domain experts of the corresponding scenario part. It can be guaranteed that the selected option is internally consistent while the user does not need to care about the detailed parameters, instead he can select one of these options. As stated by Maeda's third law "Time", "savings in time feel like simplicity" [9] and hence, reduce the subjective complexity. However, it is essential to provide an additional option for individual input in case the proposed predefined quick-access-options do not represent the user's needs.

On-screen Help: Help functionality can be implemented in many different ways. The simplest way is to provide a manual accessible via menu item. However, an alternative is on-screen help, e.g. for possible next steps. On-screen help in this case means that information is provided directly inside the current application view as overlay text describing single elements. This is similar to the layer management in geographical information systems: the basic layer shows the map, a second layer overlays street names, city names, etc. While shading the GUI except the described elements the user's focus is guided towards them.

Hidden Calculation: As stated in the requirements section, usually a lot of background knowledge is necessary to calculate influences between different options by traversing decision trees. The user is not interested in the calculation process, so this complexity should be hidden in background activities (following again Maeda's first law "Reduce"). However, the user is interested in the outcome of those algorithms. Consequently, excluded options have to be displayed as disabled option but not hidden at all. Maeda's law "Differences" supports this: find a balance between simplicity and complexity. Hence, show that there are more options but not available in the current configuration of the scenario.

The presented concepts are generalizable and not restricted to the domain of water supply and waste water disposal infrastructure. They are easily transferrable to other similar assistant tools in other domains. In the following section, we present an application use case of a real-world project where we applied our concepts.

5 Application Use Case: Waste Water Infrastructure Planning

The research project SinOptiKom has been funded by BMBF in the context of "smart and multifunctional infrastructural systems for sustainable water supply, sanitation and storm water management" (INIS) and tackles the optimization of transformation processes of infrastructures in rural areas, focusing on water and waste water system. Future climatic, demographic or economic developments require adaptations to guarantee water supply and waste water disposal in the future. The intention has been to provide a software-based optimization and decision support system in which different possible futures can be optimized, analyzed, and derived for implementation in practice.

The system includes three main software modules: a scenario generation, a mathematical multi-criteria optimization [4], and a visual analysis tool [2]. The second module requires a formal description of the scenario which has to be optimized. The scenario generation module provides a tool to set key parameters (e.g. start and end year of the given period for the optimization, rainfall forecasts, water demand forecasts, or selection of available transformation measures) and weight criterions for mathematical objective functions such as water balance, costs, and recycling.

The optimization model is based on integer linear programming (ILP). Technical functional limits are analyzed and adaptation measures and transformation strategies are calculated, e.g. for sewers, shear stress and corrosion determine a functional limit for under-utilization [2, 4]. If the optimization locates values falling under this limit, in present or future supposed states of the sewer system, actions such as decreasing of sewer diameter are proposed.

Once the optimization has finished, the visual analysis tool loads the results and provides different views including a map-based visualization and different charts to support the analysis of the resulting transformation strategy [3].

Implementation: The implementation of the scenario generation assistant followed the concept recommendations which we derived from the requirements. In this section, we present our exemplary application of the concept and the resulting graphical user interface (GUI).

The tool has been implemented in Java 8 using JavaFX for building the GUI. Hence, the scenario assistant is platform independent and can be used on desktop PCs as well as on tablets (e.g. Microsoft surface). The layout of our tool is grid based (Fig. 1) and therefore offers a responsive design.

The concept of the step-by-step workflow has been applied so that the user is able to navigate through the different categories of the generation process back and forth. A progress bar was placed above the content of the current category and, as can be seen in Fig. 1, a color-coding has been applied to indicate the state of the category. A category can have one out of four possible states: *unseen*, *current*, *in work*, *ready*. The *unseen*-state (grey) simply means that this category has not been opened yet. As soon as the user sees a category the first time, its state is *in work* (yellow). This means that the user has opened this category at least once, but there are still some parameters to adjust or set. *Ready* (green) indicates that the corresponding category is complete,

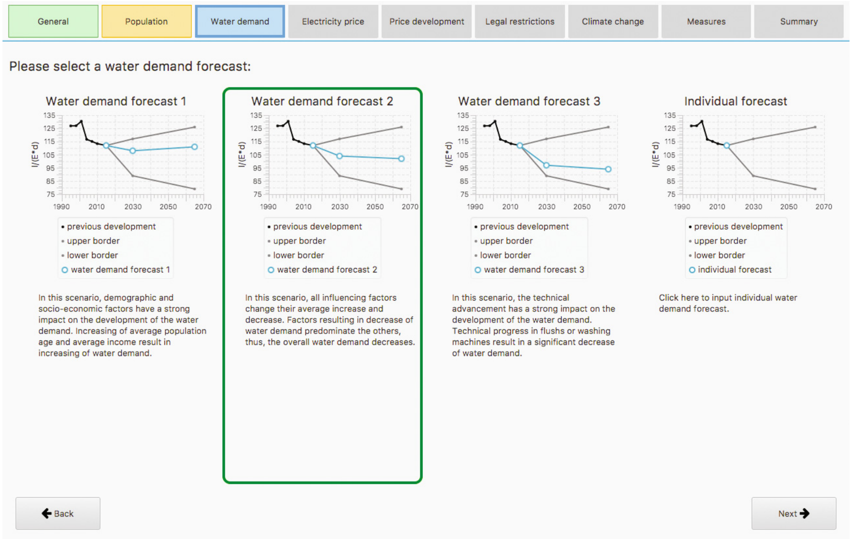

Fig. 1. Screenshot of the water demand selection.

i.e. all input fields are filled, required selections are made, and so on. Finally, the *current*-state (blue) marks a category which is currently open and can be edited by the user.

The screenshot in Fig. 1 shows the step where the user can select a future water demand development. The first three options are quick-access-options and based on real expert analysis, while the forth option offers the possibility to input individual values of water demand for future years. Each option consists of short title, a self-explanatory chart and additional short description. A green frame always indicates the current selection of the user.

The design of the other categories such as population or electricity price has been similar to the example in Fig. 1. Several options are presented in the same style, quick-access-options and additional individual option can be selected. On-screen helping hints and descriptions can be displayed as overlay via menu.

The final scenario generation assistant with its consistent design allowed users to create up to one thousand scenarios in the context of the project. Even though these scenarios are complex, experts, non-experts, and first time users were able to effectively use our tool with no difficulties.

6 Conclusion

In the paper at hand, we presented concept design recommendations for complex scenario generation and management assistants. Based on requirements gathered in workshops together with experts and end users, we conclude concepts such as step-by-step workflow with multiple usable progress bar. They incorporate the Gestalt principles, the laws of simplicity and responsive design guidelines. The application of the concepts in a real-world project context are presented in a use case in environmental engineering domain. Researchers of this domain were able to create different scenarios faster and with less effort. Overall, the presented generalizable concepts can be transferred to scenario management assistants in other domains.

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Beauty – Aesthetics – Senses Research of Attractiveness and Magic of the Built Environment

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Abstract. An objective of the taken discourse is cogitation over applicability of available research methods used to assess the built environment quality (i.e. architectural structures and urban interiors) in order to impartially and scientifically verify the beauty and appropriateness of the perception compared to subjective acceptability of a given place by its users. Methods that provide impartial data in architecture and urban solutions evaluation can be considered as quality characteristics. While the results closest to authors' expectations are obtained in the post-occupancy evaluation (POE) architecture research method, with studies in the field of environmental perception, and results of phenomenological research. Initial concept and assumptions were made for new methodology of design to be used by future architects and urbanists education, which gives more insight about the importance of *human factors* consideration in built environment.

Keywords: Human factors · Built environment · Aesthetics in architecture · Senses in architecture · Needs of users · Design quality · Design by research

1 Introduction

Aspiration and execution of a "place" where the people are willing to visit, identify with and care for by themselves, and often possessing the so called *genius loci*, is one of the biggest challenge and if successful, a source of incredible satisfaction for an architect and life creator in the built environment. A given space often "pulsates with life" since it is located for example at the intersection of transport routes, however, it does not mean the place is accepted. Users must use it having no other choice but in numerous situations, despite their monotony, depletion and untidiness, these "non-places" are life centres, spaces filled in with abundance of personal experience and memories. Another scene of the issue shows that regardless a given place potential and revitalisation efforts, the objectively beautiful/aesthetic space is deserted and unwillingly used. In the light of the foregoing, the following questions arise: why an ugly and dirty architectural space may possess "a genus loci" and assemble people, while an impartially beautiful and clean space will not? What is its reference to individual understanding of aesthetics and ergonomics (comfort and safety of use), to

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getting used to a place or social relations predominating at that place? What methods can be used to check/verify the issue so as to drawing up relevant conclusions not to make design mistakes or make less of them? Do the research, design and education methods currently used and pertaining to the architectural space development respond to contemporary needs and challenges? Finally, does creating a new paradigm for the problem in question make sense and take a chance?

Research results that are closest to authors' expectations may be brought by the expert groups' criticism of architectural/urban space known from environmental psychology in terms of behavioural quality. The assessment, in most general terms, refers to recipient's studying perception of a given place and observation of the place method of use and the user's behaviour at the place. References to proxemics, a notion introduced into a dictionary a half age ago by E.T. Hall are also helpful in the research. According to its scientific argument, the space "talks" and it is done via behaviour and mutual human relations and relations between humans and their surroundings [1].

The aforementioned research spheres background originates from the border of sociology and psychology. Furthermore, the essence of the problem in question that refers to the sense of the surrounding *beauty* and *aesthetic* experience are issues from phenomenological research area. Phenomenology is a philosophical direction that rejects being guided by traditional assumptions and suppositions. The trend assumes that the world should be perceived as individually experienced phenomena. Everything may become a subject of phenomenological experience: an object, event, situation, experience that can be seen, heard, smelled, tasted, felt, felt by intuition, met or understood [2]. The final objective of phenomenological research is reaching a universal i.e. repetitive and available to put into certain framework "essence" of the said research object [3] (Fig. 1).

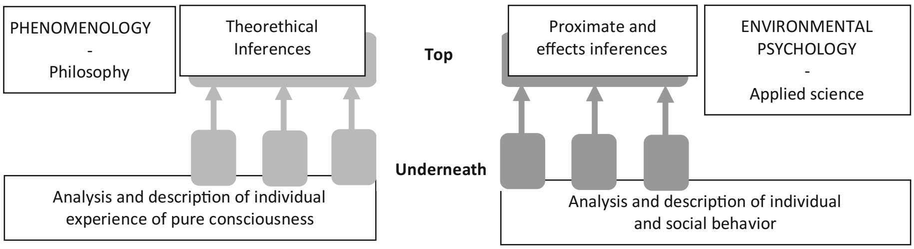

Fig. 1. Graphic overview of research methodology of phenomenologists and environmental psychologists (own study)

From methodological point of view both phenomenological and behavioural approach possess the status of qualitative studies, based on the one hand on radical empiricism assumption where critical intuition (enabling critical view) is a research tool, and on the other on the assumption that a given person and an object of cognition make upon indissoluble whole [3].

The text authors are convinced that the future of research in architecture and urban planning (in the field of aesthetics in particular), and the following support of education and professional process owed to them, lies within the methodology area that links both spheres mentioned above.

2 Aesthetics in Architecture – I Use, so I Evaluate

It is commonly believed there is no accounting for taste, that aesthetics is hard to evaluate since it can be perceived differently by everyone. Each of us, however as a user of architectural and urban space (the internal one of the structure and external of the surroundings), everyday evaluates the place he or she currently remains, sees and perhaps feels with other senses. We similarly interpret own appearance, the appearance of people we meet or objects we use.

The assessment of functionality, safety and aesthetics of the built environment is often automatic and influences making innumerable decisions, e.g. I will sit down here because the view is beautiful, I will not go there because it is dark, unpleasant and maybe unsafe, this is such a nice place that I will visit it again with friends, etc. In a certain simplicity, the conclusion is obvious – the beauty of a place is most often linked with its ergonomic and technical quality which provide a final aesthetic impression.

In the above context, it is nevertheless worth thinking about the words of outstanding figures: Edward Hall, ethnologist or Juhani Pallasmaa, architect. As early as in the 60s of the 20th century, Hall ascertained: "Architects traditionally deal with visual patterns of structures – things that can be seen. They are completely unaware of the fact that people bear in themselves certain internalizations of permanent space they learned at the beginning of their lives"[1] [1]. Pallasmaa on the other hand wrote: "the partiality of vision has never been so clear than in the art. of architecture of the last half century, when the type of architecture fixed on production of spectacular and haunting pictures became predominant"[2] [4], and "the unhuman nature of contemporary architecture and cities may be perceived as a consequence of body and senses neglect and lack of balance in our sensory system"[3] [4].

The problems of aesthetics in architecture are activities tended towards defining, understanding, and in consequence shaping such environmental features that would be a source of nice experience [5]. It is worth reminding that in terms of etymology, the word 'aesthetics' refers to sensual experience and not merely a visual one. Thus, in today's reality it seems justifiable to ask the following question: how to promote and stress in creating and reading the architecture the themes of not only its visual beauty[4], but also of opportunity to absorb the touch, read the sound, feel the smell and other experienced references. The issue becomes more complicated if we assume that there exist much more opportunities of the surrounding environment perception, just to mention the representation criteria, stimulating stimulus, phenomenal character or neural information. The question is the more justifiable when an insight at least into the

[1] E.T. Hall "Ukryty wymiar", p. 165.

[2] J. Pallasmaa "Oczy skóry", p. 38.

[3] Ibidem, p. 26.

[4] Read: spatial order, form, colour, texture, material, light, etc.

research of J.J. Gibson, psychologist is available, who recognizes senses as aggressive searching mechanism rather than passive receivers[5] [4].

In the aesthetics of Berlyne, one of the first creators of general aesthetic model, complexity of the environment, its new elements, incoherence in the environment and astonishment (level of inconsistency of what we found with what we expected) play a crucial role. Berlyne proposed to formulate aesthetic judgements on two levels: uncertainty – excitation (excitation associated with specific exploration increases along with the uncertainty or conflict increase) and hedonic value (associated with pleasure). His studies proved that we feel the best in a situation of average stimulation or uncertainty level which means we prefer non-excessively surprising solutions. Another example of interesting studies may be seen in the S. Kaplan environmental preference where authors highlighted four equivalent perception levels accounting for a higher acceptance level of such and not the other place: coherence– organization of setting; legibility – setting elements suggestiveness to allow better understanding and its content categorization; complexity – number and diversity of the setting elements (especially in the case of natural landscapes); mystery – number of information hidden in the setting that the observer is willing to discover. In other words, the complexity and its various aspects support a place perception as an attractive one but also make an indispensable condition for the perception to occur. "Complexity determines change and only the change is the source of information"[6] [3].

Coming back to practice – the architectural and urban space is co-created i.e. conceptualized, programmed and designed by architects, urban planners, constructors, interior and equipment designers, artists as designers of decor elements and investors themselves or their advisors. While designing targeted to a specific or anonymous user, they create aesthetics of a given work of art in accordance with their own sense of style, views and perspectives, possessed qualifications, investor's expectations, current fashion inspirations, studies and consultations performed, etc. Every originator must be aware that his work will be exposed to constant assessment throughout its "lifespan" (operation). The assessment may vary: from praise and delight through minor remarks up to overwhelming criticism.

Many designers, still convinced of their infallibility and uniqueness, deem any slightest symptom of criticism unauthorised and unworthy of attention. However, understanding and taking into account the needs, restrictions or aesthetic preferences of users seems unquestionable nowadays and in the future. The question is how to combine different user tastes (they like the structure they have been once enthralled by or the one owned by their rich neighbour or a building that cannot be built at a plot because of the exciting context and/or legislative conditions, etc.) with intuitive sense of beauty and pragmatism preferred by the creator? Can the architect without taking the recipient into account, impose his "own" aesthetics? Is he entitled to do this? Maybe he should create a "compromise aesthetic" based on surveys and research performed? It seems that the most favourable solution providing the designer with an impartial reasoning in at least certain scope would be presentation of the combined architectural

[5] J.J. Gibson after: Pallasmaa "Oczyskóry", p. 51.

[6] S.R. Maddi: after: Lewicka "Psychologi a miejsca", p. 97.

research made within the scope of environmental perception and in accordance with the phenomenology method.

Two concurrent trends have functioned in Poland so far: artistic approach to architecture and research approach based on human needs analysis. The latter type of design called *Design by Research* is the state-of-the-art approach, targeted at satisfying the users' expectations. It does not exclude an interesting and fashionable form of a building or space between buildings. Whereas the first, traditional approach where an architect-creator imposes many aspects, including aesthetics, on the user, is exposed to numerous faults and problems during utilisation.

In order to avoid the future disappointments, non-fitting in the needs of a given space users, and in consequence creation of a place that is ineffective, unfunctional, and unaccepted in terms of aesthetics, one of successfully used methods is participation design i.e. with the co-participating user. Today, the simplest method of perceiving the aesthetic preferences, i.e. their articulation by user, is presenting ready models of existing places (e.g. photographs) to enable the user's easy defining by indication during a survey or interview his favourite and disliked architectonic solutions. The indicated photos depict the user's sense of aesthetics, expectations towards the place "climate" (preferred places in a historical part of city or modern "sterile" architecture, colourful facades, lots of greenery, etc.). There however, we repeatedly go back to the starting point: architects still perceive aesthetics within the scope of vision sensations with omitting the other senses. Hence the need to deal with the problem.

3 Designing and Research in Architecture and Urban Planning

There are numerous methods of searching for design solutions in general. These are proposals worked out by psychologists, educators, praxeologists or creators (i.e. designers) themselves. They are rarely used in a "clear", textbook form. Every experience-supported designer, with the time works out his own, many a time intuitive and therefore original method which being analysed appears a compilation (mixture) of various well-known methods. An intuitive search is for instance division, analogy, guessing, association, compilation of images and notions, recollection of similar problems and their transposition as well as improvement of solutions. The main task of all design methods is support of intellectual and creative effort.

The most common methods in scientific world are the ones whose objective is to find new problem solutions based on earlier-known methods that did not bring satisfactory effects. They for instance include the following methods:

- morphological (a new quality is received via a new breakdown of known elements – parts);
- solution trees (we must approach a theme in a summary way i.e. create a summary problem solution);
- system methods (abstract models, mathematical, graphic, analogue or digital model or simply a description are used). Here methodical design, providing (with a great probability) instant satisfying results, is of primacy.

In designing, the architect mainly uses all heuristic methods that allow new solutions discovery via advancing relevant hypotheses. The methods known from the respective literature are for instance: synectics, brainstorm, morphological analysis, ideal solution method, and superposition method [6, 7]. The methods however, do not guarantee an anticipated result though obviously increase its probability. Moreover, they are not excessively formalised to remain a certain margin for human intuition. Neither strict obeying of activities sequence nor preciseness of their use are required in the said methods. The creator may fully use his knowledge and imagination. A certain downside of applying heuristic methods in design that they originally do not refer to opinions of the future solution user/users since the practical knowledge and expertise possessed by specialists i.e. designers constitute the foundation.

When taking into account user needs, expectations and restrictions, the urban design in particular, but also the architectural one is dominated by the architects' need/inclination/obligation to implement: the research results elaborated by sociologists, quantitative and statistical studies where obtained results are presented in descriptive form or expressed in digits and percentage. This is the basis to work out conclusions on the phenomena frequency, intensity and dependences existing between them. User opinions on a given subject are examined within the above studies; the opinions for instance include: where and how they want to live, what do they expect in their working environment, where and how would they most preferably spend free time, in what situations they come across most spatial barriers, etc. In that spirit, though guided by own considerations, Christopher Alexander developed an individual design method based on the concept of matching human needs or demands to possible object forms rooted in the context. His *"A Pattern Language"* is, in a certain sense, a collection of models originated from different disciplines: theory of systems, natural science methodology, linguistics, cognitive psychology, biology, genetics and others. *Pattern language* is from philosophical point of view an expression of holistic attitude to the problem and as a design method a manifestation of participation. *Pattern language* derives from the beauty of culturally-denominated form and defines the process targeted at creating a type of this form found in tradition, but from the start afresh, with no imitation but taking into account current cultural considerations [8]. Though Alexander's approach is of humanistic nature, the fact that his concept faced criticism of the architects' environment, does not seem astounding. It was blamed for its characteristic feature – additivity that enables selection and adding models to each other as well as putting one model onto the other that leads to creating the architecture that is impartially friendly in use but lacking the strength characteristic for great architectonic works, where the form of structure adopts a dominant role.

In recent years, a noticeable trend has exited that shows a growing interest of architects – designers in qualitative studies they intend and are able to apply in their design output. The following are known research methods in architecture: POE (Post Occupancy Evaluation), ABSIC (Advanced Building Systems Integration Consortium), and BiU (Building-in-Use) [7].

With reference to the aspects dealt i.e. research of space attractiveness and magics, the POE method checking behavioural quality is the closest method for the paper authors. In 2012, two original quality research methods were developed: the first is used to perform the pre-conceptual design research and the second to evaluate the built structure. However, according to this paper authors' opinion, the future of architects will also depend on skilful application of research results related to environmental perception and phenomenological expertise.

3.1 Quality Research Method (According to K. Fross 2012)

On the basis of 15-year experience, two original methods of built environment research have been developed. They involve schemes of procedure when doing research, that in sequence picture the required activities to be performed. The first "8-step" method is used to perform pre-design studies to formulate design guidelines. The second, "7-step" method is intended for evaluation of a structure accomplished by its designer, in order to verify decisions made at the design stage. The methods are of universal and open nature, may be modified, complemented and adjusted to specific research demands. Different tools have been applied, such as: observation of users' way of use and behaviour, quality assessment (e.g. behavioural quality), surveying, interviews, spontaneous and occasional talks, etc., that should be individually picked out according to needs and anticipated results.

The author's method to pre-design studies of facilities with similar functions as sources of knowledge useful in design. The method objective is to obtain knowledge from the existing built environment of a similar function, as the information basis for the author's own design. The research is conducted in pre-design stage before starting to build a programme and to create a concept. It focuses on making an assessment of architectonic and urban structures according to pre-set criteria and quality. The results obtained are analysed and grouped, conclusions are drawn to make the basis for formulation of the design guidelines. The assessments may be of general nature or be directed onto a specific problem e.g. aesthetics. The research preparation involves: defining the research objective and scope, make a list of properly selected buildings or fragments thereof, select relevant evaluation techniques and methods (e.g.: building round, making photos and films, interviews, occasional talks, surveys, graphic analyses, calculations etc.), make auxiliary tables of quality assessment (e.g. technical, functional, organizational, behavioural or economic assessment) specifying the assessment scope (exterior, interior, selected elements, functions, zones, rooms) that during assessment facilitate the recording, control and systematization of research, prepare graphic materials such as maps or site development plan, projections or schemes thereof, photos of solid (facade), etc. [9].

The author's method of evaluation of facilities implemented as verification of design decisions. It is the method of quality evaluation at the stage of the designed building utilization and make up a feedback tool for the designer or designer team to verify the design decisions that have been made and obtaining experience to be used in further tasks. The method is an important element of the designer's self-improvement. It is targeted at obtaining information from the implemented project. The research involves the facility quality assessment and observation of user behaviours. The research should be performed repeatedly: obligatorily in the first month of use, after 6 months, 12 months and e.g. 2 or 3 years. The research may be done in all quality categories or may be focused on a given problem. Occasional talks with users or surveys are recommended. An interview with the facility administrator is obligatory. A talk to the investor and obtaining his opinion are also recommended. The scope of observation may be restricted to definite problems such as user behaviours, work comfort, safety, aesthetics, etc. [9].

3.2 Problems of Environmental Perception and Phenomenology

Perception also named cognition or impression, like aesthetics, refers to human perception of certain phenomena or processes that occur due to specific stimuli affecting our sensory system. It covers not only a complex, subjective cognition process or experience and memory but introduction of one's activeness (i.e. expectations, values, objectives, ensuring safety, etc.) into the environment as well. Also, culture significantly influences the perception processes.

The said process takes place on two following levels: the sensory and motor level (of automatic nature, the stimuli are received by senses owing to whom people identify colours, sounds, roughness, smoothness, characteristic smell, etc.), and meaning and activity level (here stimuli are assigned with the meaning: perceiving and interpretation of a human smile, noticing the feelings of an observed person, etc.). while studying the perception issues, psychologists very soon (i.e. in 19th century) realized that people are sufficiently different so as each of us can perceive and describe own sensory experience in a various way. Today, in the scientific circle dealing with the problem, anyone doubts that solvings the perception issues present an unusually complex task and it should be studied in different ways and aspects. In other words, there is no space in contemporary science for conventional perception approaches that often deal with the way the sensory mechanism records single aspects of an object in the surroundings. There, the problem is to be solved as a holistic i.e. overall process [5].

And here, in some measure, the phenomenological methodology comes as aid which "refers to "practicability" of subjective personal experience, contrary to external, impartial reality". The phenomenological experience, including the experience of a place still has sensual nature and its contents depends on the shape and position of our body. It is worth noticing that a new paradigm in cognitive psychology has introduced a notion of *embodied cognition* and for several decades has been a basic notion of phenomenological approaches[7] [3].

When carrying out the above deliberations, one cannot omit in architecture and urban planning the issue of *Genus Loci* and its objective reality. It is an important theoretic notion in the works of phenomenologists of place who try to inquire what features of these places respond to the subjective sensation of their unique specifics. *Genius Loci* is recognized by humans but its source originates in the off-subject features of the place.

And the last issue absorbing the authors in the above discussion. A new theoretical category has recently appeared in the works of the complex systems theory representatives who seek biological references to the analysis of processes that govern the

[7] M. Merleau-Ponty, Y.F. Tuan after: Lewicka "Psychologia Miejsca", p. 40.

organic development of cities. This category is a concept of urban and regional DNA which like biological DNA guarantees the identity of a place, despite various changes it undergoes[8] [3].

4 Summary

Today, when critics deal with the problem of aesthetics and beauty (whether in a professional or amateur way), they undertake an evaluation of architectural and/or urban solutions, almost always use only their vision and based for example on photographs, historical memory. Generally, it can be noticed that people who have the ability to see rarely attach importance to the other senses. The perception applies especially to the situation of admiring the beauty (in popular opinion - aesthetics) of the surrounding landscape. And the second regularity, that does not require scientific evidence: the experience of other senses counts mainly in the moments when, for example, despite (theoretical or objective assessment) beautiful views reach other stimulants that are inappropriate for us, such as unbearable noise or odours or when we feel a complete lack of orientation in the field. On the other hand, the current activities of marketing specialists successfully use not only the vision but other senses as well. We feel good during the visit in the store that smells good, when someone or something subtly guides us to the goal, and therefore we are not lost when there is a lot of space for exploration of the goods or when the "soothing voice" tells us about the different promotions. In other words, in today's world, supported by a marketing techniques, consumer goods are beginning to occupy a significant place in the consciousness and trivialize our ability to analyse and evaluate (Fig 2).

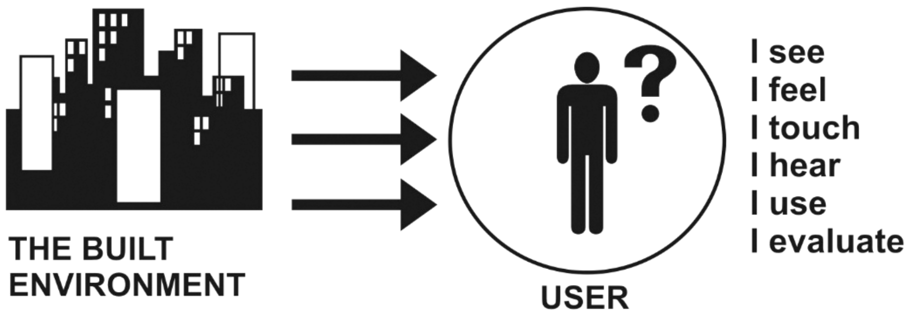

Fig. 2. Modern understanding of the role of the architect in the designing of the built environment (own study)

In a natural way, for the inquisitive researcher of architectural space, the following question arises: why in the European realities designers of individual buildings or space "between the buildings" extremely rarely encourage customers to use other senses than

[8] E.A. Silva, N. Wu after: Lewicka, "Psychologia miejsca", p. 61.

sight to admire the beauty, and the implied aesthetics? Where is the problem? Whether in public education, or even in education of professionals?

Reading the above arguments and considering them to be right, it is worth asking why this is happening? Is the reason for this that modern architecture assimilated psychological strategy to promote the work, its advertising and insistent persuasion? Maybe the problem lies in healthy (based on hygiene) lifestyle as a priority? Is that why we do not want to or even cannot use other senses than sight? An alternative for the search for the causes of cherished sense of vision can also be delving into the historical theses of theory of architecture, which consisted mainly standard - visual proportions of the human body in relation to the building under construction, according to the Vitruvius "measure of all things is the man," the search of ideal proportions of the human body, or the use of modernist "Modulor" of Le Corbusier to shape the immediate human environment [10].

It should be emphasized that the article tried to look at the problem of the scientific search for the principles of aesthetics from the architect's point of view, not only in professional way but also from a university teacher and researcher's point of view, the authors are both representatives of. It is not their ambition to independently create a new methodology of design and learning because they believe that today this task is interdisciplinary, where a much greater extent than in environmental psychology permeates the knowledge of psychologists, sociologists, anthropologists, architects and other scientists. The task, which was set, is primarily an indication of the issue that directly affected and now extremely trouble architects and urban planners.

The basic problem noticed by the paper authors still lies in the fact that scientists, especially those in the first two mentioned areas, are not able to communicate – they are using different methods and techniques of research and they are recognizing its methodology for more appropriate. Such cooperation, which aims to identify new formula of approach to the development of environment, that is friendly for human, is extremely desirable. The combination of "strength", the interdisciplinary nature of the research, the expected development of the methodology will serve architects and city planners in the process of taking into account the human factor, and consequently also the aesthetic attitudes. Apparently, most of us feel that the border between everyday usual life and science seems thicker.

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Accessibility, Easy and Comfort of Using Sanitary Devices by Preschool Children: Pre-design Studies

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Abstract. Using the standard bathroom facilities and equipment designed for adults by small children presents numerous difficulties. Due to the smaller size of the child, its motor space (particularly space of reach and grasp) is also reduced. For this reason, the use of standard full-size sanitary devices intended for adults is uncomfortable and dangerous for the child, and usually requires a help of parents or caregivers, what in turn results in limited development of the child self-reliance and independence. Actions taken during design hygienic-sanitary rooms used by preschool children should include the possibility of creating favorable conditions for the availability, safety, and adaption of them to the needs and demands of small users in terms of entire functional-spatial structure and individual functional elements of equipment. The bathroom facilities should also be friendly, cozy and inviting aesthetically. The paper will be presented the motor-space analysis associated with the use of bathroom devices by children of preschool age. The work will also be discussed ways to introduce facilitations and additional improvements in the bathroom for small users. The possibility of introducing to the bathroom devices with reduced dimensions adapted to the needs and motor skills of small children, as well as additional support elements will also be considered.

Keywords: Ergonomics · Architectural design · Interior design · Bathrooms design · Toilets design · Hygienic-sanitary facility · Kindergarten bathroom · Sanitary devices · Preschool children · Motor skills · Accessibility · Safety · Comfort · Well-being

1 Introduction

Hygienic and sanitary spaces because of its utility character is a special place in the house structures, as well as in public institutions. Comfortable bathroom, which is convenient, safe and allows optimal psychophysical condition for users, to a large extent determines its functionality. The layout, size and equipment of the bathroom and its location should be adjusted to ensure maximum comfort and safety of all users, regardless of differences in age and physical fitness, including children of all ages, also toddlers and preschoolers that require special extra care. Therefore, already at the design stage, the possibility of bathroom adaptation to diverse and ever-changing needs of all users

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should be considered. Convenient and easy implementation of hygiene activities and physiological functions by children, both in the home bathroom, as well as in other hygienic-sanitary places, such as kindergarten bathroom, requires properly arranged space, adapted equipment, comfortable psychophysical terms and conditions associated with the sense of safety. In order to accomplish the above tasks, it is necessary to fulfill certain ergonomic criteria, among other things, related to the characteristics and motor skills of children, selection of sanitary devices and ensuring adequate health conditions and terms affecting the safety of the bathroom.

2 Ergonomic Criteria for Accessibility, Ease and Comfort of Using Bathroom Equipment by Children

Accessibility of bathroom equipment intended for adults and use of the standard bathroom facilities by small children is associated with numerous difficulties and can be a serious problem for them. These inconveniences are usually caused by too highly placed sanitary devices. Due to the smaller size of the child, its physical, motor space is also reduced and limited. These limitations include particularly space of handling - space of reach and grasp. For this reason, using the standard equipment of bathroom and full-size sanitary devices is uncomfortable and dangerous for the child, and usually requires a help of parents or kindergarten teachers, what in turn results in limited development of the child self-reliance and independence.

Ergonomic actions taken during design hygienic and sanitary spaces and rooms used by preschool children should include the possibility of creating favorable conditions for the availability, safety, and adaption of them to the needs and demands of small users in terms of functional and spatial. Providing friendly, ergonomic bathroom space for kids can guarantee not only their comfort and safety, but also willingness to use, which may contribute to their interest in taking care of hygiene from an early age. Therefore, if it is possible, insertion into the bathroom sanitary devices with reduced dimensions designed for children, is advisable. Adapting the bathroom to the needs of children is also possible with the help of additional elements that facilitate the use of various pieces of equipment [1, 2, 5].

3 Spatial-Motor Requirements of Preschool Children Using Hygienic-Sanitary Space and Devices

Analysis of spatial-motor requirements of people with diverse physical fitness and motor skills is the basis for shaping the hygienic-sanitary and its equipment. Therefore, in designing the hygienic-sanitary space used by children and the selection and arrangement of sanitary devices should take into account the following demands:

- determining the range of reach and grasp space on the basis of the characteristics and motor skills of children of preschool age,
- taking into account the specific requirements of space and movement in preschool children, whose mobility is limited due to the still undeveloped full physical fitness,

- considering that kids due to head proportions relative to the whole body, which differ from the proportion of adults, have the center of gravity shifted towards the head,
- taking into account the lack of children's sense of distance and their vulnerability to accidents,
- considering the possibility of application of the elements supporting the use of sanitary facilities.

4 Use of Hygienic and Sanitary Devices - Analysis of Spatial-Motor Requirements Based on the Characteristics and Motor Skills and Abilities of Children of Preschool Age

In order to determine the extent of reach and grasp space with respect to the use of individual sanitary devices it is necessary to examine the characteristics and motor abilities of users - children of preschool age. The spatial-motor analysis in relation to the anthropometric features of preschool children (4-year-old, 50th centile) that use sanitary devices (washbasin and toilet bowl) are presented in Sects. 4.1. and 4.2. Different types of activities, different positions and different phases of the movement were examined. The results of the analysis provide a basis to determine the extent of reach and grasp space - dimensions of movement surface in horizontal and vertical views. Different ways of functions realization were compared (using the full-size and the small-size sanitary devices), their advantages and disadvantages were identified. Also, the possibility of the use of additional facilities and support elements were taken into account [3, 4].

4.1 Use of the Small-Size and the Full-Size Washbasin - Analysis of Spatial-Motor Requirements Based on the Characteristics and Motor Skills and Abilities of Children of Preschool Age

Figures 1, 2 and 3 show the spatial-motor analysis of the child (about 4-year-old) using the washbasin. Figure 1 presents the approximate dimensions of the child (about 4-year-old), its spatial-motor requirements and the extent of its motor skills and capabilities - the extent of reach and grasp during activities related to the use of washbasin. Figure 2 shows the spatial-motor analysis of 4-year-old child using full-size washbasin located at the standard height - 85 cm, with the help of the children's stool with height of 22 cm. Figure 3 presents the spatial-motor analysis in relation to the use of the full-size washbasin located at the standard height - 85 cm by a 4-year-old child, with the help of universal stool with height of 17 cm. The analysis includes the following range of activities performed by the child:

- standing at the washbasin,
- setting children's stool,
- getting on the children's stool,
- turning on the tap,
- washing face.

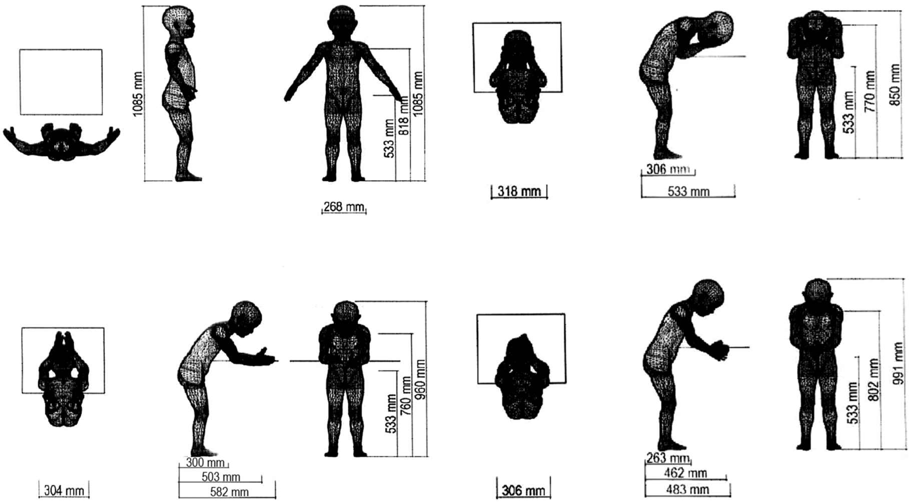

Fig. 1. The approximate dimensions of the 4-year-old child, its spatial-motor requirements and the extent of its motor skills and capabilities - the extent of reach and grasp in relation to the use of washbasin. (Source: own work)

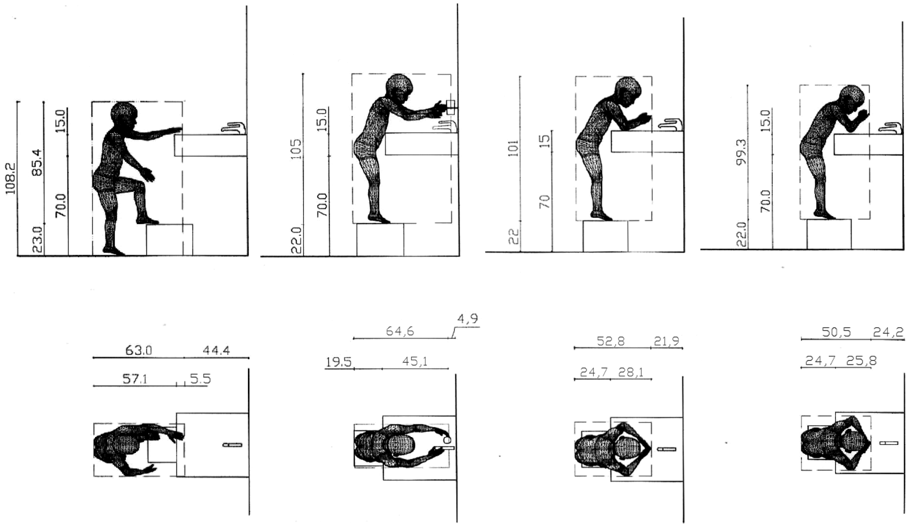

Fig. 2. Spatial-motor analysis in relation to the use of the full-size washbasin by a 4-year-old child – getting on the children's stool (22 cm), turning on the tap, washing face. (Source: own work)

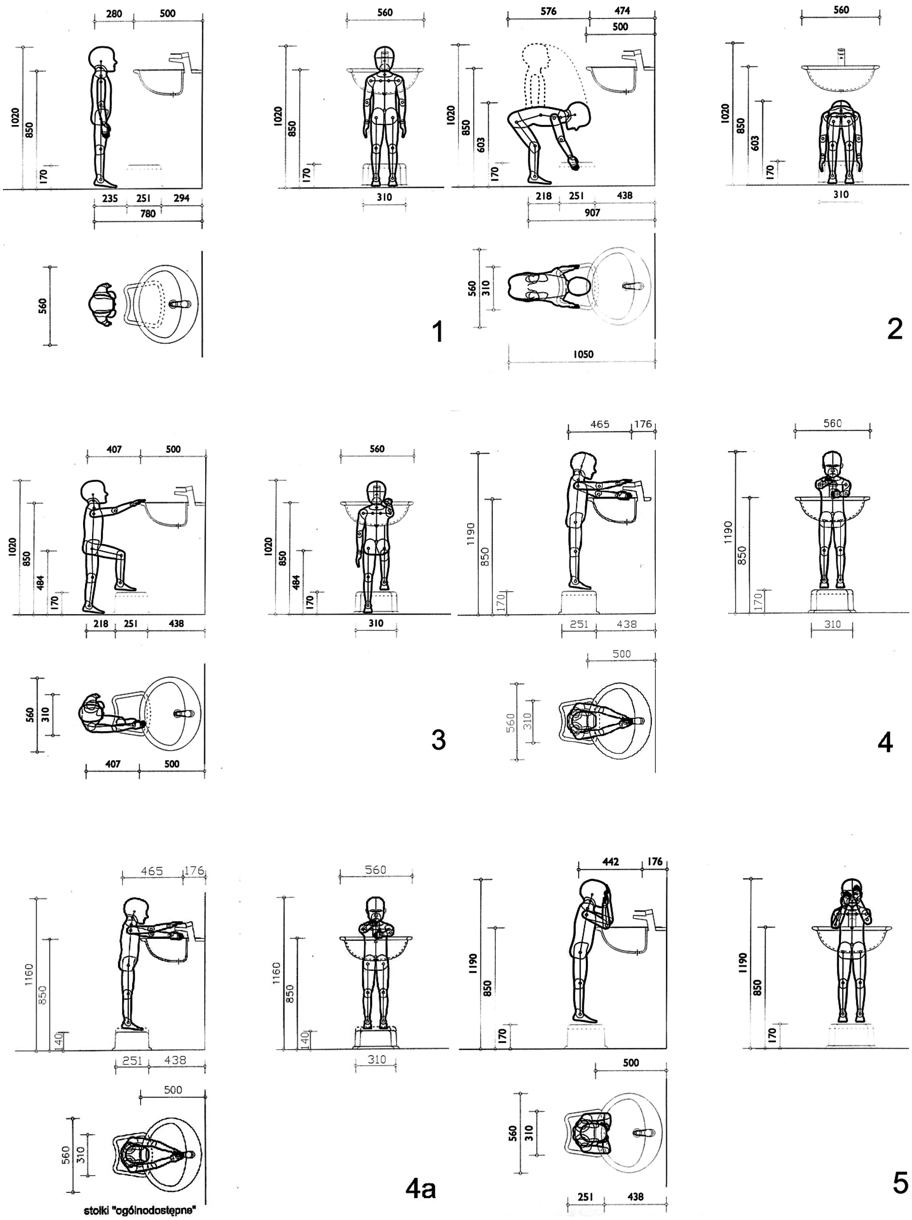

Fig. 3. Spatial-motor analysis in relation to the use of the full-size washbasin by a 4-year-old child – getting on the children's stool (17 cm), turning on the tap, washing face. (Source: own work)

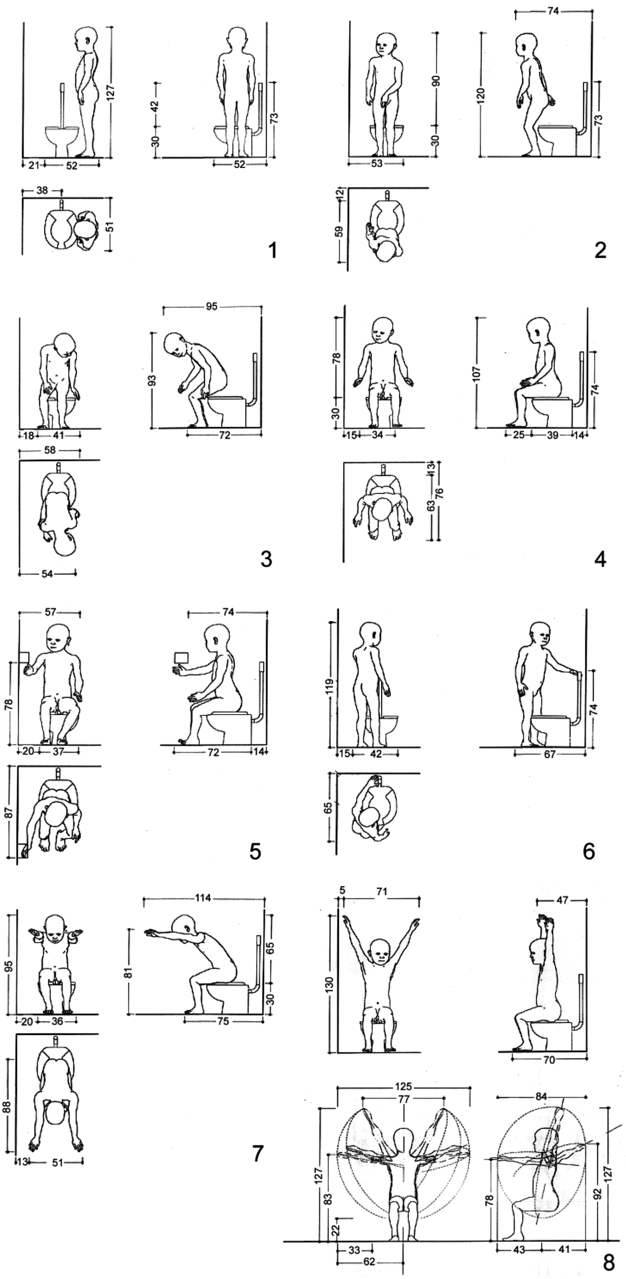

Fig. 4. Spatial-motor analysis in relation to the use of the small-size toilet bowl by a 4-year-old child - sitting down and sitting on the toilet seat, reaching for toilet paper, flushing, the range of motion space. (Source: own work)

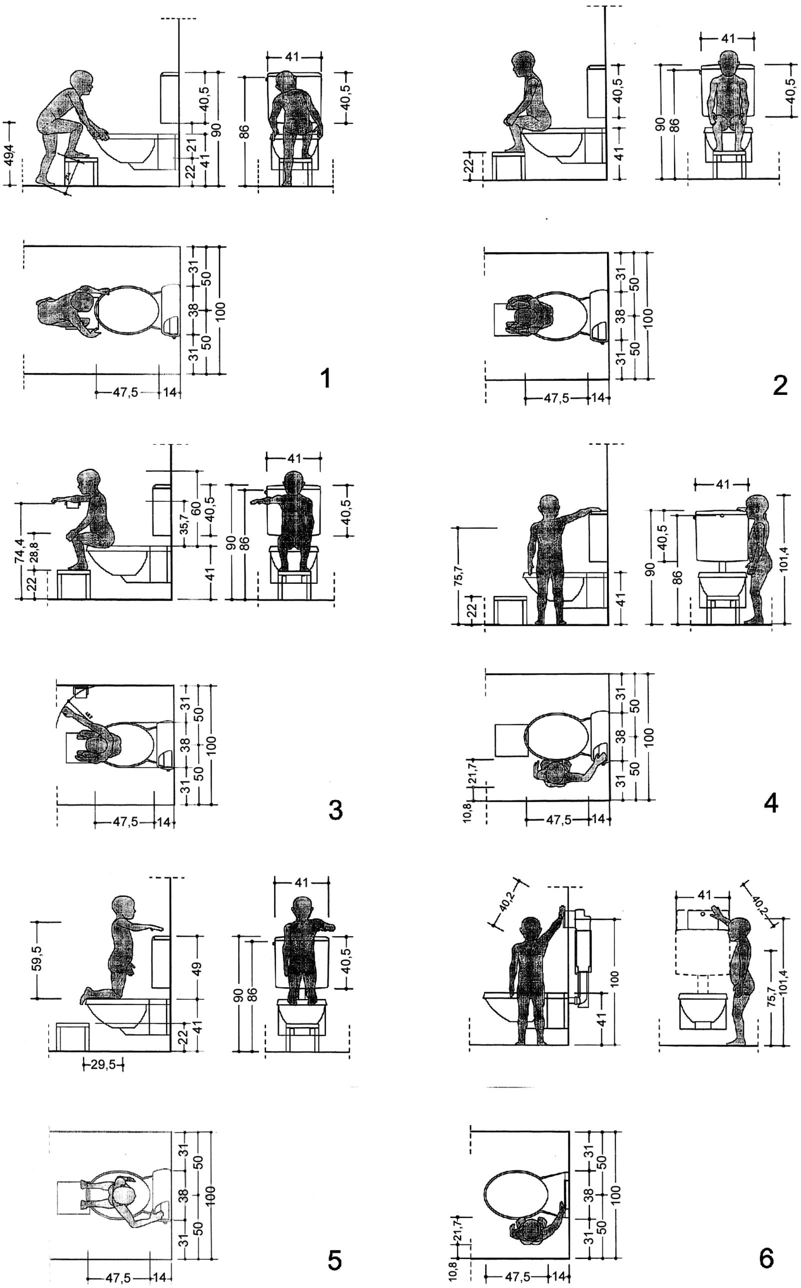

Fig. 5. Spatial-motor analysis in relation to the use of the full-size toilet bowl by a 4-year-old child - sitting down, sitting on the toilet seat, reaching for toilet paper, flushing. (Source: own work)

4.2 Use of the Small-Size and the Full-Size Toilet Bowl - Analysis of Spatial-Motor Requirements Based on the Characteristics and Motor Skills and Abilities of Children of Preschool Age

Figure 4 presents the analysis of spatial-motor requirements in relation to the characteristics and skills of a 4-year-old child that uses the small-size toilet bowl (height 30 cm, length 39 cm). It includes the following steps (functions):

- sitting down on the toilet,
- sitting on the toilet,
- reaching for toilet paper,
- flushing.

Figure 5 shows the spatial-motor requirements and the range of motor skills of children (4-year-old) using the standard full-size bathroom facilities.

Figure 5 shows the spatial-motor analysis of 4-year child that uses the toilet bowl hung on a standard height of 41 cm (with a flush tank suspended at a height of 90 cm and with a flush tank flush mounted at height of 100 cm) using a children's stool with a height of 22 cm. The analysis covers the following:

- sitting down on the toilet,
- sitting on the toilet,
- reaching for toilet paper,
- flushing (2 ways - kneeling on the bowl, standing at the flush tank - 2 variants).

5 Conclusion

Based on the analysis and the measurements it was found that for spatial-motor reasons, small-sizes sanitary devices (with reduced dimensions) should be implemented into the bathroom used by preschool children:

- suitably shaped a small washbasin (e.g., with dimensions of 49 × 42 cm or even smaller with dimensions of 40 × 33 cm) installed at a level corresponding to the child's height allows the child to comfortably and safely use of it,
- recommended installation height of washbasin is 55–65 cm above the finished floor,
- mounting height is also important for additional equipment: mirrors, dispensers for soap, dispensers for paper towels, hangers, holders,
- small toilet bowl, e.g. with a width and a height of 30–33 cm and a length of about 40 cm provides comfort to use of it even for the smallest children,
- a 33 cm high toilet bowl will eliminate the necessity of a child climbing on "adult" toilet bowl,
- in addition, the small size of the toilet bowl increases the safety of use, for example, by reducing the risk of falling child into the toilet bowl - proportions of child head relative to the whole body differ from the proportion of the adult and the center of gravity is shifted towards the head,
- preschoolers have different dimensions and adjusting the size of the toilet bowl by using a special children's toilet seat can be useful,

- location and mounting height of the toilet paper dispenser should be convenient for small children (approx. 75 cm above the floor),
- the minimum distance between mounted sanitary devices or between the device and the wall should be approx. 20–25 cm,
- in the case of the opposite arrangement of devices to each other or to the walls, the distance between them should be 75 cm [1, 2, 5] (Fig. 6).

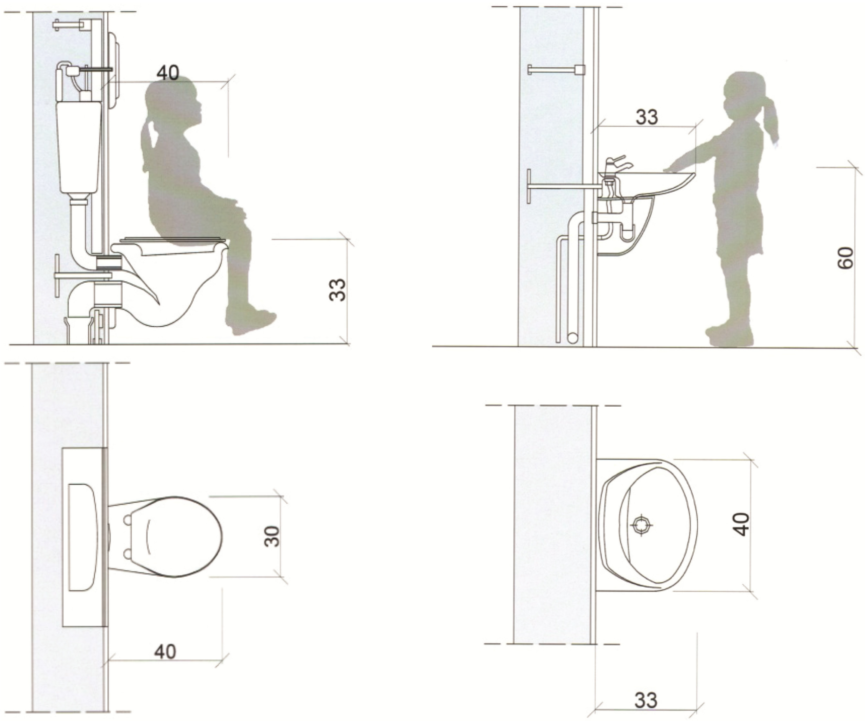

Fig. 6. Examples of sanitary facilities adapted to the needs of a preschooler. (Source: own work)

The bathroom, in which for various reasons is not possible to install devices intended for children should be equipped with other simple facilities and improvements. Thanks to them, the daily activities related to taking care of hygiene will be much safer, more comfortable and enjoyable at the same time:

- special children's toilet seat for adjusting the size and shape of the toilet seat, combines the functionality and safety of use toilets,
- low, wide tabletop under the washbasin can be mounted to provide better accessibility,
- convenient children's stool or platform (with a height of about 20 cm) finished with a soft rubber, on which the child can safely stand and reach for the tap, should be easily and directly accessible,
- special shelf for the bath toys can be located within the child,

- hangers and towel holders should be located on two levels - higher for older and lower for younger family members.

The necessity of adapt optimal height of locating sanitation to children's needs should be considered, taking into account that bathroom will be also used by adults and that children grow very quickly. The location and installation of bathroom equipment in a way that they can be used both by adults and children is a compromise. For example, the use of low-tabletop under a high washbasin is a universal solution. It will be located at the standard height - 85 cm above the floor, while the low tabletop will facilitate use of washbasin by child that with the help of a children's stool or platform will be able to reach the tap, propping up safely on the tabletop. In this situation, stable mounting of the washbasin is very important. The tabletop under the washbasin should be fairly wide - it will facilitate supporting the child, and at the same time it can be used to store toiletries and rubber toys [1, 2, 5].

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Kitchen Chores Ergonomics: Research and Its Application

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Abstract. Kitchen is a functionally complex room, where various complex chores, related mainly to meal preparation, are performed. Therefore, apart from gainful employment, it is necessary to devote many hours of work to various household chores. The desire to reduce the time of everyday duties has always been a drive to progress and has led to various rationalization activities. Ergonomics, together with related scientific research, focuses on improvement of performance and work comfort, which, for a long time, has been applied in the "work environment". Nevertheless, in the "household environment" such solutions were rarely used. Household chores (including kitchen chores) still remain outside the interests of contemporary scientists and researchers. The paper focuses on scientific achievements concerning organization of kitchen chores and improvement of their ergonomic quality. What is more, the paper indicates potential conveniences which are not implemented and popularized; it also presents postulates of further improvement of work conditions in household kitchens.

Keywords: Domestic kitchen · Household engineering · Human factors in design

1 Introduction

Everyday human activity includes performing various chores, most of which are related to gainful employment and household duties. Gaining of livelihood is performed mainly outside of one's home, as an average person spends approximately 8 h a day at work. Free time after work is theoretically devoted to rest and relaxation, that is why home is often claimed to be "the place of leisure". Household chores concern mainly the fulfilment of nutrition needs, as well as maintaining of cleanness and tidiness in the dwelling place. The load and course of work in the kitchen depend on numerous factors, both social and technical, such as specific nutritional habits, ways of meal preparation and the degree of dependence from food services.

The improvement of conditions of everyday life is provided by, among others, diverse technical equipment, whose use aims mainly at reducing the effort and time devoted to household chores and eliminating stressful situations. What is more, scientific and social initiatives aiming at humanization of work processes and creation of more bearable environment for their performance have been undertaken for a long time. Previous, systematic rationalizing activities concentrated mainly on the environment of gainful employment, where the implementation of improvements is justified

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economically or normatively. Nevertheless, similar initiatives are more difficult to implement in households, where the conditions of living are shaped individually by their inhabitants.

2 Scientific Organization of Kitchen Chores Until the Beginning of 20^{th} Century

The issue concerning domestic life was addressed as early as in the antiquity. The Middle Ages and modern period were also times when numerous rules concerning running a household were formulated. Those issues were undertaken mainly intuitively, however, oftentimes, also in a scientific manner. The oldest observations and studies gave rise to “household economics”. The cyclicality of agricultural work and household activities served as a basis to distinguish regularities and repeatability of various actions. Also kitchen chores were dependent on the daily cycle as well as changing seasons. Researchers of everyday life were describing certain regularities and suggested practical solutions. Thanks to various publications it was possible to popularize rationalization of activities aiming at improving the performance of everyday chores. The implementation of such recommendations was supposed to influence, i.a. technological progress and reduction of the most tedious activities. Nevertheless, the principles of household organization were mainly passed down from generation to generation as a result of participation in everyday chores by all family members.

Scientific research of households has been undertaken on a bigger scale only since 1850s, mainly in the USA. Studies concerning productivity and comfort of household chores, especially kitchen chores, were conducted in the second half of 19^{th} century and at the beginning of 20^{th} century by two American homemakers, Catherine E. Beecher and Christine Frederick, who formulated the theoretical principles of organization of work in kitchens with the use of designed functional layout of furniture and mechanical equipment.

In 1841, Catherine E. Beecher published a book entitled *A Treatise on Domestic Economy for the Use of Young Ladies at Home and at School*, where she described, in detail, kitchen functional layout and assigned the location of kitchen centers [3, 16]. Beecher assumed that the chores would be performed singlehandedly, without domestic help [3]. In her second book, *The American Woman’s Home: Principles of Domestic Science* the author postulated kitchen layout divided by a sliding door into two sections [2]. The first part of the room was devoted to preparatory activities and doing the washing up. The workflow located there was carefully divided according to the types of activities, while specific items were strictly assigned to particular cabinets. In the second part there was a designated place for the stove used for cooking and baking. Its location was determined by a need of isolation of excessive heat. Food supplies, tools and crockery sets were placed within reach and distances between kitchen centers amounted to one or two steps.

Ideas presented by C. Beecher served as prototypes of small, monofunctional kitchens with carefully organized workflow. While the cabinets designed by the researcher can be assumed as the beginning of the concept of contemporary built-in kitchen furniture with seamless kitchen worktops. The research accomplishments of C. Beecher, without a doubt, fall into the category of, being developed at that time, so called, household engineering.

Another American household researcher – an economist, Christine Frederick, at the beginning of 20th century, conducted a study aiming at reduction of effort connected with kitchen chores. The researcher wanted to achieve the rationalization of chores through a careful planning of functional and spatial layout of the kitchen. In the handbook *The New Housekeeping Efficiency Studies in Home Management*, the author presented the lengths of distances covered while walking between kitchen centers. Basing on schemes, she proposed an optimal placement of kitchen centers, heights of worktops and dimensions of cabinets. Standardization of equipment aimed at a better organization of space. The author also addressed the issue of running of households without domestic help, as well as lack of education of women in the scope of running a house (as opposed to men who were prepared for gainful employment) [9]. In 1915, C. Frederick published a book *Household Engineering. Scientific Management in the Home*, where she analyzed the course of chores aiming at reduction of distance covered during a daily cycle of work. The author counted the number of steps taken while walking in various types of kitchens in order to optimize the distribution of equipment [8]. Juxtaposition of faulty and correct layouts of rooms revealed the possibility of reduction of distances covered during everyday meal preparation (Fig. 1). That is why the author postulated placement of equipment according to the workflow in order to improve its effectiveness, as well as setting the height of worktops with consideration of the height of a person, both in sitting and standing positions. Frederick also recommended separation of the sink and stove with worktop and arrangement of foods and equipment in particular kitchen centers, as well as using easy to clean materials to produce the furniture. A new solution was introduction of a dishwasher and small electric engines in household appliances. The author popularized the idea of, so-called, household without domestic help and engaging all household members, including children, into everyday chores [8].

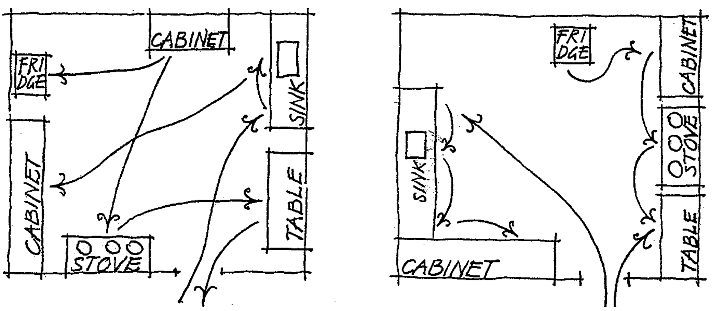

Fig. 1. Reduction of distances during everyday kitchen work. Faulty and correct kitchen plan analyzed by C. Frederick (illustration by the author).

Another milestone were experimental “studies of time and movement” conducted by Frank and Lillian Gilbreth, whose aim was to reduce unnecessary activities and maneuvers in order to decrease effort and increase work efficiency [10].

However, the aforementioned results were not implemented because of, among others, lack of interest of the majority of architects. The interiors of homes were arranged quite spontaneously, without the contribution of architects and interior designers. What is more, the furniture and equipment popular at that time were not suitable for the postulated organization of workflow. In spite of that, until the outbreak of WW II, household kitchens remained the most thoroughly researched household zones.

With time, the results of research concerning the workload conducted by, i.a. F.W. Taylor, C. Beecher, C. Frederick and Frank and Lillian Gilbreth served as the prototype of the 20$^{\text{th}}$ century rationalization of industrial production, application of assembly line and adaptation of economic laws in households of the industrial era. In between 1910–1930 numerous studies concerning the economy laws and work conditions were published mainly in the USA, and, only somewhat later, also in Western Europe [11]. Those publications represented the aforementioned household engineering movement and were justified by the emancipation of women and their professional activation at the expense of household chores [4, 16].

3 “Work” Kitchen Model and Its Practical Application

The 20$^{\text{th}}$ century rationalization of kitchen chores concentrated mainly on systematization and reduction of the workflow. In 1920s the idea of “work” kitchen was born. Its characteristic feature was a small space and functional layout enabling only one person to work at a time. Its prototype were kitchens located on ships and in dining cars. First “work” kitchens were designed in Frankfurt in 1926. The author of this concept is a Viennese architect Margarete Schuette-Lihotzky.

In a prototype “Frankfurt” kitchen model the length of covered distance and amount of time necessary for performance of subsequent chores were measured and compared with the measurements obtained in traditional kitchens. It was discovered that the distance covered in kitchens representing the older type amounted to 19 m, while in “Frankfurt” kitchens only 6 m [1]. It was also noticed that certain sections needed to be covered multiple times, for instance from the cabinet with kitchenware to the stove or from the sink to the cabinet containing crockery. That is why those kitchen caters were located next to each other as it enabled to maximally shorten the covered distance and reduce unnecessary activities. Usage of successive kitchen centers required merely a turn or taking a few steps to the side. In the analyzed kitchen model the chores were performed along the walls in a standing position and next to a window in a sitting position.

In 1927, a German designer, Erna Meyer, also addressed the issue of improvement of work comfort in households. She postulated, among others, the implementation of kitchen furniture adjusted to the height of its users (Fig. 2), as well as performance of the most laborious chores in a sitting position [12]. At that time, this was an innovative approach to the issue of ergonomics and relations human – machine. A more systematic approach was implemented only at the end of 1950s together with the introduction of normalized sizes of kitchen furniture.

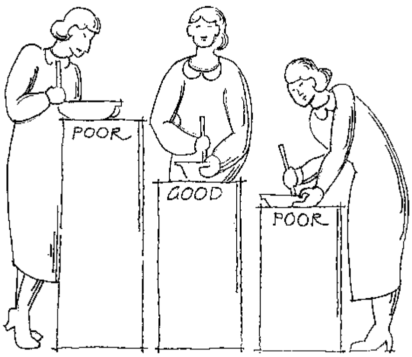

Fig. 2. Kitchen furniture adjusted to the height of its users by E. Meyer (illustration by the author).

"Work" kitchens gained popularity in the second half of 20th century, especially in mass multi-family housing. Back then it was assumed that those types of kitchens would ensure ergonomic quality of technological workflow and an ease in maintaining the room clean. What is more, the cost of equipment (especially furniture systems) produced in series was low. Placing of the workflow in a small space resulted in the improvement of work comfort and reduction of time devoted to kitchen chores. However, it were the economic reasons which resulted in building very small kitchens. The size of space devoted to moving around in the kitchen and the workflow itself enabled placement of household appliances only next to each other (at the expense of worktop space), as a result it was possible for only one person to work in the kitchen at the same time. Because of the abovementioned reasons, functional layouts of rooms and their equipment did not meet basic requirements connected with meal preparation. Frequently there was no space for certain household appliances (especially a dishwasher, or even a big refrigerator) or a slightly longer worktop. What is more, eating meals together was possible only outside the kitchen, in the living room.

4 Work Ergonomics and Its Application in Modern Kitchens

The main area of concern of the contemporary ergonomics is the dependency between humans and their work environment. A dynamic development of this field took place in the second half of 20th century. Ergonomic criteria formulated by researchers have been implemented in the work environment for several dozen of years. Nevertheless, the process of implementation of the above criteria in households is considerably slower, as the improvement in this scope is made only as a result of increasing awareness and knowledge concerning ergonomics of average people (easier access to information) and a systematic improvement of the standard of living (new, more sophisticated needs).

Previous publications concerning ergonomics concentrated mainly on researching the human – machine relation as well as the rules of shaping of work environment (gainful employment). Nevertheless. the home (leisure) environment may be viewed similarly, as households operate like small enterprises and house kitchen is a technologically complex work place, where the workflow is an elaborate work station including a system of equipment and appliances.

The issues of working in the kitchen were addressed after the WW II initially mainly in the USA as well as in Western and Northern Europe (in particular in West Germany, Switzerland and Sweden). The movement was caused by the popularization of cost-efficient "work" kitchen model and the necessity of coordination of industrial production of modular equipment elements.

Basic furnishings, such as refrigerator, sink, and stove designated essential work zones included in, so called, work triangle, which was first introduced as a functional scheme in 1950s at Cornell University, USA. It was advised that the abovementioned pieces of equipment were separated by worktops [15]. The pretext to address this issue was popularization of "work" kitchen model and the necessity to shape a well-formed workflow.

Joining particular elements of kitchen equipment together enforced their modular coordination as well as standardization of their types and sizes. First European prototypes were created at the beginning of 1950s. Modular furniture, in particular worktops, placed against walls, immediately gained attention of customers. Traditional, free-standing butler's pantries and tables placed in the center of the room started to be regarded as old-fashioned [7]. Despite a great interest, the implementation of standard solutions was not simple. The delays were caused mainly by the lack of cooperation in scope of modular coordination between producers. However, they were overcome after 1956, when several big furniture producers from West Germany united and created Modern Kitchen Association (Ger. *Arbeitsgemeinschaft die Moderne Kueche – AMK*) [13]. The beginning of 1960s is also the time of production of first household appliances adjusted to normalized furniture systems (i.a. sinks, stoves, ovens, dishwashers, refrigerators and even washing machines). Another factor which favored the modular coordination was publishing in mid-1950s of DIN norms concerning designing kitchens and their suitable equipment [5, 6]. Similar norms were introduced later in other countries. According to them, equipment was based on a 10-centimetre module and the majority of cabinets had the following measurements: 60 cm (width), 60 cm (depth) and 85 cm (height). A 10-centimetre module enabled production of kitchen cabinets with various widths and door layouts. What is more, the regulations introduced at that time are still valid in many countries.

Another issue is the adjustment of kitchen equipment to body shapes and motoric abilities of its users, since providing optimal work conditions requires maintaining correct posture and reduction of both static and dynamic muscle strains during performing of various activities. The ergonomic quality of technical equipment was studied on this account until the end of 1980s, among others, thanks to use of flat mannequins presenting human silhouettes (Fig. 3). The sizes of mannequins were based on characteristic human centile measurements. The data was published in numerous countries in, so called, anthropometric handbooks. However, using of flat mannequins was encumbered with an error, as it did not take into the consideration the spatial layout of particular parts of the body in various positions (so called "dynamic positions"). Only use of three-dimensional, plastic mannequins, or participation of real people enabled to conclusively determine the correctness of the designed piece of equipment.

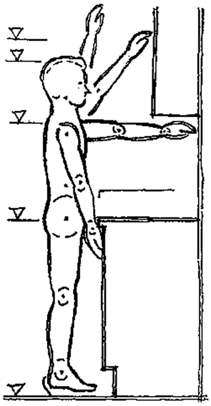

Fig. 3. Flat mannequin presenting human silhouettes standing at the kitchen countertop (illustration by the author).

The design processes became more effective thanks to the introduction of computers and ability to use virtual space. In 1990s, in Germany a thorough study concerning the elements of kitchen furnishings was conducted with a use of virtual human forms with diverse heights derived from centile measurements. The silhouettes were depicted in dynamic positions (Fig. 4). The obtained results confirmed the need to produce furniture and household appliances in diverse sizes adjusted to users who work in different positions. However, the aforementioned data is not commonly known. The majority of furniture is still produced in accordance with the DIN norms, which brings about negative consequences. The majority of kitchen chores is performed in a standing position and the normalized height of worktops, assumed over 60 years ago, amounting to 85 cm is too low for the majority of European and American population [14].

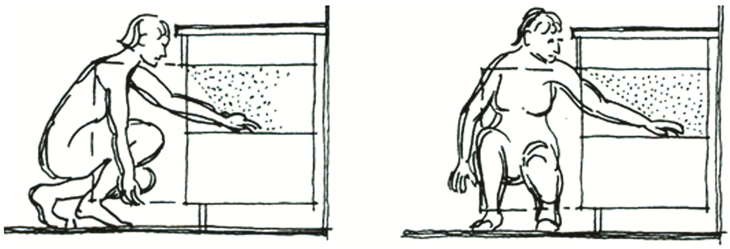

Fig. 4. Human silhouettes depicted in dynamic positions at the kitchen cabinet (illustration by the author).

Taller people, therefore, need to assume a forced and uncomfortable slouchy position. The producers of kitchen furniture systems still do not offer products adjustable to people with different heights, which means that a simple and common solution of adjusting the steering wheel to the needs of the driver has not been applied in the furniture industry yet.

5 Factors Influencing Functional Program and Technical Standard of Kitchens

Technical progress and development of industry provided a high supply of technical goods. Nevertheless, despite a wide offer, the goods do not undergo the process of standardization and typification, which is a result of, i.a.: production technology, user safety and user aesthetical expectations. Kitchen space is a place of concentration of household chores, whose performance is currently facilitated by suitable furniture systems and various tools and mechanical appliances. Kitchen has therefore become the most technologically advanced room in the house. Appling appropriate furnishings and household appliances enable to functionally adopt any available kitchen space in a given household. On the other hand, individual placement of work storage spaces may result in freedom of movement and performing of particular activities in comfortable positions.

The necessity of undertaking gainful employment outside the place of dwelling changed the structure and social approach to household chores. The need to regenerate after work oftentimes requires minimization of effort and time "wasted" on household chores. In technologically advanced kitchens there are numerous tools aiming at simplifying the organization and performance of chores and, sometimes even a total elimination of human effort. Their use aims at a reduction of both physical and psychical effort required in performance of household chores.

The ergonomic requirements in the kitchen space concern mainly the determination of the size and proportions of the room, organization of workflow, lighting of the entire room and particular kitchen centers, maintaining constant and comfortable microclimate conditions and eliminating accident-causing threats. The selection of particular elements of equipment should also take into account the possibility of maintaining a neutral (straight) standing or sitting position, as well as protection against threats (accidents, stress and other undesirable occurrences). In regard to using household appliances, the requirements refer to the replacement of hand labor with safe mechanical labor in the widest possible scope, while providing an ease to operate devices both during and after their use (assembling, cleaning).

6 Kitchen Functional Programing and Actual Workload

Use of tools aims at aiding people in performing various tasks. Such tools are often associated with reducing the effort needed for everyday chores and with the feeling of comfort. What is more, certain tools are oftentimes perceived as symbols of social status and wealth.

Producers of household appliances, furniture, and "smart home" systems frequently praise the benefits of using technology and programming in the course of performing activities at home. They try to convince users that using various appliances and following certain patters will result in reduction of effort and time needed for household chores, by providing detailed calculations of the number of covered steps, carried kilograms or times one has to bend down during performing a given activity [7]. However, the industrial organization of work and cautiously selected equipment cannot be “programmed” and applied in every household, which is influenced by various nontypical situations, as well as diverse patterns of behavior and the quality of living. Many human behaviors stem from individual habits, or even concerns, especially when undertaking new rationalizing activities. The course and timing of activities also cannot be clearly determined, due to different conditions and psychophysical states of members of households [17]. When compared to the former types of kitchen, the modern, scientifically and technologically advanced models of household environment still do not provide projected considerable relieve from household chores.

7 Summary

Selection of the functional program of the kitchen and the equipment, as well as organization of everyday chores determine the ergonomic quality of a house. Thanks to the above, the users of the kitchen gain the sense of comfort and the following additional benefits as: reduction of both physical and psychical effort, feeling of content and pleasure drawn from using technical goods, as well as increase in satisfaction from work, motivation, work efficiency, creativity and improving safety. Average kitchen users often attempt to implement some of the abovementioned ergonomic criteria intuitively. However, self-reliant verification of certain technical solutions is not possible, since users lack proper measuring tools. That is why it is worth considering to draw up such aids as: tabular comparisons of sizes of furniture and big household appliances with the dimensions of sizes of human body, various schemes of workflow and their equipment, check lists and safety warnings. The demand for creating such tools should serve as a stimulus for further scientific research concerning “household environment”.

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Genius Loci – Examples of Changes of the Image of Post-industrial Areas in Poland in the Region of the Upper Silesian Conurbation

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Abstract. The objective of these deliberations is to broaden the discourse relating to the effect of revitalisation measures undertaken in post-industrial areas and their references to issues connected with preserving the identity and heritage of a place. Upon the example of the Upper Silesian conurbation, the Authors shall present research reflecting how post-industrial areas can become creative urban spaces. The first to be presented will be the case of the city of Gliwice, where the territory of a former coal mine assembles the most innovative IT and R&D companies. The second case will focus on the city of Katowice, where the territory of the former coal mine have been included in structures of a zone assembling cultural facilities. In both cases, a phenomenon that seems to be extremely valuable is the attempt to change the negative image of post-industrial areas into an attractive urban space, preserving the industrial heritage.

Keywords: Human factors · Genius Loci · Identity of the place · Post-industrial areas · Revitalisation

1 Introduction

In Poland, industrial cities and agglomerations which came into being along with the intense industrialisation process in the 19th and 20th century, are still affected by the crisis connected with the need to restructure traditional industry. Cities search for development potential in abandoned and degraded areas and in historic post-industrial buildings, and while waiting for new investors, they open up new paths for innovative measures (economic and social ones) which will help them become more competitive. Nevertheless, there is also a different side of the ongoing changes – municipal authorities and investors, aware of the value of their history, wish to create a new image basing on heritage preservation, simultaneously building the sense of identity and commitment of local communities.

Nowadays in Poland abandoned and neglected post-industrial areas, following in the footsteps of Western European states, more and more often become a subject matter of activities aiming to include them in the urban structure of cities, transforming them into innovative commercial or cultural investment grounds. This tendency reflects the urban

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policy consistent with guidelines of the European Union in this respect. It leads to the creation of new places, valuable in aesthetic terms, which combine the old with the new. Nevertheless, when analysing this topic, the Authors posed a question whether the very fact of respect for the history of a place, protection of its identity and heritage, is the guarantee of certainty that its Genius Loci will be preserved. And the other way round, does the preservation of tradition of a place guarantee the success of the project? How much depends on allocating new functions to a place, and how much on the implemented architectural and urban project? Analyses relating to this subject matter, conducted on the basis of literature research, in situ research, and observations carried out over the span of several years, do not provide a clear answer. They do, however, allow to continue the discourse devoted to the directions of sustainable development of cities with respect for their heritage.

2 Genius Loci – A Good Spirit of the Place

Identity of any place is one of the most crucial notions that link the human factor with the built environment. Christian Norberg-Schulz believes that even the identity of man has its source in the identity of the place [1]. Krzysztof Lenartowicz defines identity of the place as a deep relationship between elements which exist despite the external lack of any similarity [2]. With reference to the subject of identity comprehended this way, Zbigniew Myczkowski characterises the notion of identity of the place as “the deepest relationship between landscape perceived by man along with its historically accumulated elements: its contents (culture, tradition of the place) and its form (canon of the place)” [3]. Therefore, it is justified to state that identity is an established representation that identifies a person with a specific place – a representation based on the recorded cultural patterns, traditions, and history, as well as the physical form of this place. It consists of the spatial form (the natural land relief as well as elements of architecture) on one hand and the cultural, social, and historical dimension of a specific area on the other. An inseparable attribute of strong identity is genius loci – according to the definition of Norberg-Schulz an imperishable quality which makes a place or landscape assume its unique character [1]. Thanks to it, if we discard the initial meaning of *Genius Loci*, which derives from the ancient Rome and stands for a protective spirit of a place (a good or bad one) and for the sake of our discussion we accept the 18th-century concept of this notion meaning uniqueness, we will notice that industrial heritage can be a valuable element of urban landscape, which needs to be protected. Naturally, on the other pole of these deliberations there is still a question concerning the future of the region which so far has been developing on the basis of heavy industry, and which as a result of transformation of the local economy, as well as of global economic phenomena, must find a new path for its development.

Genius Loci – ‘the spirit of the place’, is identified with everything we perceive as its intangible value. It may come into being as an effect of intentional actions, or it may emerge gradually as a result of appropriate treatment of the place and – in consequence – concentration of emotions it is filled with. Genius Loci can appear in a building, in between buildings, in urban districts, in the entire city, and even in the whole region or country. The richer the history of a place, the richer its complex nature. Not only does the past connected with the place address our reason, but it also stirs our emotions. Landscape, a result of combination of e.g. specific natural forms with diversified development systems and forms, can appear as distinct, native, evoking positive associations, building identity. Physical properties of form and substance of such landscape evoke the 'spirit of the place' also when they are perceived as unique, intriguing, or exceptionally beautiful. Genius Loci resides in pleasant places, where it is nice to be and where we return frequently. Although it is a very valuable phenomenon, regrettably, it is perishable, and thus it sometimes disappears. It needs to be recognised and understood in order to be preserved [4].

Places endowed with 'the spirit' function as landmarks according to which people claim the space around them. The condition for the occurrence of such places is their uniqueness, distinctness, easy identification, ability to evoke multitude of experiences, permeation with contents reaching to the essence of human needs and feelings. History and contemporary times provide us with a lot of evidence confirming the fact that appropriate decoding of the essence of Genius Loci and being inspired by it results in solutions which are not only pretty, but captivating [4].

At this stage, it is truly difficult not to touch upon the subject of aesthetics, which among Europeans is often mistakenly perceived exclusively in the visual category. And the etymology of the word 'aesthetics' - *aisthetikos,* suggests the meaning 'aesthetic, sensitive, sentient, pertaining to the sense of perception'.[1] Manifestations of glorification of the visual order in urban planning are divisions allowing for visual accessibility of space and physical communication in time followed with one's eyes (moving around), or the rules of zoning of space functions. Despite the fact that architects can easily deal with such challenges as maintaining 'spatial order', designing 'in the context of the surrounding environment' and in accord with the principles of 'universal (accessible) architecture', or modelling 'the image of the place', they still have a problem with understanding. Both Petr Zumthor and Juhani Pallasma observe at the same time, that concentration at the stage of conceptualising the idea of a design that dominates the designing process contributes to pushing aside – and consequently eliminating - the reflection referring to other than visual sensual ways of perceiving architecture and the built environment, which leads to dehumanisation of space and architecture, which due to the disappearance of *Genius Loci* get deprived of the character of *the place* [5, 6]. Pallasma categorically claims that "(…) the inhuman character of contemporary architecture and contemporary cities can be perceived as a consequence of neglecting our bodies and senses and of lack of balance in our sensory system" [6].[2]

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[1] Perception (from the Latin *perceptio, percipio*) is the organization, identification, and interpretation of sensory information in order to represent and understand the environment. All perception involves signals in the nervous system, which in turn result from physical or chemical stimulation of the sense organs. For example, vision involves light striking the retina of the eye, smell is mediated by odor molecules, and hearing involves pressure waves. Perception is not the passive receipt of these signals, but is shaped by learning, memory, expectation, and attention [Wikipedia.org].

[2] Pallasma, J.: Oczy skóry (oryg. *The Eyes of the skin: Architecture and the Senses*), p. 26.

What, therefore, should we do to preserve ‘the spirit of the place’ and/or to create it, and what should we do to enable its identity to survive? It should be expected that a person or a team of designers which have the privilege of transforming landscape know not only the principles of spatial composition, high culture, sensitivity, humility or knowledge in the field of aesthetics. Most of all, it should be expected that they understand the history and tradition of the place. As Norberg-Schulz observed, “To protect and conserve the ‘genius loci’ in fact means to concretise its essence in ever new historical contexts” [1].

In Poland, industrial cities and agglomerations which came into being along with the intense industrialisation process in the 19th and 20th century, are still affected by the crisis connected with the need to restructure traditional industry. Cities search for development potential in abandoned and degraded areas and in historic post-industrial buildings, and while waiting for new investors, they open up new paths for innovative measures (economic and social ones) which will help them become more competitive. Nevertheless, there is also a different side of the ongoing changes – municipal authorities and investors, aware of the value of their history, wish to create a new image basing on heritage preservation, simultaneously building the sense of identity and commitment of local communities.

3 Examples of Urban Realisations in Upper Silesia Region

The Upper Silesian Conurbation is located in the south-western part of Poland. Today, it is the largest and most densely populated region of Poland, comprising 17 cities and municipalities. Its surface area is ca. 1300 km^2 and it is inhabited by ca. 2.5 m people[3]. Similarly to other European industrial agglomerations, it came into being as a result of intensive development of mining and metallurgy in the 19th and 20th century. Industry, started here by the State of Prussia at the end of the 18th century, was developing here until the World War II basing on the then most advanced technologies. After the World War II Upper Silesia found itself within the Polish territory and its further development was based on centrally controlled socialist economy and overexploitation of natural resources. The political and economic transformation of the 1990s brought about a fall of numerous obsolete and underinvested industrial plants and the need to restructure the traditional Silesian heavy industry.

The rapid industrialisation process, launched here in the early 19th century, within just 100 years transformed an area with a very low urbanisation factor into one of Europe’s largest industrial agglomerations. The mushrooming mines, steelworks, industrial settlements, and very few historic towns were gradually linked with a network of roads and railways, giving rise to an urban structure deprived of any hierarchisation. The price that needs to be paid for such an unplanned urbanisation process, subordinate exclusively to narrowly comprehended economicalness of industry, is the current amorphous urban structure of the Upper Silesian Conurbation, the most characteristic feature of which is intermingling of industrial and residential areas with post-industrial waste [7].

[3] According to the Central Statistical Office for the year 2013.

Consequently, in the period of economic transformation and restructuring of industry there appeared vast and completely ecologically degraded post-industrial areas, which are often adjacent to city centres and constitute barriers for further development of cities. At the same time, the most valuable examples of industrial architecture were disappearing, although they had constituted important landmarks that identified the cultural landscape of the region – the landscape which due to the origins of Silesian towns and cities is often deprived of such elements that we traditionally consider to be indicators for the identity of the place. Their loss is even more painful when we realise that they were/are very few elements in the landscape of towns and cities of exclusively industrial origins that created very strong identity, allowing for identification of local communities with the tradition and culture of the place.

In western European countries, the economic transformation leading to recession and the downfall of traditional branches of the industry started about 30 years earlier. Cities and whole regions were faced with the problem of utilising areas and historic industrial buildings degraded by industrial activities. Many architecturally and culturally precious buildings were destroyed before they acquired a historic value. Often it turned out that such radical decisions were incorrect and the continuous modernisation and financial support of the collapsing industry was not bringing the desired effects. In the 1980s, together with the change of the way of thinking and perception of historic industrial architecture, the idea about the restoration methods of degraded areas underwent a change. Beauty and cultural values started to be perceived in historic industrial sites and they were included in the field of the broadly understood cultural heritage. Today such an attitude is not surprising at all; nevertheless, years of experience were necessary to recognise the industrial culture as part of the European cultural heritage and to acknowledge that it needs similar protection. Experiences of rich countries of Western Europe demonstrate that the potential residing in the industrial heritage offers an opportunity to create a new, positive image of degraded spaces and brings measurable economic profits. We can find examples of such measures in historic industrial regions of Europe: the territory of a former hard coal mine in Lens, Nord-Pas-de-Calais, France transformed into a branch of the Paris-based Louvre Museum, or the IBA Emscher-Park Programme in the Ruhr District, Germany, within the scheme of which numerous valuable industrial facilities have been preserved and transformed into new functions, including the industrial complex Zeche Zolverein in Essen. A facility that deserves our attention, as well, is a plant located ca. 50 km away from the Upper Silesian Conurbation – the Steelworks in Ostrava Vitkovice, where a part of historic post-industrial installations was transformed into a museum and a magnificent concert hall.

This attitude is consistent with the concept of the creative class of Richard Florida. In his opinion "the creative class is composed of people who increase the economic value (of a company) thanks to their creativity" [8]. Representatives of the creative class, however, aware of their own value, get involved with places which on one hand can provide them with the appropriate workplace quality and which can benefit from their full potential, and on the other which offer them appropriate residential opportunities, with an interesting recreational and cultural offer, which will secure their further development. They expect something more from a place than an air-conditioned office, which actually may look the same in any other location in the world. In the era of dissemination of patterns, what becomes a superior value is uniqueness and authenticity, the source of which is local history and tradition, rich cultural heritage, and Genius Loci, which endows a place with a unique character.

3.1 'Silicon Valley' in Gliwice City

A model of city development based on the creation of innovative workplaces has been adopted in Gliwice – one of 3 cities of the conurbation with historical background. Innovativeness has a long tradition in this city – it was here that in 1796 Europe's first coke-fired blast furnace was launched, and specialists necessary to build and operate it had been brought here from Scotland and Western Europe [9]. Thanks to this development stimulus, Gliwice was always one of the best developed cities of the emerging conurbation. In the period of economic transformations, in Gliwice, similarly to other towns and cities in the region, there appeared vast degraded post-industrial areas. In search of a concept of a path of development in the new economic reality, the municipal authorities got interested in the degraded territories of the hard coal mine and the coking plant.

The history of the Gliwice Mine (as this is the mine referred to above) reaches back to 1901, when a decision concerning its establishment was made. Over subsequent years buildings of the elevator shaft were erected, and in the period 1912–1914 the most characteristic buildings were added (the pithead building and the engine room) according to a design by Emil and Georg Zillmann from Berlin. In the interwar period, due to the perfect quality of coal extracted here, the mine was extended and a coking plant was added, which operated until the 1990s. Eventually, in 2000 it was decided to close the mine, and this decision resulted in over 15 ha of incredibly degraded land, covered with waste heaps, trackways, shafts, and coke oven batteries. On one hand, this territory posed an ecological threat, but on the other hand, owing to its location, it was a perfect spot for new investments. Therefore, it was decided to undertake revitalisation measures, and already 5 years after the shutdown of the mine and taking over of the land by the city, they were successfully launched. The concept of revitalisation of this area consisted in the creation of a new, dynamic educational centre and business incubator, and in providing innovative R&D and IT companies with development opportunities. The concept developed by MEXEM, Gliwice, consisted in preserving the majestic buildings of the pithead and the engine room and in adapting them to the purposes connected with new functions, as well as in recultivation of the degraded area around them and in creating recreational premises and plots of land for new facilities of the future industry and science park (Fig. 1).[4]

The unique buildings of the pithead and the engine room, which with their form resemble palaces rather than industrial plants, preserved their original façades. Wherever possible, during the works investors tried to preserve the original structure of the massive roof, the historic floors, the internal linings made of glazed brick, and the cast iron balustrades (Fig. 2).

[4] The works lasted 3 years and were completed in 2008. The cost of this project reached over EUR13m, and the financial support from the Phare fund amounted to EUR9.5m.

Fig. 1. Aerial view of a former Gliwice Coal-Mine, transformed into a Centre of Busines and Education (source: google maps).

Fig. 2. The pithead building and the engine-room building converted into an education center and an office building (photo: A. Sulimowska-Ociepka)

The building of the pithead, with an integrated water tower, was transformed into a higher education facility. On both sides of the centrally located hall independent structures of lecture halls and workshops were arranged, with the total floor area of over 9000 m^2. The main lecture hall was located in the space of the tall roof, revealing the original wooden roof framework and the vault. The neighbouring building of the engine room was transformed into an office buildings. The initially huge one-space interior was filled with an independent structure offering 9000 m^2 of office space for rent, and a bracing structure of the external walls. The top floor is occupied by lecture halls and the Artistic Casting Museum, the history of which is also bound with industry in Gliwice – the Royal Iron Foundry from 1796. The Museum presents a fully interactive collection of the 19th- and 20th-century art of casting.

The area around the historic buildings was organised and divided into plots, where today there are headquarters of innovative companies combining science and technology with industry, and new ones are being erected. 15 ha of recultivated post-industrial land has been transformed into the local 'Silicon Valley'. A place of dirty and hard work of thousands of miners has changed into a creative work space consistent with top ergonomics standards (physical, cognitive and organizational ones) and it constitutes an architectural test site.

3.2 Culture Zone in Katowice City

The city of Katowice received its municipal rights in the second half of the 19th century. Its dynamic development was inseparably connected with the extraction of hard coal deposits. 50 mines used to operate in Katowice. Today there are only three [10]. When in the 1990s the mining industry collapsed as a result of the economic transformation, there appeared post-industrial wasteland, neglected and degraded areas in the very centre of Katowice. One of such areas was the territory of the former Katowice Hard Coal Mine, which operated in the period 1823–1999. Thanks to considerable support from the European Union funds, an urban project was implemented, entitled the Katowice Culture Zone. Next to the Spodek Arena, which was built in 1971 (authors: M. Gintowt, M. Krasiński, J. Hryniewiecki, and constructor A. Żórawski, Poland) – new facilities of a supraregional character were erected, stimulating the entire region, and along with their surroundings give this place a new quality in functional and aesthetic, as well as in social and cultural terms.

Over the last three years the next three buildings were erected:

- The main seat of the Polish National Radio Symphony Orchestra, 2014 (author: Konior Studio, Poland) - the strength and the spirit of this place is not only the reference made by the form and the elevation of the building to historic construction materials or the beautifully clear surroundings; most of all it is the interiors of the

Fig. 3. View of NOSPR (the Polish National Radio Symphony Orchestra) building (source: Wikipedia)

philharmonic, where the main concert hall, endowed with fabulous acoustic parameters, can bring associations with a pearl locked in a shell, or with rose petals in a rough palm. The designer's sensitivity gave rise to a multifaceted, sensual space, expressed in its structure, materials, textures, light, and sound, which steadily builds up emotions, creating a unique atmosphere for meetings of musicians and music lovers. The implementation of this investment consumed an amount higher than USD66m (Fig. 3).

- The main seat of the Silesian Museum 2015 (author: Riegler Riewe Architekten, Austria) – the designers' intention was to respect the existing characteristic although strongly damaged architecture of buildings of a former mine, standing for the tradition and identity of this place. The concept of this bold urban and architectural solution consisted in making maximum use of the space located under the ground surface for the purposes of the museum and the accompanying functions, and therefore it assumed only slight intervention in the post-industrial landscape. There are – as if to say – three types of development on the surface: glass cubicles, which allow to enjoy the exhibitions in daylight, although they are located at the depth of over 14 m below the ground surface, a headframe of the mining shaft, which was extended with a panoramic lift, and other revitalised facilities of the former mine (the former building of the engine room turned into a coffee shop – restaurant, and a warehouse of clothes, which today is the seat of the Centre for Polish Scenography). The cost of the investment implementation reached over USD 65m (Fig. 4).

Fig. 4. The main seat of New Silesian Museum (photo: A. Sulimowska-Ociepka)

- The third investment is the International Congress Centre (MCK), completed in 2015 (author: JEMS Architects, Poland). It is a multifunctional building, the largest section of which is addressed to guests of events held here (congresses, conferences, exhibitions, fairs, or shows). It does, however, have a zone that is fully accessible to the public: a green diagonal passage intersecting the roof, in this place assuming the form of a pass, as well as the main foyer, linking the entrance from the side of Honorowy square in front of the aforementioned Spodek Arena with the entrance from the side of the newly designed Olimpijska street. Designating these spaces as public ones constituted an important citygenic element for this post-industrial area developed anew. Moreover, the building designed this way satisfied the expectations relating to its intended use and prestige as well as to the need to inscribe it in the landscape of the surroundings of the Spodek Arena, which will always be a significant and dominating element in the space of this part of the city. The construction of this facility cost nearly USD 95m.

Currently, the fourth, commercial building is in the progress of construction; it is called 'the KTW Towers'. Consequently, culture is completed with a business centre, which could be a signal that combining two so different spheres of human activities should be, and perhaps will be in the future, a natural method of supporting such places in economic terms on one hand, and on the other of preserving their *Genius Loci.*

4 Summary

The examples presented above, in the past were a stimulus for development of cities the economy of which was based on heavy industry. In the period of political and economic transformation in the 1990s, in both cases discussed after the fall of mines there were vast degraded post-industrial areas left behind. These territories, located in city centres, constituted serious barriers for harmonious development of Gliwice and Katowice. In both cases decision makers noticed development potential in them, although the objects set by both cities were different. Gliwice, which had always been a strong centre of science and technology, decided to develop innovative workplaces and to connect science with industry. The capital of the region – Katowice focused on the quality of urban space and on permeating it with cultural contents of the regional and supraregional character. The common denominator of these measures was the wish to change the appearance of the degraded grounds, preserving valuable industrial heritage sites. In both cases the objective set by the cities was reached, although with different effects. The Gliwice 'Silicon Valley' is still in the process of transformations. However, even now it is clear that it will function differently than the Katowice Culture Zone, because its goal is different. Private investors do not make any references to the past in their new headquarters. Instead, they look into the future in search of innovative architectural solutions, which will reflect their innovative technological solutions. The Katowice Culture Zone, on the other hand, thanks to its rich offer and accessibility, attracts many users every day, and is permanently inscribed in the landscape of the city. Its relationship with history and tradition of the place has been perpetuated in new glamorous buildings, which make subtle references to the tradition of the region, and is clearly legible for a skilled observer. In this case *Genius Loci* resides rather in the continuation of functions of the place, and its history is reminded only by monumental edifices of the historic mine. Nevertheless, as Norberg-Schulz clams, "To respect the '*Genius Loci'* does not mean to copy old models. It means to determine the identity of the place and to interpret it in ever new ways" [1].

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Ergonomic Formation of Hygienic-Sanitary Spaces in Consideration of Health, Safety and Well-Being of Children

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Abstract. Issues of safety and comfort of use are among the main objectives of ergonomic design hygienic and sanitary spaces, rooms and facilities. Their proper ergonomic quality plays a key role in shaping the conditions affecting the health and safety of users. These are people of different age and psychophysical condition, including children in different age groups, also small and preschool children, which require special, extra care. Every day they are exposed to the risk of fall, slip, bump, wound, fracture, shock, drowning and poisoning, while using the bathroom at home and in other places such as kindergarten. The probability of an accident is very high due to the specifics and amount of different tasks for which they used the bathroom and because of the type of the bathroom equipment. The increased vulnerability of children to accidents is a result of their large mobility and spontaneity. Children manifest a special interest in the environment and the desire to learn about it, but often their attention is distracted, due to their temperaments. In addition, still undeveloped full physical fitness and lack of sense of distance and ignorance of risks and hazards, enhance their vulnerability to accidents. Preventive actions aimed at adapting the hygienic-sanitary places to meet the needs of children with particular reference to their health, safety and well-being can improve the quality of bathrooms for all users. Therefore, consideration of this issue at the stage of their planning and design is extremely important. The work will be discussed the types of inconveniences and risks to which children are exposed using the bathroom. The paper will be presented ways to prevent them by introducing precautions and additional improvements in the bathroom. The bathrooms, which are used by children should not only be functional and safe, but also attractive and interesting, therefore, work will also consider the aesthetic criteria of shaping these rooms.

Keywords: Ergonomics · Architectural design · Interior design · Bathrooms design · Toilets design · Hygienic-sanitary facility · Kindergarten bathroom · Preschool children · Safety · Comfort · Hygiene · Health · Well-being

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1 Introduction

Safety and comfort of use of hygienic and sanitary spaces and rooms is a very important issue, especially if a small children are among users of these places. The amount of time spent in the bathroom, the specifics and diversity of the tasks for which they used the bathroom and the type of the bathroom equipment - all these factors make the probability of inconvenience and accident in this place is very high. Every day children while using the bathroom, both at home as well as at kindergarten, are exposed to the risk of fall, slip, bump, wound, fracture, shock, drowning and poisoning. The bathroom space is a very specific place, where small children should stay only under the full supervision, whereas preschoolers (children aged 3 to 6 years), are a group of users, which requires a special, extra care. Ensuring the safety of the youngest users of the bathroom is the most important, because the bathroom space contains many dangers threatening careless children, such as hot water, slippery and wet floor, sharp edges of sinks and cabinets, a risky device as razors, scissors and also chemicals, toxic agents and detergents. The increased vulnerability of small children to accidents is a result of their large mobility, spontaneity and carelessness. Preschool children manifest a special interest in the surrounding environment and the desire to explore and learn about it, but often their attention is distracted, due to their temperaments and outstanding activity. In addition, still undeveloped and incomplete childlike physical fitness and lack of sense of distance and ignorance of risks and hazards, enhance their vulnerability to troubles and accidents.

Ergonomic actions taken during design hygienic and sanitary spaces and rooms used by toddlers and preschool children should include the possibility of creating favorable conditions for the health, safety and well-being of small users. Providing friendly, ergonomic bathroom space for kids can guarantee not only their comfort and safety, but also willingness to use, which may contribute to their interest in taking care of hygiene from an early age and may encourage toilet training.

Creating a friendly hygienic and sanitary space refers not only to area that is associated with a bathroom at home. Also the toilets in kindergartens are one of the most important rooms in these facilities. They have a significant impact on the well-being of children, as well as their health and safety. As it turns out, the preschoolers often avoid using the bathrooms in kindergarten due to both unfavorable sanitary infrastructure and discomfort associated with various psychosocial factors, including the lack of a sense of privacy. Such reactions can cause serious health effects. Therefore, the planning and design of bathrooms and selection of sanitary equipment for the children at the kindergarten should be done with great care and attention to the needs and requirements of this age group.

2 Criteria for Safety and Health Conditions in the Bathroom

The problem of safety is an essential issue related to the technology and methods of use of hygienic and sanitary spaces and rooms. The bathroom is a place where children are exposed to various dangers, therefore reduction in the possibility of their occurrence is so important. Due to the amount of time spent in the bathroom and the number of tasks for which it is used, the probability of an accident in this room is very high. It is also associated with a variety of functions, processes and activities realized in this place. The risk of potential accidents is also the result of the need to use of a number of devices, accessories and chemicals. Precautions, additional improvements and protections in the bathroom can help to prevent and eliminate most of the possible threats. Also raising awareness of children from an early age about the potential risks and talking about how to avoid them is crucial [9].

Issues of safety and comfort of use are among the main objectives of ergonomic formation of hygienic and sanitary spaces. The ergonomic quality of these spaces plays a key role in shaping the conditions affecting the health and safety of users. Among users of bathrooms are people of different age and psychophysical condition, including children in different age groups, including toddlers and preschool children, which require special, extra care. Safety of bathroom users often depends entirely on their own risk awareness, knowledge, foresight, skill and ability to prevent accidents and to react in the event of their occurrence. Among different age groups, children under 4 years are most vulnerable to accidents in the bathroom. Every day they are exposed to the risk of fall, slip, bump, wound, fracture, shock, drowning and poisoning, while using the bathroom at home and in other places such as kindergarten. The cause of accidents of children is often neglect, imprudence and lack of adequate childcare. Different types of items, such as razors, scissors, aerosols, electrical devices and chemicals, if they are left without control in accessible places, may be a danger to small users. Small kids are usually active, spontaneous, imprudent and unaware of dangers and hazards and at the same their assessment of the situation is limited, thus elimination of the risk of an accident with their participation is very difficult. The use of additional precautions in the bathroom, which can prevent serious threats provides a chance to avoid dangerous situations. The child should feel well and safely all over used space. In order to minimize the risk of possible accidents, it is necessary to provide adequate conditions to stay in the bathroom and to its use. Avoiding delicate injury is almost impossible, but a well-planned organization of the interior of the bathroom can provide a safe stay and movement of the child in its area, without unnecessary restrictions [9, 14, 15, 25].

The necessity of control over the child and help in use the bathroom is a fundamental principle. Small kids should stay in the bathroom only under the full supervision and care. Responsibility for daily hygiene activities of children is not always easy and convenient task, therefore increase the precautions and additional improvements in the bathroom to help as much as possible to eliminate the threats is very important in this case. The bathroom is a special space, comprising a combination of water and electricity which in the case of inappropriate actions, or due to technical errors, can lead to life-threatening situations. Raising awareness among children from an early age about the potential risks and hazards associated with the use of the bathroom is a very important issue. Instructions and tips on how to avoid and how to react in emergency situations are necessary [7, 13, 17].

2.1 Health Criteria Related to the Maintenance of Hygiene in the Bathroom

Not only taking care of personal hygiene, but also maintaining cleanliness in the bathroom is the basis of healthy lifestyle and behaviors. Many infectious diseases caused by Salmonella bacteria, E. coli bacteria and Staphylococcus bacteria have a beginning in hygienic and sanitary environment. This is due to wrong habits and practices related to hygiene in the bathroom. If it is expected that programs for preventing infections can provide positive effects, both recognition of the different customs associated with the risk of disease transmission, as well as understanding the causes of these habits are necessary. A better understanding of this issue should involve an interdisciplinary methods for the effective promotion and development of manners of hygiene. Dust, germs, mites, microscopic droplets of water from the toilet, which float in the air during flushing, settle on the towels, toothbrushes and other toiletries. Therefore, frequent replacement of these elements and thorough cleaning of the entire bathroom, especially used by small kids, who are particularly susceptible to infections and diseases, is so important. The bathroom includes representatives of almost all groups of microorganisms: bacteria, viruses and fungi. Warm and moist environment is friendly for microorganisms, so they are willing to stay in the towel. Stale towels can be a hotbed of fungi-dermatophytes causing cumbersome and difficult to treat skin lesions. Fungal infections are contagious and can be transmitted between children as a result of contact of feet with contaminated floors, shower mats, bathroom mats or through the use of common towels. Maintaining moisture in the bathroom for a long time, for example, with a malfunctioning ventilation system is the cause of molds growth on the walls. Fungal spores that are constantly present in the air, are the cause of allergies and respiratory disorders, while mycotoxins produced by some of the spores favor the formation of tumors. Ensuring efficient ventilation system in the hygienic and sanitary space and regular monitoring of the ventilation installation is an extremely important issue [12, 16].

Hand washing should be a habit of preschoolers not only at home but also at kindergarten. Unfortunately, children often avoid using public bathrooms, due to unfavorable and unfriendly infrastructure. Hand washing is essential to prevent many infections that are typical for this environment. Teachers, caregivers and parents should pay attention to the fact that children have to wash their hands always after coming to the kindergarten, after sports, before and after a meal, and always after using the toilet. It's really the bare minimum when it comes to hygiene. Toilet soap is often placed in a soap dish which collects the so-called "soap swamp" - a favorite environment for many microorganisms. The use of liquid soap in disposable dispensers is more convenient and safer, and traditional soap dishes must be kept clean [23].

According to the polish regulations on safety and hygiene in public and private schools and institutions, every educational institution is committed to providing adequate sanitation for students and pupils [20–22]. This means access to hot running water, soap, toilet paper, paper towels. Taking into account the sanitary and epidemiological requirements with respect to the bathrooms in kindergartens, selection of materials is also covered by restrictions. The project of bathroom in kindergarten should use materials designed specifically for public bathrooms: safe materials, that are easy to clean and materials with a smooth surfaces, which do not collect dirt. Equipment and hygienic-sanitary devices should be provided as safe and easy to keep clean. These requirements also apply to additional bathroom accessories, such as soap dispensers, paper towels dispensers or hand dryers, as well as toilet paper dispensers and holders, waste bins and toilet brushes [23].

2.2 Safety Criteria Related to the Use of Cleaning Products

Many scientific and technological achievements improve the majority of tasks that are associated with maintaining clean bathroom. Chemicals and detergents for easy cleaning and disinfection are becoming increasingly popular and necessary. But this chemical revolution with its new and unknown side effects can have a significant impact on our health and the health of our children. Contemporary advertising confirms the fact that the harmful chemicals are hygienic. But what are the benefits of using products that put our health in danger? About 90% of harmful substances associated with maintaining cleanliness is used exactly in the hygienic and sanitary spaces. In the past 50 years, the number of used chemicals has increased considerably. Toxic chemical blends give the possibility of different combinations. The length of time during which they may affect the environment and duration of action of side effects is usually not yet known. As the modern buildings are designed with the control of energy expenditure and maintenance of certain temperature, so all the harmful substances and impurities remain and are accumulated inside. Small children, due to the developing immune system and increased metabolism are six times more sensitive and vulnerable to the influence of these substances. It happens that the symptoms resulting from adverse impact of chemicals show up after many years, but the experiences and the evidence of the negative effects of chemicals on human health are clear. If the body is unable to excrete toxins in such a short time, in which they were absorbed, then they are collected and eventually the organism reaches a stage of chemical overload. Toxins from chemicals enter the body through the skin and lungs. Some of them have a strong carcinogenic effects, which may appear even after many years. Others can cause genetic damage and infertility. Toxic chemicals are harmful not only to health, but also have a devastating impact on the natural environment. Application of possible precautions and moderate, safe and consistent with the recommendations the use of chemical cleaners and disinfectants in hygienic and sanitary rooms used by small children is a very serious issue that should not be neglected. Also, guarantee of efficient ventilation of bathrooms can help in solving this problem [11].

2.3 Floor Finish in the Bathroom

The connection of slippery ceramic tiles and water brings to mind the risk of slipping and fall, the more that the situations in the bathroom when the floor is wet after bathing and showering are daily, ordinary and obvious. Wet, slippery floor can cause slipping, both small child and an adult. However, the danger of slipping in the bathroom is often ignored. Therefore, any attempt to maintain absolute dry floor in the hygienic and sanitary place is indicated. The use of waterproof, non-slip floor finishes, for example in the form of tiles with a special texture and non-slip mats can be an effective way to reduce slips and falls. Child while leaving the bath or shower should stand on a rug or on a towel. On the other hand, due to the unevenness caused by the edges of the bathroom mats and rugs, the child may be at risk of tripping. So we should pay attention to the introduction of contrast colors, patterns and textures between them and the floor surface, emphasizing the visibility of their edge [6, 14, 15, 25].

2.4 Safety in Use of Washbasin

A very important factor in the safe and convenient use of the washbasin is the height of its installation, which should be adjusted as much as possible to the user's height, in this case to a small child. In home bathroom, which is used by all household members, there is no need to mount the washbasin so low that it is uncomfortable for adults. A compromise may be a good option. Next to the washbasin, which is mounted at an optimum height of 85 cm, is possible to place a special stabile platform or children's stool from which the kid can reach it easily. In preparing a project of bathroom, designed also for children, keep in mind that children grow very quickly, so we need to be farsighted to create an interior that will be changing with growing children. Sanitary fittings should be placed on standard heights and equipped with special facilities for children [2].

The project of bathrooms in kindergarten should include fit of mounting height of washbasins to the height of users. This is a very important issue especially among the youngest children. Mounting height is also important for additional equipment: mirrors, dispensers for soap, clothes hangers, dispensers for paper towels. Also the dimensions of the washbasin are important for preschoolers. Smaller sanitation are safer for them. Fortunately, many manufacturers of sanitary ceramics have in offer products designed to meet the needs of small children, for example, the small-size washbasins.

In order to avoid accidental burns of children, taps with separate temperature control should not be used. Thermostatic mixer taps are safest. The safety of the youngest users of the bathroom is the most important, so the manufacturers of fittings offer a large selection of thermostatic faucets. The temperature of the water in these taps can be controlled in the range of 15–65 °C with a precision of one degree. The memory function for parameter settings or applied lock makes that every time the temperature of water has the same value. The possibility of application of electronic touchless faucets controlled by a photocell sensor and automatic soap dispensers, should be considered in order to improve the hygienic use of washbasins in kindergarten bathroom. Smart touchless faucets have another advantage - automatic cutoff the stream makes that children do not waste the water. This solution allows to reduce water consumption, but also to protect from possible flooding the bathroom. Modern outflow-overflow systems, which eliminate the overflow holes in washbasins can also secure the bathroom against the flooding [2, 14, 15, 23, 24] (Fig. 1).

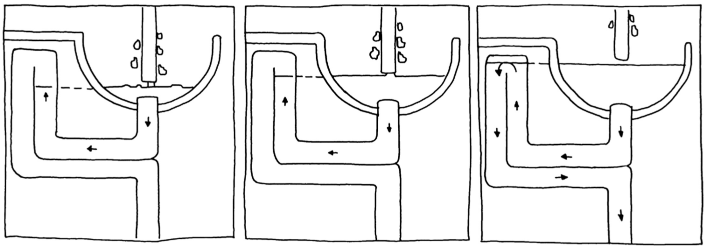

Fig. 1. The protection outflow-overflow system in washbasin. (Source: own work based on [24])

2.5 Safety in Use of Bathtub and Shower

It is well known that small children whose interest in the world and the environment is limitless are willing to do different "experiences" with the water and everything connected with it. Children make the first attempt to dive into the bathtub. Fun in bath could turn out to be not very safe for kids. It is worth to consider that kids due to head proportions relative to the whole body, which differ from the proportion of adults, have the center of gravity shifted towards the head. Analysis of the consequences resulting from a situation in which a child leaning over the bathtub or toilet can be found, should act on the imagination. Therefore, special attention and increased vigilance at a time when the child is in the bathroom is essential. The bath and shower are places of direct access of the children to the hot water. Thermostatic faucets that control the temperature of the water and thus prevent burns are the perfect solution to this problem. The ideal water temperature, which is used by small children is 48–50 °C. Therefore, setting the water heater to a maximum temperature of 40–55 °C is the easiest solution to prevent burns children. Bathtub due to the slippery surface can cause a dangerous fall, and the bathtub filled with water is a threat of drowning child. Bath mixer should be installed in a way that protect children in the bathtub before hitting the spout. The risk can be reduced by using special overlay on faucet which prevent tampering with its parts and reduce the risk of hit on the protruding part. Non-slip mats or self-adhesive pads attached to the bottom of the tub protect the child from falling. Bathtubs and shower trays, the bottom of which is permanently covered with non-slip surface (corrugated or grooved) are increasingly applied. This solution is more favorable compared to the inserted non-slip mats. Above all, the child should never be left alone unattended in the bathtub [4, 6, 9, 25].

Getting in and out of the bathtub or shower is also an action which can be uncomfortable or dangerous for the child. Handles and handrails placed in strategic locations, can be helpful. Another advantage is their surface covered with a relevant texture easy to grasp, especially with wet hands, and saturated color that distinguishes them against the walls of the bathroom. Stable and safe way of their mounting is another important issue. The same applies to hangers and towel racks. The best location for them ensuring ease of access is a place near the shower or bathtub. Similarly, using shower curtains, we should make sure that the rail on which they are hung, is properly mounted and secured. Gripping something nearby at the moment of slipping is a natural reaction of the child. It is may be, for example, curtain on the rail. The shower curtain, hung on the rail, which is securely mounted can prevent the unfortunate fall. In the case of the use of sliding glass shower doors they should be made of durable, unbreakable glass. Many existing bathroom is equipped with a shower cabin made of ordinary, not resistant to breakage glass, which in the event of an accident can cause serious injury [4, 6, 9, 25].

Also, simple accessories that improve the use of the bathroom, such as: automatic drain plug, hanger for hand shower, sponge with a handle or a special soap dish mounted under the shower, can help increase comfort and safety. Another issue which should be considered regarding the safe bathing is the use of liquid soap as a substitute for soap bar, which can prevent slipping in the bathtub or shower tray.

Properly equipped kindergarten bathroom should include a safe and aesthetic shower cabins, taking into account the number of kids. Cabins and spouts should be adapted to the height of users (lower than for adults). The shower cabins should be equipped with a special lock, which opens the door from the outside, in case the child locks himself in the inside [23].

2.6 Safety in Use of Toilet

Availability of full-size toilet bowl designed for adults can be difficult for children. The standard dimensions of toilet bowl and the standard mounting height is right for the home bathroom, because kids grow fast. However, in the period when the children are still small, special facilities supporting the use of the toilet, turn out to be helpful. Bathroom footstool, which facilitates the use of the toilet is very useful. The children's stool appears more secure if it is finished with a soft rubber. Too much toilet seat can be reduced by using a special children's toilet seat adapted to the dimensions of the child. This ergonomic facility provides comfort and safety, and can be adjusted to most toilets. Toilet seats should be antimicrobial [2, 4, 25] (Fig. 2).

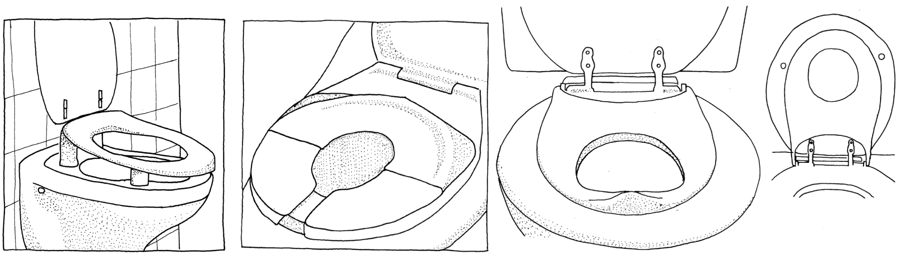

Fig. 2. Facilities for adjusting the size, height and shape of the toilet seat. (Source: own work based on [1, 3])

The kindergarten toilets design should take into account the needs and requirements of small users. Therefore, installation of small-size toilet bowls and fit of their height to the height of children should be included in the projects. Solutions in the form of wall-hung toilet bowls that are installed on the in-wall support frame, work perfectly in this kind of establishments, as in other public institutions. They allow installation of equipment at any height and provide comfortable use and ease of cleaning. The innovative rimless toilet bowls "no collar" turn out to be more "hygienic". They are designed without an inner rim, thus there is no place for dirt and limescale to hide. Therefore we should consider the use of such solutions in the kindergarten bathroom [2, 4, 19, 23, 25].

2.7 Safe Storage in the Bathroom

Most of the medicines and chemicals are commonly kept in home bathrooms. This is associated with the risk of poisoning and burns. Most people are used to storing detergents in the bathroom, usually under the washbasin or in the toilet area. This is not sufficiently safe location, taking into account the interests of small children whose desire and the ability to get to the most hidden places is unlimited. The best opportunity to store cleaners are places protected from the reach of kids, with a marked and closed containers. Storage in the upper cabinets, the use of interlocks and safeguards can prevent children access to chemicals and medicines. All kinds of medicines should be protected against contact with chemicals, which is associated with their proper storage and the appropriate indication of their content. Also, secure storage of cosmetics is important. Especially flammable agents, such as nail polishes, nail polish removers, hair sprays should be treated with extreme caution and stored at a safe distance from the heat source. Moreover, also the things that are no longer needed can be a source of danger. Empty containers, used razor blades, expired drugs, unnecessary cosmetics, aerosols, all of these things, when are already useless and are thrown carelessly in the trash, cause serious danger to inquisitive children [4, 25] (Fig. 3).

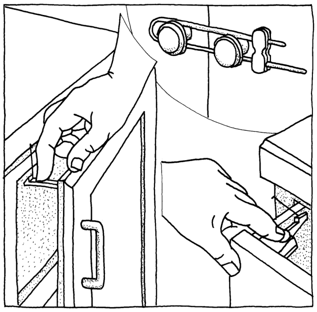

Fig. 3. The ways to prevent children access to chemicals and medicines. (Source: own work based on [8])

2.8 Electrical Appliances

Due to the increased electrical shock hazard in an environment of high humidity, problem of electrical installations in the bathroom requires a specific approach, especially if among its users are small children. Guarantee and assurance that the electrical installation complies with currently applicable standards, are necessary. Enabled electrical equipment should not be left near water. Children's curiosity and imagination know no bounds, so parents of young children should be especially alert and careful. Transfer of children from an early age the principles of safe use of electricity and electrical equipment is necessary. But apart from that, the power sockets must be adequately protected by waterproof covers, whereas electrical appliances should be stored in places that are out of reach of children [9, 18].

3 Aesthetic Criteria

A child in the first years of life gains experience, which shapes its relationship to itself and to the environment. The surrounding space should not only be safe, functional, adapted to its needs, but also attractive and interesting. The impact of the nearest environment is of great importance, because the kid uncritical assimilates everything, that the world around offers him. A wise choice of what we offer to children and what use they make of this, is very important [10].

The child should feel good also in the bathroom. Of course, home bathroom turns out to be the most significant in this respect, but the bathrooms, which are used at the kindergarten or in other public places also play an important role. Children often avoid using the bathrooms in public places, mainly due to the unfavorable and unfriendly infrastructure. This behavior can cause not only serious discomfort, but also health problems. For this reason, the creation of appropriate conditions for convenient and safe use, as well as proper aesthetics and user-friendliness of these rooms is so important. This action seeks to provide protection of children from the unpleasant impressions and feelings, and sometimes even traumatic experiences associated with the use of bathrooms and toilets. On the other hand, friendly hygienic-sanitary spaces should encourage to take care of personal hygiene and health from an early age.

Competent involvement in the organization of structure, equipment and appearance of the hygienic-sanitary spaces used by children can have a big impact on their safety, harmonious development and well-being. Since the child becomes interested in the surrounding environment, parents should make an effort to places where the child lives and stays every day would be safe, but also attractive and friendly, taking into account its needs, interests and physical activity characteristic of that stage of development. This process runs until the age of puberty, but is particularly intense precisely in pre-school. Everyday objects become elements of fun and everything that surrounds the child develops its imagination [10].

With age, the child pays more attention to hues and learns the names of colors. Appropriately designed bathroom should satisfy the curiosity and cognitive needs of child. It is important the more that the development of a child's imagination is stimulated by external impulses and incentives. For small children the bathroom is a place where they can play the different scenes, create sea fleet, lead a flock of rubber ducks, arrange boat races and conjure up fluffy foam. Child development is actuated, motivated and inspired by such fairytale stories. In the bathroom in addition to the sense of sight, the sense of smell in children may be excited, so the use of scented bath amenities that encourage the child to take care of hygiene is important. Fun is the key - in this way the children are encouraged to use the bathroom and taught proper hygiene habits. Colors, shapes, patterns provide joy, and the best way to introduce them in the bathroom is the use of multi-colored tiles, or original decors. Also, elements of equipment, such as a washbasin and toilet with an interesting shape, colorful cabinets or patterned shower curtain or towel can give rise to a good mood and great fun. Also, multicolored rugs and non-slip mats in the shape of animals or characters from favorite fairy tales are attractive for the youngest children. All accessories for bathing and washing and dispensers, soap dishes, cups - if they are decorated with patterns and characters, the children will be happy to use them. Innovative battery with an LED that illuminates the water stream and gives it color can be a way to attractive children's bath [5, 10, 14, 15].

To create a child-friendly bathroom we need some thoughtful treatments aimed at the practical use of this room, without depriving the children the opportunities for fun. The bathroom should be a reflection of a child's room, where a preschooler feels safe and joyful. Brushing teeth and evening bath can become a daily adventure in a colorful oasis, not a necessary evil. Complement of the bathroom decor should be a mirror to which children "grin" during brushing. Also towel hangers are necessary - the perfect choice for kids are colorful hangers on the suction cups that we can easily move higher when the child gets older. The set should be supplemented by bathroom boxes, where children can store their toys or cosmetics [5, 10, 14, 15].

Creation of individual separated bathroom for child that meets all its needs is rarely possible. In order to ensure the child-friendliness of a common home bathrooms we should plan in its area separate space designed just for kid. With this action the presence of the youngest family member in the bathroom is emphasized and then the child willingly uses it. It can be a shelf or cabinet, placed in an easily accessible place in which the child keeps utensils to wash and bath toys [14, 15].

Shaping of the child-friendly aesthetic is also a great challenge for designers of kindergarten bathrooms. In this respect, the kindergarten bathrooms usually do not have any restrictions, because among users are practically only children and too colorful interiors are not burdensome to the eye of adults. There is no risk that the colors, shapes, patterns, decorations will be boring for children. The main objective of the design and implementation is to create a child-friendly, encouraging the use and exceptional hygienic and sanitary places.

4 Conclusion

The ergonomic quality of hygiene-sanitary spaces plays a key role in shaping the conditions affecting the health, safety and well-being of users. Among users of bathrooms are people of different age and psychophysical condition, including children in different age groups, including toddlers and preschool children, which require special, extra care. Safety of bathroom users often depends entirely on their own risk awareness, knowledge, foresight, skill and ability to prevent accidents and to react in the event of their occurrence. When among users of the bathrooms are small children, the matter is more complicated, because these factors do not exist and we can't rely on them. Therefore, the health and safety of children using the bathroom depends primarily on the treatment of their parents and caregivers, but also on the actions of the bathroom designers and manufacturers of bathroom facilities.

The main function of the hygienic and sanitary space related to personal hygiene is undeniable significant in terms of health, both on the individual and society, which emphasizes its importance. Nowadays, hygiene is mainly associated with purity, although it has undeniably close relationship with preventive medicine and should be treated as medical prevention [7, 13, 17].

Among the basic preventive principles of safe use of bathrooms by children can be found mainly:

- anticipation and knowledge about type of hazards that may occur in the bathroom,
- avoidance, prevention of risks, taking into account the warnings, application of precaution, improvements and additional amenities,
- reaction, exercise and develop the correct reactions to emergency situations [9, 25].

Parents, caregivers, bathrooms designers and manufacturers of bathroom equipment should pay special attention to the first two principles, so that the latter does not have to be put into practice.

Observations and analysis of contemporary trends in the development of hygienic and sanitary spaces and rooms show that the number and diversity of devices supporting their functioning increases and develops with technological progress. Courses of actions of designers and producers and solutions resulting from their activities include criteria for: hygiene, health and safety.

But even the most secure bathroom does not encourage children to use and does not make they feel good in it, if it is not interesting, pleasant and inviting place for them. Fortunately, ergonomic operations of the bathroom industry include both functionality and the widely understood aesthetics and visual attractiveness of bathrooms.

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"Student Zone" as a New Dimension of Learning Space. Case Study in Polish Conditions

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Abstract. With the quick development of Information Technology, there occurred changes in the ways of knowledge acquisition. Its expansion influenced the new methods of studying and learning. It modernized the tools to support it as well. Students are looking for greater practical cognizance and experience. Progress of information network and work means related to flow of the information, carried weight on its simple acquisition. Activities, connected with the use of network and new forms of work, are forcing new functional and spatial relations and interactions in the university buildings. Nowadays, the process of gaining knowledge is taking place in different locations - not only in lecture rooms, but also in social links and electronically. With the support and through access to digital resources and mobile devices, learning can take place anywhere in many ways. These new trends have their reflection in the architectural spaces of universities. The paper describes a way to create a modern and innovative student zone on Faculty of Architecture, Silesian University of Technology in Poland. There were presented the following steps: an idea, schedule of the task, surveys carried out among students, student competition for interesting thoughts, creation of project team involving students, accomplishment of the project financing and implementation. Zone for student of architecture has a chance to become a model for the other faculties.

Keywords: Higher education · University building · Students' space · Learning space · Teaching space · Participatory design · Qualitative research

1 Theory – New Ways of Acquiring Knowledge and Skills – New Functional and Spatial Needs in Contemporary Universities

Universal access to sources of knowledge through a network created a great progress in terms of work organization. The role of the personal computer has become leading. Its evolution into a personal portable device (Laptop, notebook, iPad, smartphone, etc.) meant that modern human can be "present" everywhere. To create a good environmental and spatial organization, the main concentration should be on those assumptions. The main problem is the modern form of work in the contemporary university. Currently,

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university space cannot be considered only in the traditional way, because the pattern of learning and acquiring knowledge is constantly changing [9, 11].

What now has a significant influence on forming the buildings and their spaces, is the knowledge of what the contemporary forms of work and cooperation in the field of learning, relationships of people and using the Internet are.

Referring to the OECD1, basic form of development of universities and their buildings (in the sense of space) is knowledge about the needs of utility.

XXI century, according to OECD, follows the new image of the university spaces and facilities based on fundamental assumptions:

- Use of Information Technology (ICT);
- Close cooperation with industry (with external partners);
- Students Expectations, their lifestyle (informational society);
- Social interaction in the field of learning.

The forms of learning and activities have changed, in the direction of such models as:

- Collaboration – activity based on cooperation – learning in the group; tasks demanding mobility, can be loud;
- Immersion – individual work, absorbing, requiring concentration, quiet;
- Corporate or individual (mixed) with the network use– operation, for example in workshops or laboratories, requiring a good network connection and space for group activities;
- Learning everywhere – in informal spaces[1].

The process of transformation at European universities (in the EU Member States) took place much earlier than in Poland. It started in the 90s of the twentieth century.

Development of technologies and techniques coincided in Western Europe took place also earlier – 70–80s of the twentieth century, when personal computers were distributed and the first intelligent buildings were built. Western Europe made a great progress in the science development. It meant that these countries and the United States of America, have become leaders in the research development, science and higher education as a system. For Poland, the entrance into the European Union in 2004, created new possibilities for its huge breakthrough. Since then, many new university buildings, which have innovative teaching and research spaces, have been built. At the same time, the buildings of the old generation (established by the end of 80s) required modernization. Many of them have not been adjusted to the present norms in the range of functional space for contemporary needs. One of such objects is the building of the Faculty of Architecture, Silesian University of Technology.

[1] The division according to the OECD, author's commentary, source: OECD – Organization for Economic Cooperation and Development, A. Blyth "OECD Programm on Education Building" www.oecd.org/edu/facilities.
OECD – international institution dedicated to qualitative research in higher education, assesses, supports and promotes good practices for the quality of the scientific community.

2 The "Student Zone" of the Faculty of Architecture, Silesian University of Technology – Inclusion of Scientific Potential in Creation of New Functions

The building of the Faculty of Architecture, Silesian University of Technology has been designed in the 60s of the twentieth century, as a building with exercise halls for the then Department of Civil Engineering and Architecture. With time, when the Department of Architecture became independent and more and more students have been appearing – arrangement was continually modified. Today, the building holds a number of different types of classrooms, laboratories and department offices. However, in case of halls and their divisions, systems of corridors and public areas has been improved several times. The space in those regions was opened as much as possible.

The idea for the "learning area" at the Faculty of Architecture, Silesian University of Technology was established several years ago. However, then authorities did not see the point in making any substantial changes to the building of the Faculty. From year to year there could be heard the demands of students who very carefully refined their needs in terms of work and leisure between their classes. There were also carried out numerous student projects and concepts of arrangement modification which contained the creation of places to learn and broaden social contacts. The current authorities have taken a decision to execute and implement such project. To do it well, there was included scientific potential of employees and students of the Faculty. There were carried out pre-designing studies, followed by a workshop competition for students of the Faculty of Architecture, so they can design their zone by themselves.

3 Description of Pre-designing Research Methods

The research method, used in the pre-designing studies, is simplified POE (Post-Occupancy Evaluation). Firstly there were taken following steps:

- An on-site inventory of places potentially suitable and similar to "Student Zone" design.
- Preliminary interviews with the student council of the Faculty of Architecture.
- The survey, which included questions addressed to students. The research was focused on the identification of needs in relation to the planned space and on the assessment of the existing building in the field of "learning".
- At a later stage, after the completion of the project, there will be carried out an evaluation of the level of user satisfaction which will be used for improvement activities.

The survey included questions about the functional and organizational needs of the students in relation to the Student Zone.

The methods are described in: Fross K., Sempruch A.: The qualitative research for the architectural design and evaluation of completed buildings – part 1 – Basic principles and methodology, ACE vol 8, no 3/2015, Silesian University of Technology, str. 13-19, 2015 [3] and in the book Fross K.: Quality evaluation in architectural design on selected examples, Publisher Silesian University of Technology, Gliwice, Poland, 2012.

4 The Results of the Survey

The purpose of the survey was a cognition of the student community opinion about the existing student zone located in the building of the Faculty of Architecture.

The questions were also formulated in order to meet the opinions on how this space should look like. The survey allowed broader understanding of the user's needs and allowed to gather knowledge necessary for the proper conduct of future modernization works.

There were asked following questions:

1. Define the functions (for example work, recreation, etc.) that should be in the room, list the 4 that you think are obligatory.
2. Determine which features are most important to you - list 1 or 2.
3. Replace the 3 pieces of equipment listed in your functions in question 2, in range of furniture, equipment and installations.
4. If you can - define the style of the room – as a description or using the names.
5. Define your color preferences in terms of primary and the dominant colors.

Based on the collected surveys, in such area there should be located mainly places for work and rest. For the positive functioning of space it is needful to design such functions as: social, kitchen, reading, zone of silence, learning and the place for making models (Fig. 1).

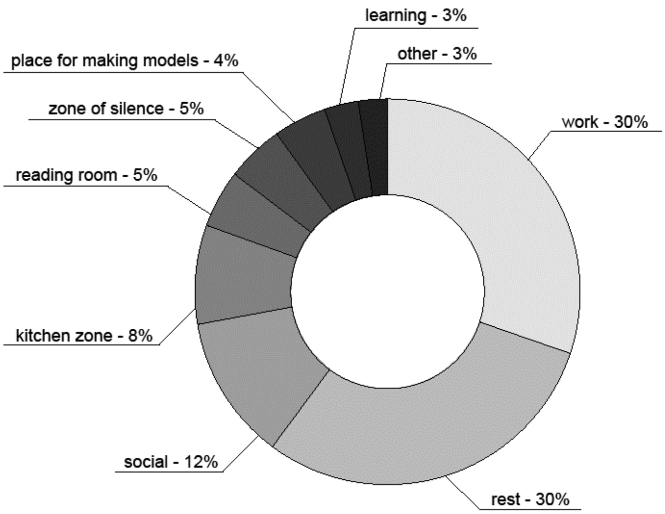

Fig. 1. Features that should be included in the student area. (the author's elaboration, 2017).

As the most desirable equipment, the respondents listed following elements of furniture: poufs for resting, sofas, armchairs, couches; deep, large table tops; comfortable chairs, adjusted to the height of countertops. An important component was also the technical equipment: sockets, media ports; desk lamps which provides good lighting; extension cords; small appliances (refrigerator, coffee maker, microwave, kettle).

Students were also asked to indicate the style of the room. They detailed many ideas for the look and colors of the place. On the one hand, the students pointed out the need to minimize the amount of stimulants acting on the users, room should be raw, bright, modern - no ornaments, minimalist style. On the other hand, there should be paid attention to need for stimulating creativity and encouraging the creation.

As the primary colors most often chosen were: gray, white and black. Frequently named dominant color was white. Student also indicated such colors as: gray, red, orange, yellow.

The space does not meet the expectations of users, it lacks the basic elements of the interior equipment. Obtained information not only allowed to identify the problem, but also to gain valuable and necessary knowledge, opinions, and ideas of future users to improve the functioning of the area. This will help in the later stages for fuller and more appropriate matching of functions and equipment that should be there. It can even allow to avoid design errors and help in making the correct design decisions (Fig. 2).

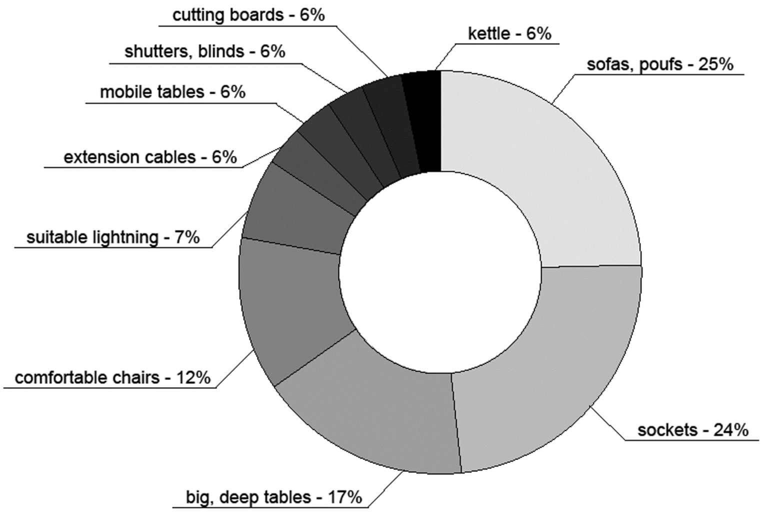

Fig. 2. The most frequently mentioned equipment, which should be placed in the student are (the author's elaboration, 2017).

On the basis of pre-designing research, the functional program of "Student Zone" was developed. Then there were made projects during the workshops which ended up with competition. The Student Place contains three zones: main room – which includes space for work and leisure as well as other amenities that allow students long and comfortable stay and the activities associated with the process of learning; main hall with the so-called gallery, in which there was arranged a space for social interaction; the corridor, in which eventually will be carried out modernization of the electrical systems and there will be created more outlets and seats for laptop use.

5 Summary and Conclusions

– It is needful to design for the user with their participation - participatory design (here with the participation of students at all stages of the investment process).
– Pre-designing qualitative research is a source of knowledge for designing process and it helps to meet the expectations of future users.
– The survey gave a great set of information about the real needs of users (Fig. 3).

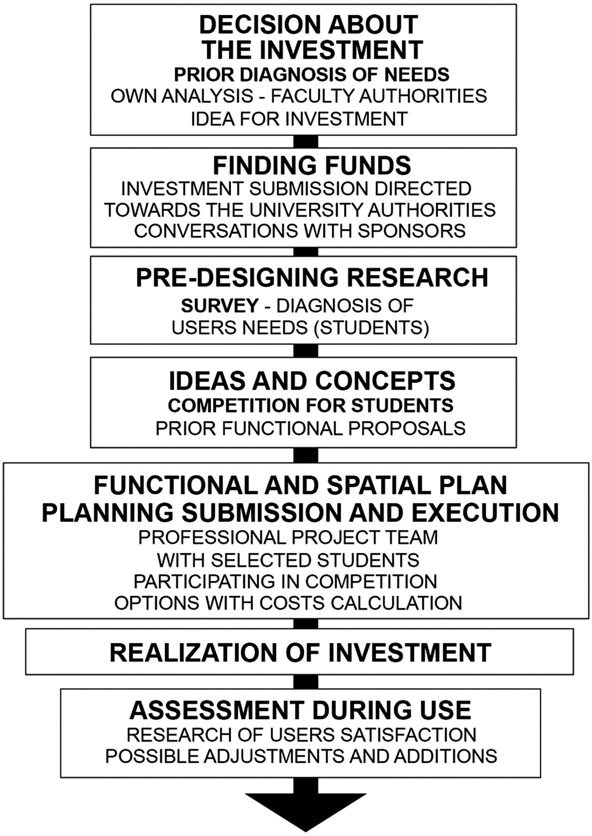

Fig. 3. Diagram showing the entire investment process with design based on research – design by research (the author's elaboration, 2017).

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Causes-Effects Relationship of Construction Project Delays in Ghana: Focusing on Local Government Projects

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Abstract. Project delays in the construction industry are a worldwide phenomenon and local government construction projects in Ghana are not an exception. The paper presents the results of a survey conducted to identify and assess the severity of the causes of local government construction project delays and their effect in Ghana. In previous research, the causes and the effects of project delays has been studied without considering the possible relationship that exist between them. This study takes a combined approach and also sought to analyze the relationship between specific causes on specific effects. The results of the study revealed the main causes of schedule delays in local government construction projects as: delay in progress payments; variation orders during construction; difficulties in financing projects by contractors; delay in material delivery; and unforeseen site conditions. The study further identified the effects of delay as: time overrun; cost overrun; delay by contractor in repayment of loans; disputes; and poor quality work due to speeding up of work. The study also established an empirical correlation between each cause and effect. The study revealed that bulk of the effects of delay of local government construction projects is triggered by client-related and contractor-related causes.

Keywords: Causes · Construction · Effects · Ghana · Local government · Project delay

1 Introduction

The world is experiencing exponential population growth in this 21st century. Mulcahy and Partners [15] predicted that this growth could continue until the year 2050, placing the world's populations at nine billion. This high continuous population growth would invariably affect the demand for infrastructure [16].

Construction is an important component of the Ghanaian economy. For instance in 2012, construction sector of the industry category recorded a growth rate of 11.2% that is GH¢ 18.72 billion (US $ 6.6 billion) of the overall GDP of GH¢ 73.1 billion (US $ 26 billion) as compared to the growth rate of 5.6% in 2010 and 4.5% in 2009 [7]. Along similar lines, Ghana National Development Planning Commission [6] had also

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argued that the construction industry in Ghana, as in other parts of the world, is a huge and a crucial sector in economic development.

Despite the enormous economic significance of construction projects to a nation's economy, public projects are frequently behind schedule all over the world due to various uncertainties. This is confirmed by Mohd [14] who opined that, the challenge of schedule delay in public projects is a global phenomenon and there is no exception. Throughout Ghana, it is a common knowledge that construction projects, especially public projects are almost always delayed. Construction project delay is a major challenge facing the construction industry in Ghana. Fugar and Agykwaah-Baah [5] indicated that project delays invariably have a great repercussion on the various stakeholders within the Construction Industry in Ghana. Some of these challenges include financial, conflict, termination of contracts and litigation. Additionally, in Ghana, financial inconsistency is the major impact of project delay in Ghana [4]. Whenever projects execution is delayed it results in negative effect on some or all of the following: inflation, interest rates, and foreign exchange rates. These have an immense influence on constructional budgetary allocation. Schedule delays in construction projects have caused the public sector to pay more than the budget allocated for the projects. A budgetary statement by the Ministry of Finance [13] stated that, most public projects are mismanaged, incurring much delay and cost overruns. These costs overruns are sometimes due to the payment of interest to contractors, increase in material cost due to inflation and change in the exchange rates in the market etc. In paying interest on delayed projects, government loses substantial amount of money that could have been used for other commendable projects. The negative impact of public project delay on the economy is great and needs to be tackled with utmost urgency. Aibinu and Jagboro [1] conclude, thus, that project delays are not without cost consequences.

In previously published studies in Ghana, researchers primarily looked at the causes construction project delay in areas such as government funded projects, donor funded projects, ground water projects, Building Construction projects etc. However, none of these studies in Ghana specifically focused on Metropolitan, Municipal and District Assembly (MMDA's) construction projects. In contrast to the most common research areas on schedule delays in previous studies, this study attempts to assess the causes and effects of local government construction project delays in Ghana. The study sought to also consider the relationship between the causes and effects.

2 Methodology

The paper adopted a two stage data-gathering approach. At the first stage, exploratory method was used to identify the causes and effects of local government construction project delays. This involved the use of purposive sampling of fifteen (15) major stakeholders. The sample was chosen based on their rich experience from being involved in management of MMDA construction projects in Ghana for over two decades. The stakeholders comprised five District assemblies, five major consultants with huge experience in MMDA construction project management, five major contractors who have handled major local government projects in Ghana.

Data were collected by the use of semi- structured interview and then transcribed and coded using Nvivo 8 Software. Nvivo offers a useful toolkit for thinking, reflecting and linking elements of qualitative data to develop memos and also annotate the contents of responses for factors to emerge [9]. Here the Nvivo helped in identifying forty-six (46) causes and thirteen (13) effects of local government construction project delays. It was observed that thirty-seven of the causes are consistent with literature on project delay, whilst the remaining nine are inconsistent, suggesting that they might be peculiar to conditions pertaining to local government construction project delays in Ghana.

The second stage involved the use of constructs generated at the exploratory survey stage in designing questionnaire, using a five-point rating scale. The essence was to help subject the forty-six causes and thirteen effects to a questionnaire survey. The respondents were asked to rate the level of severity of each identified cause and effect of local government project delay in Ghana. The five-point rating scale for the levels of severity range from 1 = 'Not Severe', 2 = 'Less Severe', 3 = 'Quite Severe', 4 = 'Severe', and 5 = 'Very Severe'. In all 133 questionnaires were distributed to local government staff (MMDA's), consultants and contractors involved in the management of local government construction projects in the eastern region of Ghana. Out of these, 89 were retrieved representing response rate of 67%. This high response rate was achieved through personal distribution of the questionnaires and several follow ups made for retrieval.

Data generated from the survey was further analysed with statistical methods such as descriptive statistics, severity index analysis and correlation. For the severity index analysis, the frequency analysis was first carried out to determine the frequency of responses which were then used to calculate severity indices [8]: Severity Index (SI) = $[\Sigma ai.xi/5\Sigma xi]$ where 'a' is the constant expressing the weight assigned to each response (ranging from 1 for 'not severe' to 5 for 'very severe') and 'x' is the frequency of each response.

3 Results and Discussion

3.1 Demographic Characteristics of Respondents

It is always important to have a reasonable idea of the respondents who took part in a survey in order to place the response within context. The result of the demographic characteristics of respondents indicated that of the 89 respondents in the survey, 38 (43%) were clients (MMDA's), 19 (21%) were consultants whilst 32 (36%) were contractors. The professional experience of most of the respondents (40%) ranged between 6–10 years. It was also revealed that majority (52%) of the respondents had university education. As far as area of specialization of the respondents is concerned, 51% is into building works, 10% is into civil works whilst 39% is into both building and civil works.

3.2 Causes of Schedule Delay

The questionnaire was analysed from contractors, clients and consultants' perspective. In order to identify the most severe causes of local government construction project delay, the items were ranked in the seven groups of causes. On the basis of ranking of the causes by the various groups it was possible to identify the most severe causes of delay. A summary of all the causes of delay in local government construction projects, severity index, ranking by the groups, and overall ranking as identified by all groups is shown in Table 1.

Table 1. SI and ranking of causes of delay

Causes of delay	Client		Consultants		Contractors		Overall	
	SI	Rank	SI	Rank	SI	Rank	SI	Rank
Client/owner causes								
Delay in progress payments	86%	1st	94%	1st	96%	1st	91%	1st
Delay in handing over site to contractor	74%	5th	76%	3rd	72%	4th	74%	11th
Variation orders during construction	82%	2nd	88%	2nd	92%	2nd	87%	2nd
Lateness in revising and approving design documents	76%	4th	74%	4th	68%	6th	73%	12th
Delay in approving shop drawings and sample materials	68%	6th	64%	6th	60%	8th	64%	18th
Poor communication and coordination	78%	3rd	72%	5th	74%	3rd	75%	10th
Slow decision making	64%	7th	62%	7th	62%	7th	63%	19th
Suspension of work	58%	8th	56%	8th	70%	5th	61%	21st
Contractor causes								
Delay in sub-contractors work	84%	1st	78%	3rd	76%	2nd	79%	7th
Difficulties in financing project	82%	2nd	86%	1st	83%	1st	84%	3rd
Rework due to errors during construction	72%	5th	74%	6th	68%	4th	71%	14th
Conflicts between contractor and other parties	62%	9th	60%	10th	58%	9th	60%	22nd
Poor site management and supervision	80%	3rd	76%	5th	60%	7th	72%	13th
Poor communication and coordination with other parties	68%	7th	62%	9th	54%	10th	61%	21st
Improper planning and scheduling of project	78%	4th	80%	2nd	70%	3rd	76%	9th
Improper construction methods	70%	6th	77%	4th	65%	5th	71%	14th
Inadequate contractor' experience	68%	7th	70%	7th	62%	6th	67%	17th
Delay in site mobilization	64%	8th	64%	8th	59%	8th	62%	20th
Consultant causes								
Poor contract management	78%	2nd	62%	7th	80%	2nd	73%	12th
Delay in performing inspection and testing	76%	3rd	64%	5th	70%	8th	70%	15th
Delay in approving major changes in the scope of work	75%	4th	66%	4th	78%	4th	73%	12th
Poor communication/coordination between consultant and other parties	72%	6th	68%	3rd	76%	3rd	72%	13th
Inadequate experience of consultant	70%	7th	58%	9th	73%	6th	67%	17th
Mistakes and discrepancies in design documents	80%	1st	74%	1st	86%	1st	80%	6th
Delay in producing design documents	68%	8th	63%	6th	72%	7th	68%	16th
Unclear and inadequate details in drawings	74%	5th	70%	2nd	75%	5th	73%	12th

(*continued*)

Table 1. (*continued*)

Causes of delay	Client		Consultants		Contractors		Overall	
	SI	Rank	SI	Rank	SI	Rank	SI	Rank
Misunderstanding of owner's requirements	64%	9th	59%	8th	65%	9th	63%	19th
Material causes								
Changes in material types and specifications during construction	64%	2nd	70%	2nd	68%	2nd	67%	17th
Delay in material delivery	83%	1st	86%	1st	80%	1st	83%	4th
Delay in manufacturing special building materials	58%	3rd	60%	3rd	56%	3rd	58%	23rd
Lateness in selection of materials due to availability of many types in market	54%	4th	48%	4th	50%	4th	51%	25th
Equipment causes								
Equipment breakdowns	79%	1st	79%	1st	82%	1st	80%	6th
Shortage of equipment	73%	2nd	75%	2nd	76%	2nd	75%	10th
Low level of equipment-operator's skill	52%	3rd	54%	3rd	48%	4th	51%	25th
Low productivity and efficiency of equipment	48%	4th	50%	4th	52%	3rd	50%	26th
Labour causes								
Shortage of labour	54%	3rd	44%	4th	46%	3rd	48%	28th
Unqualified workforce	74%	1st	76%	1st	78%	1st	76%	9th
Low productivity level of labour	68%	2nd	64%	2nd	72%	2nd	68%	16th
Personal conflicts among labour	52%	4th	48%	3rd	44%	4th	48%	28th
External causes								
Weather condition	76%	2nd	76%	2nd	78%	2nd	77%	8th
Unavailability of utilities on site (such as, water, electricity etc.)	52%	5th	49%	5th	46%	4th	49%	27th
Problem with neighbours	44%	6th	38%	7th	43%	6th	42%	29th
Traffic control and restriction at job site	42%	7th	40%	6th	38%	7th	40%	30th
Accident during construction	58%	3rd	52%	4th	48%	3rd	53%	24th
Unforeseen site conditions	82%	1st	80%	1st	83%	1st	82%	5th
Changes in government regulations and laws	55%	4th	53%	3rd	44%	5th	51%	25th

Client/Owner Causes. The severity indices of the client/owner causes of delay under this group are presented in Table 1. It is realized that 'delay in progress payment' is the most severe cause of delay in local government construction projects (with SI of 91%) overall, as all three categories of respondents (Clients, Consultants, Contractors) ranked it as the first most severe cause of delay. This cause of delay may be due to the existing culture in the local government sector. In Ghana, local governments mostly get their revenue from internally generated funds (IGF) which is woefully inadequate, the common fund (CF) which is hardly disbursed and the district development facility (DDF) which is also not adequate. Most local governments award construction projects with the anticipation of disbursement of these funds from central government. However, these funds are always in arrears and therefore delay these construction projects. As a result, there is inadequate cash flow to support construction expenses especially for contractors who are not financially sound. According to the initial interview conducted, majority of the interviewees also attributed delay in payment to bureaucracy in the local government procedure for payment. Regular monthly payment to contractors for work done removed constraints which otherwise may have impeded project progress to cause delay. Failure to provide adequate funding resources to contractors for the job done will make it difficult for the contractors to meet project objectives [12].

'Variation orders during construction' overall is ranked as the second most severe cause of delay in local government construction projects (with SI of 87%) on the list of causes of delay. Clients, Consultants, and Contractors all ranked it as the second most severe cause of delay.

'Poor communication and coordination' overall is ranked tenth (with SI of 75%) on the list of causes of delay. Clients and Contractors ranked it as the third most severe cause of delay under this group whereas Consultants ranked it as the fifth most severe cause of delay. Since there are many parties involved in a project (client, consultant, contractor, sub-contractors), the communication between the parties is very crucial for the success of the project. There is the need for proper communication and coordination between the client and the other parties. Proper communication channels between the client and various parties must be established during the planning stage. Any problem with communication between the client and any other party can lead to severe misunderstanding and therefore, delays in the execution of the project. The details of the remaining causes of delay under this group are indicated in Table 1.

Contractor Causes. Under this group of causes, 'difficulties in financing project' was ranked first by both Consultants and Contractors while clients ranked it as the second most severe cause of delay under this group. In total, it was ranked as the third most severe cause of delay in local government construction projects. Construction works involve huge amounts of money and most of the contractors find it very difficult to bear the heavy daily construction expenses before payment is done. Work progress can be delayed due to delay in purchase of materials and payment to labourers by contractor. 'Delay in sub-contractors work' overall was ranked seventh (with SI of 79%) on the list of causes of delay. In this group of causes, it was ranked by clients, consultants, and contractors as the first, third, and second most severe cause of delay respectively. Sub-contractors ineffectiveness affects the main contractor's schedule. Typically in huge projects, there are many sub-contractors working under main contractors. If the subcontractor is capable, the project can be completed on time as planned. The project can be delayed if the subcontractor under performs because of inadequate experience or capability. 'Improper planning and scheduling of project' was ranked fourth by clients, consultants ranked it at second, whereas contractors ranked as third most severe cause of delay. In total, it was ranked as the ninth (with SI of 76%) most severe cause of delay of local government construction projects. Contractors who work with local governments often fail to come out with a practical and workable "work program" at the initial planning stage. This failure is interrelated with lack of systematic site management and inadequate contractor's experience towards the project. The consultant only checks and reviews the work program submitted by the contractors based on experience and intuitive judgment. Improper planning at the initial stages of a project manifests throughout the project and causes delays at various stages. Only a project that is well planned can be well executed.

Consultant Causes. Table 3 further indicates that in this group of causes of delay, 'mistakes and discrepancies in design documents' was ranked by all three categories of respondents as the first most severe cause of delay. On the whole, it was ranked as the sixth (with SI of 80%) most severe cause of delay of local government construction projects. ‘Poor contract management’ was overall ranked in the twelve (with SI of 73%) position. But it was ranked by both clients and contractors as second, whilst consultants ranked it as seventh most severe cause of delay in this group. This can be attributed to the way contracts are managed by local governments. In most cases, most local government projects are managed ‘in house’. They have the works department that mostly serve as consultant to these projects. Conversely, most of these departments lack the technical capacity to manage these contracts, therefore goes to affect the project. The three categories of respondents all ranked ‘delay in approving major changes in the scope of work’ as the fourth most severe cause of delay in this group. On the whole, it was also ranked in the twelve (with SI of 73%) position.

Material Causes. According to Table 3, all three categories of respondents ranked ‘delay in material delivery’ as the first most severe cause of delay in this group. In total, it was ranked as the fourth (with SI of 83%) most severe cause of delay of local government construction projects. Clients, Consultants, and Contractors all ranked ‘changes in material types and specifications during construction’ in the second position under this group. However, on the whole, it was ranked in the seventeenth position with SI of 67%. ‘Delay in manufacturing special building materials’ was ranked by all respondents in the third position under this group of causes of delay. Overall, it was ranked in the twentieth (with SI of 58%) position. Shortages in basic materials like sand, cement, stones, blocks, and iron rods can cause major delays in projects. Since Ghana is a country that is developing very fast, often times demand exceeds the supply and this causes prices to increase. The contractors at times delay the purchase activities until the prices decrease. Manavazhia and Adhikarib [11] investigated material and equipment procurement delays in highway projects in Nepal and found these delays to cause cost overrun.

Equipment Causes. In this group of causes of delay, all three categories of respondents ranked ‘equipment breakdowns’ as the first most severe cause of delay. On the whole, it was ranked as the sixth (with SI of 80%) most severe cause of delay of local government construction projects. All three groupings of respondents further ranked ‘shortage of equipment’ in the second position under this group. It was overall ranked in the tenth (with SI of 75%) position. ‘Low level of equipment-operator’s skill’ was on the whole ranked in the twenty-fifth (with SI of 51%) position. Clients and Consultants ranked it in the third position while Contractors ranked it in the fourth position under this group of causes of delay. Many of the contractors who work with local governments do not own equipment that are required for construction works. They rent the equipment when required. During the season when there are many construction projects, the equipment are in short supply and are poorly maintained. This leads to failure of the equipment causing the progress of work to be hampered.

Labour Causes. Table 1 shows that ‘unqualified workforce’ was ranked by all three groupings of respondents as the first most severe cause of delay in this group. In total, it was ranked in the ninth (with SI of 76%) position. ‘Low productivity level of labour’ was ranked by all three categories of respondents in the second position in this group of causes. On the whole, it was ranked in the sixteenth position with SI of 68%. Clients and Contractors ranked ‘shortage of labour’ in the third position whereas consultants ranked it in the fourth position in this group of causes of delay. On the other hand, in total, it was ranked in the twenty-eighth position with SI of 48%. The quality and quantity of labor supply can have major impact on the projects. Most of the labourers who work with local government Contractors in Ghana are not highly skilled, therefore their work quality is relatively low. The low quality and productivity of the workers have impact on the progress and efficiency of the project.

External Causes. In this group of causes of delay, all three groupings of respondents ranked ‘unforeseen site conditions’ as the first most severe cause of delay. Overall, it was ranked in the fifth position with SI of 82%. All three categories of respondents further ranked ‘weather condition’ as the second most severe cause of delay in this group. It was ranked on the whole in the eighth position with SI of 77%. Weather condition is one of the most difficult and unknown factors because it cannot be controlled. In Ghana, the effect of these natural factors may not be very significant, but it is worthy of consideration. Ghana is located in a tropical zone with only two climates: wet and dry. Rain would definitely stop construction activities because of the works nature. In the dry season, the average temperature varies between 30 and 38 °C while the humidity ranges from 25 to 80%. Temperature and humidity affect the productivity of workers. If the temperature and humidity are high, workers feel dullness of senses and poor coordination [10] and generate body heat and subsequent discomfort [11]. Therefore, productivity in hot climates is certainly low. Clients and Contractors ranked ‘accidents during construction’ in the third position whilst consultants ranked it in the fifth position under this group. On the other hand, in total, it was ranked in the twenty-fourth position with SI of 53%. The details of the remaining causes of delay under this group are indicated in Table 1.

3.3 Effects of Delay

The primary data collected from the third part of the questionnaire was also analyzed from the perspective of clients, consultants and contractors. The calculation of SI and ranking were done as explained in the previous section. Based on the overall ranking, the five most severe effects of local government construction project delays as perceived by the three group of respondents were: time overrun (SI = 91%), cost overrun (SI = 88%), delay by contractor in repayment of loans (SI = 85%), disputes (SI = 82%), and poor quality of work due to speeding up work (SI = 78%). Table 2 presents the ranking of effects based on response of all respondents (clients, contractors and consultants).

Client-related and contractor-related causes of delay have effect on time overrun. Out of the ten most severe causes of delay, five causes belong to client-related and contractor-related factors. Factors such as delay in progress payment, variations during construction, difficulties in financing project, delay in sub-contractors work, and improper planning and scheduling of project directly affect the completion of the project and cause time overrun.

Client-related factors such as variations during construction (changes in the deliverables and requirements) and mistakes and discrepancies in design documents result in cost overrun. Mistakes and discrepancies in design documents can be in scope, deliverables, resources available and allocated, payment terms, achievement of various milestones, and the project duration. In most of the instances, time overrun leads to cost overrun.

Client-related, contractor-related, consultant related, and external causes have effect on the disputes that arise during the course of the project. Causes such as delay in progress payment, frequent owner interference, variations during construction, lack of communication and coordination, and unforeseen site conditions give rise to disputes between the various parties. The disputes, if not resolved amicably, can lead to arbitration or litigation. Contractor-related and labour-related causes have effect on poor quality of work.

Table 2. SI and ranking of effects of delay

Effects of delay	Client		Consultants		Contractors		Overall	
	SI	Rank	SI	Rank	SI	Rank	SI	Rank
Time overrun	92%	1st	90%	1st	91%	1st	91%	1st
Cost overrun	90%	2nd	88%	2nd	86%	2nd	88%	2nd
Negative social impact	80%	6th	72%	6th	78%	6th	77%	6th
Idling resources	70%	11th	58%	11th	54%	11th	61%	11th
Disputes	83%	5th	80%	4th	84%	4th	82%	4th
Arbitration	78%	7th	69%	7th	70%	7th	72%	8th
Delay by contractor in repayment of loans	86%	4th	83%	3rd	85%	3rd	85%	3rd
Poor quality of work due to speeding up of work	89%	3rd	77%	5th	67%	8th	78%	5th
Delay in getting profit by clients	75%	8th	67%	9th	60%	10th	67%	9th
Bankruptcy	53%	12th	49%	12th	63%	9th	55%	12th
Litigation	72%	10th	65%	10th	52%	12th	63%	10th
Create stress on contractors	74%	9th	68%	8th	82%	5th	75%	7th
Total abandonment	48%	13th	38%	13th	46%	13th	44%	13th

3.4 Relationship Between Causes and Effects of Delay

The next step in the analysis was to identify the empirical relationships between the causes and effects of delay of local government construction projects. Empirical relationships endeavor to describe, explain, and make predictions through observation. In this research, attempt is made to establish the relationship between causes and effects through observable data. Since the data collected through survey was based on likert-scale, it can be considered as interval data. Correlation analysis is a powerful method to study the relationship between variables that have interval data. Therefore, a correlation analysis was carried out to study the empirical relationships between the groups of causes and effects. Table 3 presents the results of the analysis.

Table 3 indicates that there is a direct relationship between Client - related causes of delay and cost overrun, time overrun, disputes, arbitration, delay by contractor in repayment of loans, and creating stress on contractor. Part of this result is comparable to that of Chan and Kumaraswamy [3] where client-related causes was linked to the probable time overruns in construction projects in Hong Kong. It was also revealed that, there is a positive correlation between contractor-related causes of delay and time overrun, disputes, arbitration, poor quality work due to speeding up of work, litigation, and creating stress on contractors. This result is in line with the work of Assaf and Al-Hejji [2] where contractor-related causes was also linked to the probable time overruns in construction projects in Saudi Arabia. Consultant-related causes also have a direct relationship to the probable disputes in local government construction projects in Ghana. Labour-related causes have a linkage to the probable poor quality work due to speeding up of work. Finally, External-related causes have a relationship with disputes and litigation. The major findings of this section of the study are that bulk of the effects of delay of local government construction projects is triggered by client-related and contractor-related causes.

4 Conclusion and Recommendation

The study investigated the causes and effects of local government construction project delays in Ghana. A questionnaire was designed and distributed among the three major groups of participants (clients, consultants and contractors). The research identified main causes of delay and ten most severe causes were: (1) delay in progress payments, (2) variation orders during construction, (3) contractor's difficulty in financing project, (4) delay in material delivery (5) unforeseen site conditions, (6) mistakes and discrepancies in design documents, (7) delay in sub-contractors work, (8) weather condition, (9) improper planning and scheduling of project, and (10) clients' poor communication and coordination.

The study also identified main effects of delay and they were: (1) time overrun, (2) cost overrun, (3) negative social impact, (4) idling resources, (5) disputes, and (6) arbitration. As an important contribution, the study also looked at the empirical relationships between the causes and effects of delays. The research isolated the causes of delay for each of the thirteen effects. The study revealed that bulk of the effects of delay of local government construction projects is triggered by client-related and contractor-related causes.

The results of this study can be of immense help to the practitioners (clients, contractors and consultants) and researchers. The practitioners in the local governments can better understand the dynamics of project management and make efforts to reduce the incidences of delays. The researchers can conduct similar studies in other parts of the world, other sectors and identify causes and effects of delays. As stated earlier, some causes and effects of delay may be unique to certain sectors and countries.

Table 3. Correlation between the groups of causes and effects of delay

Effects	Causes of delay						
	Client	Contractor	Consultant	Material	Equipment	Labour	External
1. Time overrun	0.482**	0.465**	−0.106	0.054	0.001	0.099	0.050
2. Cost overrun	0.503**	0.109	−0.115	0.077	0.021	0.067	0.084
3. Negative social impact	0.080	0.103	0.121	0.133	0.100	0.019	0.106
4. Idling resources	0.033	0.039	0.132	0.082	0.087	0.023	0.105
5. Disputes	0.529**	0.487**	0.162*	0.036	0.012	0.014	0.198*
6. Arbitration	0.239**	0.356**	0.058	0.007	0.030	0.028	0.108
7. Delaying by contractor in repayment of loans	0.220**	0.052	0.107	0.06	0.037	0.087	0.004
8. Poor quality work due to speeding up of work	0.090	0.156*	0.095	0.108	0.072	0.184*	0.066
9. Delay in getting profit by clients	0.061	0.022	0.001	0.006	0.05	0.023	0.041
10. Bankruptcy	0.013	0.037	0.088	0.122	0.077	0.065	0.000
11. Litigation	0.102	0.141*	0.064	0.003	0.107	0.137	0.223**
12. Create stress on contractors	0.550**	0.570**	0.084	0.172	0.104	0.266**	0.051
13. Total abandonment	0.109	0.074	0.021	0.041	0.071	0.084	0.172

**Significant at the 0.01 level. *Significant at the 0.05 level

The study therefore suggested that in the selection of contractors by local authorities, contractors should not be selected based only on the lowest evaluated bid. The selected contractor must have enough experience, technical capability, financial capability, and adequate manpower to execute the project. Local authorities should also not interfere regularly and make major changes to requirements during the execution of construction projects. Local governments should have the finances in time to pay the contractors during execution and after completion of work.

In the course of drawing contract between a local government and contractor, the consultant should include items such as mechanisms to solve disputes, means of assessing and predicting causes of delay, and risk management plans. Consultants should also develop and approve drawings on time. For Contractors, they should not take up jobs in which they do not have sufficient expertise. Also, they should engage qualified and experienced site managers for the smooth execution of works. Contractors should also ensure that their works are properly planned and also have a sound financial backing.

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Regenerative Ergonomic Design – Biocentric Evolution

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Abstract. Sustainability is not enough to solve global problems and to reform our bioculture in the Anthropocene epoch. The objectives of ergonomic design should be defined from wider perspective, beyond human – machine system interaction. To achieve synergy and symbiosis between the built environment (where optimized workplace spaces and infrastructure are located) and the natural environment, the way of thinking should be changed from technocrats regulations to ecosystems dynamics holistic perspective, from the anthropocentric hegemony to the biocentric co-evolution between culture and nature. Biophilic indicators applications and resilient or regenerative design implementation in the field of ergonomic design, together with innovative bio thinking, biomimicry or idea of ecoliteracy will build social and natural capitals to mitigate negative impacts of climate change and environmental degradation within the framework of the intergenerational biosphere community`s cooperation.

Keywords: Bioculture · Capacity building · Biophilia · Resilience · Regenerative design

1 Introduction

Our relationship with nature is weaker, because more humans are living in urbanized, low quality built environment. Facing global problems of climate changes, frequent natural disasters, resources depletion or deforestation we can conclude that sustainable planning and design is inefficient today. The concept of sustainable development and its meaning have been discussed for more than 25 years. Present sustainability is not enough to solve or to correct our global problems. Probably more radical operational solutions are needed, an evolution of sustainability in ergonomic planning and designing processes should be introduced. Traditionally ergonomic design related to human factor is radically anthropocentric. Its fundamental principles identify interactions in man – technology systems, human mental workload, cognitive relations in different models of stress and strain or dilemmas of organizational management. Ergonomics basic activities are focused on the built environment (mostly inorganic) and its effect on human performance. Contemporary development of urban dwelling environments and our working conditions and tools, equipment and devices which are used in everyday practice are influential for our common attitude tohuman– nature relationship. Urbanized societies are less conscious of livable ecosystems services and their importance for

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comfort of life and regenerative ability. Spending more time indoor spaces, surrounded by artificial landscape and adapted to HVAC customized climate we have accepted large scale mental migration from natural to unnatural or artificial habitats. Going back to roots of ergonomics, the pioneering work of Polish scholar Wojciech Jastrzębowski[1] "An Outline of Ergonomics, or the Science of Work Based upon the Truth drawn from the Science of Nature" [1], which was published in the weekly "Nature and Industry" in 1857 presented holistic perspective on natural systems connectivity and spirituality. His outlook was less a scientific text but more a philosophic manifesto. The author was a professor of botany, zoology and physics, representing bioculture of the 19th century Poland. He was experienced in wood areas cultivation and forests conservation. From the time perspective history of design and ergonomics is an evolution process of human–nature relationship characterized with upgraded bioculture – named a second nature. Taylor [2, 3] defines bioculture as "that aspects of any human culture in which humans create and regulate the environment of living things and systematically exploit them for human benefits". Brand [4] located culture (where bioculture is included) in slower layer of simple, symbolic model of civilization order. Presented (Fig. 1) six pace layers might be applied to various ergonomic design levels, where influences of "fashion" trajectory are associated with innovation and new technologies implementation or the nature stratum is related to biophilic senses and basic human needs fulfillment in the field of universal design.

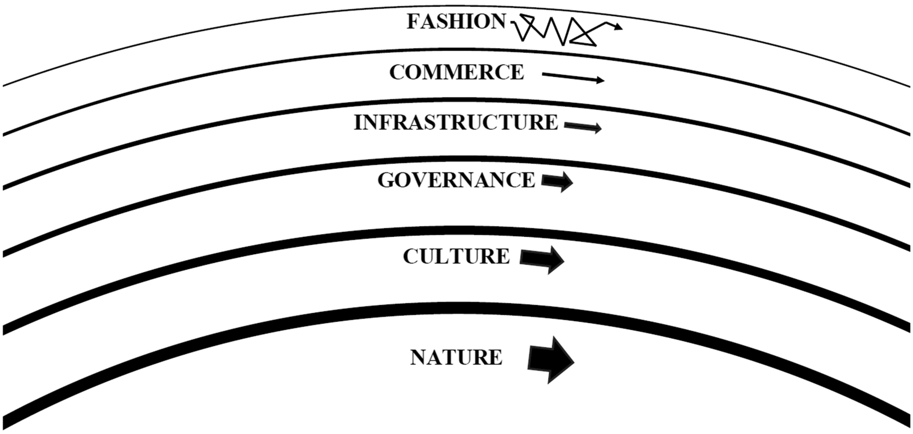

Fig. 1. Simple model of civilization order. Pace layers applied to ergonomic design levels. Source: Adapted from [4]

2 Designing the Next Artificial Nature – Ergonomics Collaboration

When societies moved from greenfield to zones of built environment we've lost our natural connectivity. Contemporary design thinking is limited without understanding

[1] W. Jastrzębowski was inventor and naturalist, for the first time he defined a term: ergonomics.

rules vital for living ecosystems. To achieve synergy effect and symbiosis between built and natural environment, the way of thinking should be changed, from technocrats regulations to ecosystems dynamics perspectives. Too passive the triple bottom line framework of sustainability should evolve to more active, regenerative planning, improved by resilient design, ecological engineering, biomimicry implementation strengthened by the natural human beings biophilia engagement [5].

Being a part of nature in the past, industrial development and its design patterns transformed our attitude to biosphere, creating artificial, built environment – kind of third nature alienated from vital ecosystems. Classical anthropometric or anthropomorphic, ergonomic design is focused on anthropocentric view of mostly abiotic work place (or leisure) environments. Human – machines interactions and their context were a basic subject of ergonomics fields of interest in the industrial era (Fig. 2). Today, growing ecological awareness and kind of social and ecological intelligence capacity create a new perspective of regenerative development. After destroying nature in the industrial era, a new paradigm of relationship between human and ecosystems is needed in a global scale.

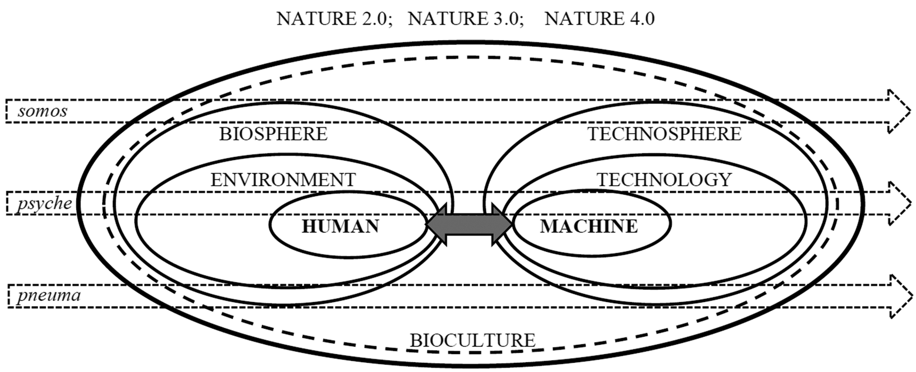

Fig. 2. Broader perspective and context of human – machine relationship system

The pace of modern live, accelerated by on-line communication readiness, rapid cyber culture lead our urbanized civilization to the fourth nature – the uncertain future of next generations associated with post human, synthetic biology development, biohacking and genetic modifications or returning to the real wild and free nature. Standing in the turning point, our common future will be shaped with alternative scenarios: anthropocentric hegemony (within dystopic enframing context) or biocentric coexistence and co-evolution including all environmental consequences. The chosen scenario will be influential for design processes, life cycle management, concepts of mass and energy flows in the global scale economy. When pandustry with its digital fabrication replaces industry, the global economy is dematerialized, based on emergent, recirculation systems and knowledge society development, we have to understand our role as an integral part of natural ecosystems, to transfer it to design processes. Because the rapid development of globalization, present mankind status should be recognized as a biosphere community taking responsibility for nature in the scale of whole living planet.

3 Generational Differences on Space and Nature Perception - Human Habitats Development Dimensions

A forms of human habitats were changing in the history of civilization. Modern Architecture and contemporary design, based on mechanistic philosophy and linear systems strongly exist in our present culture. The house, as a machine for living in, promoted by Le Corbusier in the last century is still alive. Many high performance buildings including office estates, warehouses or industrial constructions are spatial machines for working in, seem to be only a kind of improvement of mentioned Le Corbusier`s idea. In the process of architectural form evolution, industrial design or ergonomic design based on sustainable or regenerative development is quite slow. Mentally, we can accept that our inhabited and permanently adapted spaces, covered with building envelopes are our third skin. Technically we are able to develop intelligent biodegradable structures, smart natural buildings, triggering the creation of our inhabited, spatial systems as living organisms, but forms and methods of biodesign are still far away from a mainstream. The holistic approach to the human survival space understanding as a part of living organism or ecosystems moves us to three aspects of existence, described by ancient Greeks: somos, psyche and pneuma [6]. Somos – defined as a material form of the building body with its structure, installations, technical equipment and hardware elements. Psyche – characterized as spiritual and cognitive features of the multidimensional space structure, with its indoor climate, atmosphere, soul and mood which creates coexistence between structures, indoor and outdoor spaces and their users on psychological level. Pneuma – described as a main affirmative idea which unifies all occupants and space users to keep inhabited organism and its psychological, social and cognitive relations in good conditions. Pneuma helps to feel relationships and gives aid to find own path to achieve a synergetic effect between inhabitants, building structure and its local/global environment, being a message to the others about a mission statement of living building system to keep its users and creators on the right truck. Aspects of psyche and pneuma are not measurable, but we feel them, it can be articulated in context of comfort, space satisfaction, beauty, quality of living and sense of life and human connectivity with natural, dynamic systems. Discussion about present global development should be shared among four generations identified on the labour market today (Table 1). On the demographic level (with socio-psychological general perspective) a growing gap of alienation between every next entering generations is recognized. Newcomers in global economy, on competed design markets are presenting changing attitude to nature understanding and space organization, which is characterized with differential attributes of somos, psyche and pneuma. Regenerative ergonomic design should be a part of biocentric evolution of the natural rules implementation to heal and to revitalize the built environment introduced by every active generation. Devastated natural capital should be restored with creation of the resilient green infrastructure, with providing biodiversity potency in dense inhabited areas or poor, abiotic workplace environments. Living products development or recirculation economy systems promoting upcycling and adaptive reuse are examples of regenerative design giving a crucial opportunity to improve quality of life (QOL) and to create a safe link between mechanistic still life and vital biome. Non-material or dematerialized services can replace

Table 1. Generational differences and influences ability for the human - nature system maintenance and regeneration in comparison of four generations active on labour market.

Generation	Baby Boomers BB	X Yuppie	Y Millennials	Z iGen
Born	1946–1964	1965–1976	1977–1990	1990+
Events	Cold war, Stereo, The Beatles, The Rolling Stones, Color TV	AIDS, Chernobyl disaster, MTV, Berlin Wall fall, CD	Google, Facebook, globalisation, 9/11 terror attacks	Iraq War, computer games, apps, Twitter, blogging, Web 2.0, economic recession
Attributes	"Work to survive", hard works as a success guarantee, loyal, respect authorities, persistence at work, traditional division of duties in family, fear of job loss	"Live to work", pursuit of career, independence, self-confidence, multitasking, working – private life balance, recognition of high quality products	"Work to live", novelty fans, quality of life more important, narcism, lack of authorities, tolerance, descrying of social work worth, fear of responsibility, disacceptance of critic, living with parents	"Work should be a passion", continuous Internet access, technological boom, loners, egoists, expectance of often praises, prone to advertising, flexibility of working time, passion over dutifulness, problems with real interpersonal contacts, they spend little time in the real world
			Generational alienation	
Market	Gerontocracy	Management	Precariat	
Reality	Analog world		Digital world	
	Digital immigrant		Digital native	
Bio-culture	The second nature e.g. agriculture, forest plantations			
	The third nature e.g. built environment, urbanization			
	The fourth nature e.g. synthetic biology or wilderness			

wasteful, materialistic systems and technologies. Life cycle thinking, upcycling or urban mining are components of regenerative ergonomic design according to the idea: doing more with less. Use of solar power, net positive energy or net positive impact on biodiversity are strategies to give added values to natural ecosystems, to regenerate them or revitalize. Human embodied biophilia and empathy for the wellbeing of future generations should be drivers of change in ergonomic design. It should be an imperative for new approach to solve environmental global problems with systematic evolution of our design and planning systems from anthropocentric to biocentric perspective of development and the spatial coexistence.

4 The Urban Scale Resilient Planning as a Background of Ergonomic Regenerative Design – Holistic Perspective of Ecosystems Dynamics

The climate change and extreme weather events are problems noticed in the field of urban planning and architecture as well as in ergonomic design focused on the workplace environment and working conditions development. Urban areas are more affected with natural disasters, intense storms, typhoons, floods, heat waves and drought or high precipitation. The risk of large urban structures demolition or communal education and healthcare infrastructure damages is high, as well as inhabitants living conditions are in danger. From less apocalyptic point of view, the living quality is decreasing in uncertain times and unsafe environment. Municipal living and working conditions are related to technical and moral span of properties, pollution and emissions level, social pathology or cultural disintegration parts of society. The scale or event intensity are important aspects as well as determination or motivation of citizens to fight with critical circumstances or extreme weather consequences. The demographic structure of the city and intergenerational relations are an important issue to cope with climate changes problems. “The City as a Factory” is replaced with an idea “The City as an Organism”. Broad studies of the city metabolism, energy and materials flow analyses in different time span are required when defining urban areas as a living system. Our resources circulation can be optimized and improved in the scale of workplace environment, building, commune or city organism when we can follow dynamic cycles of nature, taking in response scale of urgent destruction, catastrophe or any state of emergency. Organisms or ecosystems regenerative abilities and self-organization potential manifest an importance of crisis situations and is a matter of biomimicry in design – how to copy processes functioning in nature. Holistic perception of the built environment and comparisons to complex, living systems should be recognized as a fundamental element in regenerative design. The model of adaptive cycle systems was developed by professor C.S. Holling [7, 8] a precursor of ecosystems dynamics research (Fig. 3). He introduced four key stages of dynamics: rapid growth (r), conservation (K), release (Ω) and reorganization (α). These stages can be characterized with different level of accumulated capitals, connectedness and scales of resilience[2] with its time factor. Besides absorbing potential, resilience can

[2] The meaning of resilience (Latin: resilere – to rebound) is used in many sciences such as: mathematics, medicine, psychology, economy, informatics or ecology. It can be exploited in ecosystems dynamics studies, as a part of the complex systems theory and used in broad field of planning and design. Resilience has different scientific extensions and interpretations. As an ordinary term system resilience is an ability to rebuilt, maintain and regenerate after it has been disturbed. It has different capacity to tolerate disturbances and scale. The greater the resilience is in particular ecosystem the more it can resist large or prolonged disturbances. If resilience is low, then smaller disturbances can push the ecosystem into a different state, where its dynamics change.

be characterized by self-organization ability, self-learning and adaptability to new environment with genetic memory implementation and diversity of connections or information and structures distribution between ecosystem scales. Observing mechanisms in the nature, some of them can be copied and used for human activities.

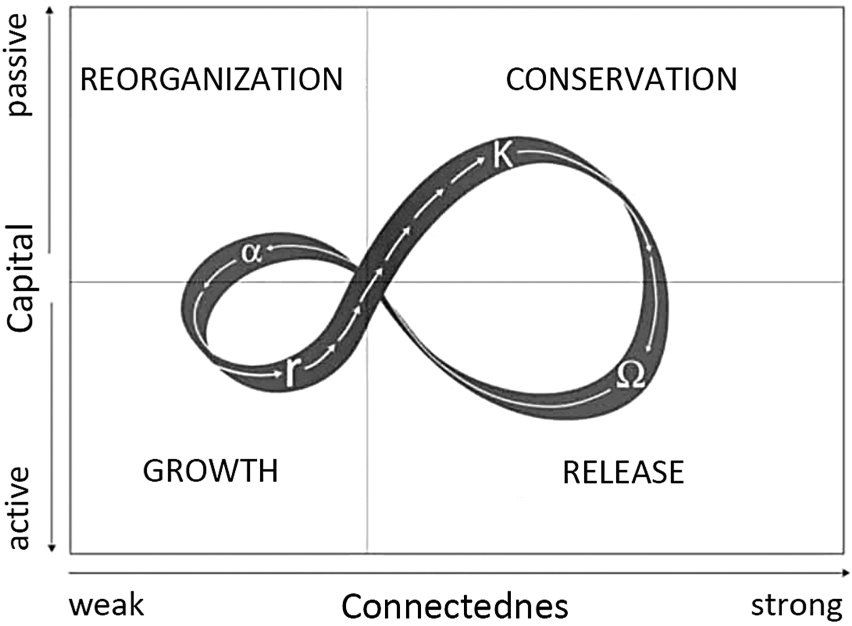

Fig. 3. The dynamics of an ecosystem as it is dominated by each of the four ecological processes: rapid growth (r), conservation (K), release (Ω) and reorganization (α). Source: Adapted from [8]

The design, including ergonomic design is a process having our future in mind. The concept of resilience reducing risk of failure and uncertainty is growing as a part of sustainable design, to introduce aspects of ecosystems adaptive capacity, long term regeneration and restitution.

Resilient Design is the intentional design of buildings, landscapes, communities, towns and regions in response to these vulnerabilities. Two types of adaptation to climate changes can be distinguished in resilience implementation, first one is Grey Adaptation depended on technical support or engineering solutions, second one is Green Adaptation based on sustainable design, green infrastructure development with social and natural capital involvement and ecological services, artificially created biotopes or urban farms or city aquaculture implementation as a part of common biophilic environments. Self-organization and interconnected networks of societal relationships are significant features in the resilience building process. Strong social structures can be achieved with vital, communal public spaces building, thematic local parks and fests organization, the allotments gardens renewal or city agriculture locations to trigger inhabitants involvement and redundancy activities [9].

5 Biophilic Indicators – Tools for Regenerative Design Initiation

To study and to measure different designing approaches and practices some biophilic indicators were applied. The most common biophilic indexes are used in urban planning where density of green areas, its accessibility and referential mass of greenery (its volume) are described. The Green Factor was implemented in Sweden (Malmoe), in Seattle or Toronto, the Biotope Area Factor was developed in Berlin to regulate the proportion of green space within densely built up locations. Mentioned indicators are focused primary on visual and aesthetic attitude to greenery and planted areas in built environment. Aspects of climate changes, resilience and ecological dynamics, CO_2 sequestration potency or biodiversity validation are still secondary in designing process measures [10]. Another interesting, biophilic indicators developed in the field of psychological sciences are influential for architectural and indoor design. To increase our knowledge and perception of human – nature relationships more another biophilic indicators should be developed and implemented. These mentioned tools will support monitoring of our changing attitudes to natural ecosystems. An important element in increasing level of cities resilience and regenerative abilities is a matter of promotion and use of local products, living building materials and regional labour force as well as local food production (so called Urban Farming). The urban structure of designed spaces should tend to a compact form, eliminate traffic preference and enforce passers-by and bikes tracks (Walkable City). This way the dependence on fuels and energy, which can be difficult to obtain during the cataclysm, decreases. The capacity of drainage and rain water systems with green infrastructure should be increased and places for natural retention of rain water (biotops, swamps) as well as systems of recycling be created. Rise of green surfaces in workplaces, residential areas, generally in cities decreases an effect of city heat island (using permaculture and xeriscaping rules), improves local climate and hydrologic conditions and strengths biodiversity. Introducing more high green extend shadow areas in the city, which work as a natural shield for rapid heat waves. Cities should promote actions of greening roofs, which can play a role of climatic buffers. Optimization is needed for city heat systems, especially regarding renewable energy sources and promoting prosumers energetic networks, stores and banks of green energy. It is important to aim at non-waste economy while promoting segregation of wastes, reuse, recycling and local composting. Degraded areas, not renovated should function as a urban resource, place for gaining recyclable building materials. Above mentioned rules, implemented for example in urban programs of revitalization or urban mining, should be developed in the form of concur planning with authentic engagement of local society und well estimated potential of feasibility [9].

6 Conclusions

Mitigation of depopulation, deindustrialization, shrinking cities processes, or urban degeneration are connected with climate changes and resources depletion become a challenge for designers. Information about potential future consequences of the Anthropocene epoch development is available. We know importance of natural and social capitals building where appropriate designing system involvement is essential. To create and maintain "Living cities" or "Living habitats" like ecosystems we have to recognize different levels of resilience, to know ability to rebuild and to regenerate existing structures. Disturbance sensitive local societies should follow dynamics of ecosystems their ability of adaptation and regeneration and build resilience while designing and creating programs of spatial regeneration. Coherent interpretation of collected, recorded terabytes of information apply to create a base of a Knowledge Society. The mechanisms that could support the diffusion of know-how should be implemented. Different knowledge models should be shared free through collaboration features or Web pages generations to increase capacity building at local and regional level. Defining knowledge as important urban resource, disproportion of knowledge transfer streams as well as material flows within the building sector should be a matter of special scenarios. We have to create synergy for minimising destructive anthropopression and increasing productivity of our economic activities by better flow of information among actors and initiated positive actions in living city ecosystems (Table 2).

Table 2. Attitudes to nature and environmental ethics. Source: Adapted from Thomson (2000)

Anthropocentric position	Egocentric	Self-interest
	Homocentric	The greatest good for the greatest number
		We are responsible for stewardship of nature for human use and enjoyment
Non-anthropocentric position	Biocentric	Members of the biotic community have moral standing
	Ecocentric	Ecosystems and/or the biosphere have moral standing
		We have a duty of care to the whole environment

How to apply gathered knowledge and how to proceed information mess in appropriate way is a challenge for a Wisdom Society. Inventing, creating and organizing a symbiotic systems of knowledge is a challenge of our generations in a global scale as the responsible biosphere community [11].

It requires interdisciplinary approach based on new town planning, new logistics of production and distribution, combining of processes and participants of all parties involved. A basic problem of our material culture today we have to face is not a quality of physical products but a completely new definition of "product – production – consumption" concept as resilient, dynamic networking systems. Today aspects of biomimicry or bionic design are emerging trends in ergonomics, but mainstream is still far away from equilibrium between economic, social and ecologic systems. Therefore bio thinking and the idea of ecoliteracy – ability to understand natural systems and living organisms promoting by Orr [12] are a challenge for next generations of designers, architects and urban planners to implement heal, evolutionary spatial development process for the future. Integrated combination of ecology, ergonomics and economy creates the new design quality, meeting an idea of rational resources use and dematerialization of the product. It seems to be a new formula for the 21st century ergonomics. It is a challenge by the beginning of next millennium to give back to future generations the Earth, which we borrowed from our children. We should follow crucial principle quoted from the Great Law of the Iroquois Confederacy: “In our every deliberation we must consider the impact of our decisions on the next seven generations” [13].

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User-Oriented Method as a Way to Humanise the User-Energy Relationship in Public Lighting

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Abstract. Current public lighting is predominately directed to reducing energy and often is understood as a technical issue rather than a human one, mostly based on photometric visual performance. By taking advantage of the inherent flexibility of current lighting technologies, this research aimed to contribute to a more sustainable lighting design practice, through the design of adaptive lighting solutions that improve the relationship between users, the space they inhabit and energy use. To confirm the hypothesis, it was developed a user-oriented method that considers a specific *user-space* relationship and the user's perception of well-being. Tested via two outdoor field experiment in an urban space in the south of Portugal, qualitative and quantitative statistical analysis of the collected data, suggest that the method can provide data to aid the design of more tailored and flexible public lighting solutions that can balance the user-energy relationship, improving the overall sustainability of our cities.

Keywords: Lighting design · Adaptive lighting · Sustainability · User-oriented design · ALDA method

1 Introduction

From a human perspective, light exists from time immemorial and our own existence and development depends on it. This relation is as much emotional as it is biological and functional. It is possible to say that artificial lighting was a disruptive technological innovation, that had and still has, a profound impact on our society [1], with outdoor lighting being one of the first industrial applications of artificial lighting. Shaping the contemporary cities as they grow to accommodate new social behaviours and needs related to the creation of the '24-hour day', altering profoundly the way we perceive and use nighttime urban space. [2, 3]. However, the massification of lighting is in conflict with the need for reducing energy consumption and its impact on the environment [4]. This aspect is influencing public lighting to be primarily designed as an energy reduction

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technique, through the use of new technologies such as adaptive lighting and LED light sources, mostly supported by a quantitative approach [5]. Within a sustainable framework, the current urban lifestyle cannot be sustained in the near future, as energy consumption, environmental impact and financial costs are currently important subjects for any city authorities [4]. As a reaction, investments are being made at a global level in low energy consumption and low maintenance lighting technologies, such as Solid State Lighting (SSL) and Intelligent Street Lighting systems (ISL) [6]. However, along with technological innovation it is necessary to develop new concepts and approaches to Lighting that are based on a well-balanced design between light and shadow, considering users' needs according to the surrounding context [7–9].

1.1 Technological Changes in Lighting

Intelligent street lighting, which in practice is recognized as adaptive lighting, are systems that have the ability to manipulate lighting parameters, such as light level, distribution or colour temperature, that react to external input, such as a person or a car [6]. Due to its digital nature, the current possibilities for light manipulation are unparalleled in the history of Lighting. However, beyond a rule of thumb of what is considered to be "appropriate", there is no apparent method to ensure a real assessment of what could be the most adequate adaptive lighting behaviour for a given user in a specific urban space. Within the current context, outdoor adaptive lighting systems will be the standard in the near future, the question is not *if* but *how* can we use it as a real design tool. Nevertheless, the shift from a static to a dynamic lighting scheme brings new challenges to design, which necessarily require to integrate a holistic view to problem-solving [5].

1.2 Research Objectives

Based on the previous context, there is an opportunity to develop new design approaches that take advantage of the inherent flexibility of these systems. This perspective, raised questions such as: *When using adaptive lighting, which is the most adequate configuration for a particular group of users in a specific urban space? How will people respond to the dynamic nature of adaptive lighting and will they accept it?*

This paper highlights the main results from a Ph.D. research [5] with the aim to contribute to a more sustainable lighting design practice, in particular public lighting, through the design of adaptive lighting solutions that improve the relationship between users, the space they inhabit and energy use. It was hypothesised that a user-oriented method could provide psychophysical information to assist lighting professionals to design more tailored and flexible adaptive lighting solutions, through the ability to customise standards based on objective data. To test the hypotheses, it was developed the ALDA[1] method, which determine the adaptive lighting scenarios for the most

[1] Adaptive Lighting Design Assisting method.

adequate and *minimum acceptable* lighting condition, for a specific *user-space* relationship, based on the user's perception of well-being, and the assessment of the perceived lighting quality of the chosen configurations.

1.3 User's Perception of Well-Being as an Assessment Basis for Lighting Quality

In the context of lighting, well-being is currently accepted as a very important psycho-physical state to convey in the nighttime urban environment. As Schreuder states "the relation to lighting is clear. The advancement of human well-being is usually considered as the main function of lighting" [10, p. 4]. However, due to its similarity to other concepts, such as comfort, the question came up as to what would be the best concept, as we can consider that *well-being* and *comfort* are synonymous. Nevertheless, well-being is a broader concept given that it encompasses other aspects that are also very important in lighting, such as *safety* and *aesthetics.* Also, in lighting, the term comfort is mostly related to glare perception and visual comfort [11] and, in this sense, is not as broad as the concept of well-being. However, if not accounted for, this strength is also its weakness, as it is a subjective concept and it depend on the perception of the user. It was necessary to determine a way to 'standardise' its understanding.

Lighting quality and well-being perception are strongly interconnected [5, 10, 12] and, as such, the latter seemed to be the best criterion to assess lighting quality. However, considering the dualistic understanding of lighting quality, from a *photometric approach*, there are well known requirements necessary to observe to achieve good quality visibility lighting, all falling into four major categories: Obstacle detection and facial recognition; Visual orientation in the environment; Glare avoidance and visual acuity; and Ability to appreciate the surrounding environment and socialise [13]. From a *perceptual approach*, it was possible to conclude that non-standard requirements, such as visual hierarchy, non-uniformity or social identity become relevant [7–9]. All are observable but not necessarily measurable. From this analysis, it became apparent that all the requirements could be condensed into smaller, more manageable categories and still maintain tendency of the underlying meaning, refining the categories to: *Sense of Security; Spatial Orientation; Visual Comfort* and *Aesthetics.* By associating these lighting categories to the concept of well-being, there was a guarantee, as much as possible, that the participants not only understood very quickly the evaluation concept of well-being, but also that it would not be prone to the personal interpretation of each participant. In effect, creating a common and operational definition for both well-being and lighting quality.

1.4 Appearance-Based Approach

Generally, approaches to describe and assess luminous environments are grouped into two main categories: visual performance-based and appearance-based.

The first represents the classical approach to lighting description and assessment, relying greatly on quantitative descriptive methods and for decades it has been the most used. Given its objectives, it was soon clear that it would not be the best approach to our own research. On the other hand, the second is more recent and favours a mixed approach, considering both, objective and subjective criteria, in an attempt to better describe luminous environments [5].

In Lighting, the appearance-based approach is linked to the seminal work of Flynn *et al.* [14], which influenced other researchers to develop their own methods and models of subjective lighting description and assessment [12, 15–17]. In particular, the work of Cuttle [18], with his concept of Perceived Adequacy of Illuminance reveals the importance of using the user's subjective perception as an assessment measure of the adequacy of a lit space and, Pont [19] with the use of the 'user-tool' as a means to accurately judge the *correctness of fit* of a digital lighting scene, were of utmost importance. Both authors demonstrate the effectiveness of the user as a highly accurate 'measurement tool' for assessing the quality of luminous environments. From this analysis, we concluded that a subjective appearance-based assessment of lighting quality was the best approach for the purpose of this research.

1.5 Environmental Psychology Approach to Public Lighting

A fairly extensive literature review by Veitch [20] reveals that most of the available lighting research have economic considerations – for instance, supported by lighting manufacturers – and are related to office lighting, mainly focusing on visual performance, well–being and individual control. In contrast, other areas such as outdoor lighting reveal very few studies, especially if using appearance-based approaches for lighting quality assessment. Nevertheless, in recent years, several researches have been conducted on the relationship between perceived safety and lighting quality, and the potential for energy management [12, 15, 21]. Moreover, for adaptive public lighting only three were identified [15–17], being the most recent and similar constructs to our own, and thus the more relevant to our research, which are the product of interdisciplinary research between Design, Architecture, and Environmental Psychology.

2 Experimental Field Testing

To test the hypothesis, two similar outdoor field experiments were conducted on two separate occasions. Based on the Perceived Luminance Continuity framework, the first experiment tested the design and effectiveness of the ALDA method as a gathering and assessment tool. The second experiment tested the consistency of the previous choices and subsequent confirmation of the effectiveness proposed method.

2.1 Perceived Luminance Continuity as a Supporting Framework for Adaptive Lighting Design

It is our understanding that when considering the use of adaptive lighting, the design should no longer be understood as a fully defined lighting scheme, but the definition of what is the 'workable interval' for each lighting parameter and *how* it can adapt over time according to the spatial reality, users' needs, resource impact. Accepting these assumptions, a framework for adaptive public lighting is suggested. The Perceived

Luminance Continuity framework (PLC) describes the adaptive behaviour pattern of light and supports the implementation of the ALDA method. By Knowing the user's field of view and controlling the lighting behaviour pattern, it is possible to provide light only in the visible vicinity of the user and adapting it, in real time, in such a way that a "bubble of light" follows the user [15, 22] (Fig. 1). Depending on the combination of the lighting parameters (brightness level and light distribution), and the speed to which the transition occurs, the user will *unconsciously* or *consciously perceive* the light adaptation, shift from the current linear approach of spatial uniformity to a non-linear approach of *user uniformity.* By providing uniformity and visibility in the perceived space, creating the illusion that the lighting condition is constant, based on user's choice, with the goal is to ensure lighting quality and user's well-being through a more rational use of energy when compared with a regular non-adaptive lighting scheme [5].

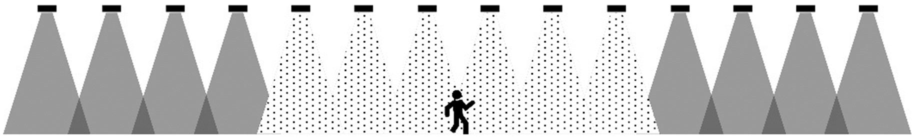

Fig. 1. Schematic profile view of one possible adaptable (following) lighting distribution in relation to the user. For instance, a 30-meter radius at 100% of light output (dotted area), around the user and the rest of the visible area at 30% of the total light output.

2.2 The ALDA Method: Procedure and Tools

The ALDA method uses a two-step process, each with its own set of tools: (1) a pre phase, with a spatial analysis (SA) – analogue and digital visibility analysis based on the user's spatial perception, and (2) a post phase of test and assessment, composed by a self-configuration exercise - ALICE[2] - allowing the participant to dynamically configure a group of light parameters (in this case: brightness level, colour temperature and light distribution, each with three predetermined levels of variation available[3]), based on the user's perception of well-being and the lighting quality of the resulting choices subjectively assessed, by the SALQQ[4] tool.

The latter, is a semi-structured questionnaire, with 18 closed items on a five-point semantic differential scale and 11 open item, developed upon on the previously defined four assessment categories as the underlying structure of the questionnaire: *Sense of Security, Spatial Orientation, Visual Comfort,* and *Aesthetics.* This known structure would later help to determine through a Factor Analysis, whether the designed construct 'fitted' the data. Moreover, by adding factor-related 'word tags', like *orientation* or

[2] Adaptive Lighting Interval Configuration Exercise.

[3] Brightness Level (Eh_{av}): for 100% = 13 lx; 65% = 8.5 lx and for 45% = 5.9 lx. Colour Temp: 3.600 K, 4.200 K and 5.400 K. and Lighting Distribution: 15, 30 and 60-meter radius.

[4] Subjective Assessment of Lighting Quality Questionnaire.

safety, to the questions (items), it was possible to trace back if the underlying construction of the factors produced by the analysis, indeed reflected the designed questionnaire structure.

This method enables to gather psychophysical objective and subjective data from the resulting configured lighting scenarios, providing the variation interval of all the lighting parameters that are intended to be adaptive for the most adequate and minimum acceptable lighting condition[5]. Although the data is context specific, the method in itself, can be used in a standard and consistent way. This method considers the active participation of the end-user in the definition of lighting quality for a specific user-space relationship. Therefore, user participation is a key point that distinguishes the ALDA method and its tools from others. It is, however, important to understand the level of participation of the user. The method is meant to be carried out only once during the design and testing phase. Once the data is gathered, it will only make sense to repeat this process if the space intended substantially changes and/or the premises that gave rise to it: function, structure and characteristics, population, or decision of local authorities. It is also important to realise that this type of information will not determine the lighting design solution, nor it is its goal. Rather, it provides lighting professionals in the early stages of the design process with an empirical basis for customising standards and design more tailored solutions when using adaptive lighting technology [5].

2.3 Spatial Characterization, Calibration of the Equipment and Pre-tests

Both experiments were conducted in Arraiolos, a village in the south of Portugal. Of medieval origin, the current urban structure consists of the historic centre, a castle up on a hill, and a peri-urban area formed by 20th century houses. Based on the official urban cadastral blueprints, it was concluded the average high and weigh dimensions of the space[6]. The final study area was comprising by two streets, Misericórdia and Cunha Rivara street in the same alignment (horizontal streets), each approximately 150 m long and an average width of 4.8 m, and a third street, Alexandre Herculano street (small vertical section) crossing at the meeting point of the first two (Fig. 2). This choice was based on the selection criteria, equipment and time constrains. It also was done a spatial 2D (analogue and digital) and 3D isovist-based visibility analysis (digital) of the village. This analysis reinforced the analogue observations of the optimal position points where the participant should be placed, in the study area, to guarantee that their field of view was controlled, perceiving only the intended lighting configurations. Before doing any tests, it was installed 25, wall mounted, dynamic white luminaires, equipped with 24 LED light sources divided into two PCBs with a CCT[7] of 3.600 Kelvin, and one with a CCT of 5.600 Kelvin, in a total of 673 lumens at 100% of flux output. The lenses used

[5] As an example, this method can find that for a specific population the colour temperature interval of 3.600 to 4.000 K is considered as the most adequate for public lighting, another may prefer an interval from 2.000 to 2.500 K.

[6] Buildings, on average, are 5.5 m high at facade level and an average street section measured between 4 and 7 m in width, varying from secondary streets to main streets, respectively.

[7] Correlated Colour Temperature.

were designed for residential areas with an asymmetrical angle[8]. All luminaires were DMX enabled and were controlled by a DMX controller[9] and managed by a regular laptop. The metric, on the initial meters on Misericórdia street, was a linear array of five luminaires, changing to an intercalated array of luminaires on an average of 10 m apart and 4 m from the ground. After the installation, the calibration the system was carried out with measurements of horizontal illuminance, done *in situ* on key points, aligned with the luminaire[10] on a 5 meter-long by 1.2 meter-wide grid distribution and, vertical luminance measured in every 5 m in the centre of the street at eye-level (1.65 m), in a segment of the study area of about 90 m.

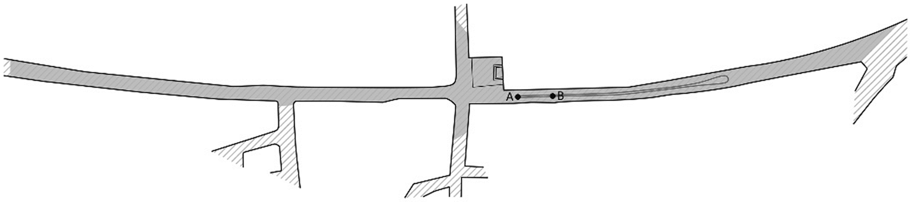

Fig. 2. Final study area: View point A and B and the path used by the participants to adjust the available three lighting parameters.

All measurements were done with a calibrated LMT Pocket-LUX 2 light meter and colour temperature with a calibrated Konica-Minolta CL-200. Regarding pre-tests, eight cases were carried out, resulting several adjustments to the way that the lighting parameters should be observed, the radius and speed of transition for the "light bubble" and to the number of items of the questionnaire (SALQQ) [5].

2.4 First Field Experiment: Participants and Procedure

The first experiment ran from 15 July to 9 October 2013. During that period, the temperatures in the nighttime were mild, being on average 17 °C, low wind and no rain (Portuguese summer period). All tests were done individually in a total of 75 participants (74 accepted), both male (42.1%; mean age = 37.7; SD = 11.24; range 17–51) and female (57.9%; mean age = 31.3; SD = 11.05; range 17–51). Gender and age groups were fairly well distributed and tests were carried out at least 40 min after sunset, with an average duration of 40 min per participant. All participants were familiar with the study area to minimize the effect of fear for not knowing the surrounding area. Data was collected through *in situ* passive observation and manual notes, assessment done by the SALQQ tool, video, and photographic recording [5].

Based on the PLC framework, participants were asked to carry out the self-configuration exercise (ALICE), being able to freely configure three light parameters from two

8 Schréder 5103: 0–180°: 71–71° and for 90–270°: 49–15°.

9 Traxon Technologies, eCue Butler XT2.

10 Peak point (directly below the light source); Midpoint (half the length of the street) and Off-peak point (symmetric position of the peak point).

stationary viewpoints for the brightness level and colour temperature parameters and from a mobile viewpoint[11] (Fig. 3), in a predetermined path[12] (Fig. 2) for the light distribution parameter, for what he or she considered to be the most *adequate* and the *minimum acceptable* lighting condition, based on his/her perceived well-being. After the configuration, the lighting quality of each lighting condition was assessed by a questionnaire (SALQQ). Moreover, it was mentioned that because the assessment was made based on a personal view, there were no right or wrong answers or lighting configurations [5].

Fig. 3. Dynamic configuration of a lighting parameter - *light distribution* - from point view A, looking at Misericórdia street.

2.5 Pre-results and Discussion

From this initial set of data, it was possible to find the preferred lighting configurations for both lighting conditions, and to determine the corresponding user's *well-being adaptive variation interval* for each lighting parameter. The questionnaire allowed us to understand the relationship between perceived lighting quality score (LQs) based on the well-being and the chosen lighting scenario configuration (LSC). To make understanding easier, the related photometric output was coded using 'D' for the light distribution, '%' for the brightness level and 'K' for the colour temperature: e.g. D60–65%-4.2K, meaning a light distribution of 60 m with an output of 65%, in a colour temperature of 4.200 K.

When descriptively analysed, the data from the ALICE exercise, corroborated with the expected preference established by the literature review that perceiving more lighting was the preferred option. From the possible 27 lighting scenarios, choices focused on 4 combinations – D60–100% (N = 29; 39%); D60–65% (N = 11; 15%); D30–100% (N = 14; 19%); and D30–65% (N = 11; 15%)[13] - amounting to almost 88% (N = 65) of the total. Nevertheless, this did not mean having physically more light in the space. For instance, the differences in semi-cylindrical illuminance between lighting scenario

[11] 'A', view of Cunha Rivara Street and 'B', view of Misericórdia Street.

[12] From point 'A', back to point 'A'.

[13] For the final scenarios, the 'K' was not considered because it was found that its configuration was random and not relevant for the final definition of the scenario, creating unnecessary variability on the data.

D60–100%; D60–65% and D30–100% (= 73% of total choices) was not very high. For example, the difference between D60–65% and D30–100% was technically zero. This meant that the perception of brightness was happening by contrast and not quantity. Also interesting, was the apparent existence of a "tipping point scenario", suggesting that a certain lighting configuration was being perceived by the participants as a "psychological frontier" between both lighting conditions. This particular scenario, D30–65%, appears in both the adequate and minimum condition. Not being an isolated case, nonetheless it was the only one that was representative of a choice. From a lighting design stand point of view, a "tipping point scenario" can be an interesting piece of information to have when designing an adaptive solution.

Regarding the results from the SALQQ tool, to assert the robustness of its underlying structure, it was tested through a Factor Analysis[14]. For the adequate lighting condition, it was used an orthogonal rotation (Varimax) using a polychoric matrix calculated using a two-step maximum likelihood (ML) estimation. The measured data consistently represented the intended design structure, explaining 72.4% of the total data. From the original designed four factor underlying structure[15], three had eigenvalues over Kaiser's criterion of 1 were retained and were robust with the majority of commonalities over 0.7, with a high Ordinal Coefficient Alpha with an average of 0.856. Meaning a high internal consistency of the produced factors and confirming the consistency of the underlying structure of the questionnaire [5]. Given that the latter was known, this analysis can be considered a Partial Confirmatory Factor Analysis (PCFA) [23].

When testing the data for the minimum acceptable lighting condition, it was used the same configuration and assumption tests, which were accepted. In this case, only two factors were retained, however, robust with the majority of commonalities over 0.7, with the total variance explaining 68.8% of the data, which is a medium percentage. The Ordinal Coefficient Alpha of the produced factors are high values with an average of 0.858. Although, statistically the underlying structure has a high internal validity, it is a fact that the resulting underlying structure is a "concentrated" version of the original design. A considerable number of participants found it difficult to define the "bare minimum" well-being, yielding a binary choice: (1) the "proportional downgrade" of what was chosen as adequate, or (2) the physical minimum that the system allowed, clustering into two factors[16]. This result suggests that for the minimum condition, there are other psychological phenomena at play – probably such as fear of the dark – altering the ability of the participants to choose more accurately, requiring further developments in future research.

After, lighting quality scores (LQs) were calculated, resulting on weighted ordinal scale, where '1' is 'very low' and '5' is 'very high', for an easier interpretation. A two-way Factorial ANOVA was conducted to examine the effects of gender and lighting scenario configuration (LSC) (independent variables) on the lighting quality score (LQs)

[14] Assumptions were tested and accepted by the Kaiser–Meyer–Olkin measure for sampling adequacy and sphericity with Bartlett's test, indicated that correlations between items were sufficiently large for a PCA or a FA.

[15] Sense of Security; Spatial Orientation; Visual Comfort and Aesthetics.

[16] Sense of Security and Spatial Orientation.

(dependent variable). The assumptions for a two-way ANOVA were assessed and accepted, confirming normality, homogeneity of variances and the non-existence of extreme outliers. The results of the ANOVA shown that there was no statistically significant interaction effect between 'Gender' and the 'LSC' in the 'LQ score', with an $F(3, 57) = .405$, $p = .699$, partial $\eta 2 = .025$, with the analysis of the simple main effect on the 'LSC' showing a statistically significant, with an $F(3, 57) = 2{,}578$, $p = .036$, partial $\eta 2 = .138$. Further *post hoc* tests, showed that the LQs' varies between configurations, but only in a statistical significant way between extreme lighting configurations, D60–100% and D30–65%, with a $p = .044$. The D60–100% is associated with a LQs of 22.04 and D30–65% with 20.43. This result supported the initial assumption of the existence of a "tipping point scenario". In this case, the D30–65% configuration significantly affected the perception of the available light in the surrounding space [5].

2.6 Second Field Experiment: Confirming Data and the Tendency of Choice

Based on what was found to be the most representative lighting scenarios, the second experiment was carried out with a new sample group, aiming to confirm whether the tendency of the choice (LSC) was the same as for the initial sample group. If so, this would reinforce the consistency of the initial results and confirm the primary hypothesis. This second experiment took considerably less time than the first one, mostly due to the size and complexity of the new exercise and assessment questionnaire, and to possibility of carrying out group tests. During this period, 37 participants were tested, (36 accepted), both male (58.3%) and female (41.7%) with a mean average of 27.2 (SD = 9.83; range 17–51). The new exercise consisted in asking the participants to experience the four lighting scenarios, found to be the most representative from the first experiment, through the same walk-through process as before, and choose and assess what was considered to be the best lighting scenario for the adequate lighting condition, based on perceived well-being. This process was repeated four times, one for each lighting scenario, and individually assessed by the questionnaire immediately after each walk-through. The assessment was done through direct questions in a total of 11 self-reported items in a semantic differential scale, ranging from '1' ('very low') to '5' ('very high'), arranged in 5 main groups. All the previous requirements were exactly the same as for the first experiment. Since it was possible to carry out group tests, the participants were randomly assigned to the groups and were also statistically tested for sequence effect [5].

2.7 Pre-results and Discussion

Similar to the first experiments, it was possible to determine which lighting scenarios were chosen for the most adequate lighting condition and the related lighting quality score (LQs). After performing a Test of Equality of Proportions on the frequency of choice, the result showed there was no statistical difference for any of the possible combinations between experiments and hence, we accepted that the frequencies had similar proportions. This meant that the results from both experiments were equivalent and that different groups of participants, in two distinct experiments, made the same choices, with a high correlation coefficient of 0.915. This result also confirmed that the configurations done in the first experiment were, in fact, meaningful and robust [5].

3 General Discussion

Based on the results it was possible to conclude some assumptions and suggest explanations for some interesting observed facts.

First, the results showed that, by applying the PLC framework, the control of the lighting in the user's field of view, through the continuous adaptation of the lighting, produced an illusion of a constant lighting condition, especially for the wider light distribution (D60), with almost 90% of participants reporting that the space looked "uniformly or continuously lit", for a 120-meter physical area with a 60-meter illuminated area. With a light distribution of 30 m (D30) illuminated area, participants reported that the space looked "brighter", and also, about 50%, still reported that the space looked "uniformly or continuously lit". This suggests that there is a relationship between the physical length of the space and length of the illuminated area. It also suggests that between 30 and 60 m of illuminated area, for this specific space configuration, the eye's adaptation to contrast is mostly stable, allowing people to perceive more with less light and still maintain the overall well-being.

Second, unlike previous bibliographic knowledge, we did not find a statistical difference in lighting quality scores between genders. One possibility could be that this was due to the fact that participants were freely adjusting the lighting to their requirements and not simple assessing a pre-determined configuration, as it is the most common procedure in this type of studies. However, to confirm this possibility further research is required.

Third, regarding the acceptance of adaptive lighting, participants grouped by the photometric and perceptual characteristics of the configured lighting scenario. From an overall perspective, at the end of the first experiment, when asked if they preferred a fixed or adaptive lighting scheme (with the same quality characteristics), most of participants (70.3%) stated that they preferred the adaptive version. This percentage rose to 94.3%, when people reconsidered based on the knowledge of energy savings from the adaptive option. These results, at least in this population, show that an adaptive public lighting scheme is well accepted, as it provides quality lighting by addressing the overall well-being and energy management in a more customised way.

In sum, the results obtained in this research allows us to confirm that it is possible to contribute to a more sustainable lighting design practice through the use of a user-oriented method (ALDA) as a valid design assisting tool and that user's well-being seems to be an effective basis to configure and assess adaptive lighting. In addition, the PLC framework seems to be an adequate way to describe the lighting behaviour pattern for adaptive lighting, by considering the user integration in the space as a whole and that perceptual illusion can be used as a design criteria to develop more sophisticated lighting schemes that take into account time, adaptability within a sustainable framework. This approach increases the probability of achieving a balanced solution, in which well-being does not overlay energy sustainability, or the search for energy efficiency undermines well-being. In essence, humanising the user-energy relationship in public lighting.

Like any research, there are always limitations to the extent to which data or the conclusions can be used. In our case, the resulting data is context and it cannot be extrapolated to another context that is socially and/or physically considerably different. However, within the original characteristics, e.g., in the south of Portugal, the data could most likely be used. This aspect is not a limitation, but a characteristic of the proposed method. Nevertheless, this aspect indeed leads us to future developments such as, (1) replications of this study conducting the necessary adjustments to the SALQQ, (2) the use the method with elderly people to understand what kind of modifications – if any – should be made for this specific target group, and (3) the implement of the ALDA method in a virtual environment.

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Barriers to Implement Building Information Modeling (BIM) in Public Projects in Saudi Arabia

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Abstract. The construction sector is a major contributor to the Saudi Arabia Gross Domestic Product (GDP). According to the Deloitte 2015, the total construction activities last year reach to $24bn ranked second after oil industry [1]. However, the current methods project are follow generates much waste and are not efficient. The recent 2030 vision plan that announced by the government of Saudi Arabia in 2016 encourages all sectors to be creative, efficient, and environmentally responsible. Technology such as Building Information Modeling (BIM) could help transform the construction industry in Saudi Arabia and improve the final outcomes. This study develops and administrates a questionnaire to identify the barriers of implementing the BIM technology in Saudi Arabia. Additional barriers are also identified through a case study for a public project after implementing BIM trough the feasibility and the design phase. The barriers are fallen under tow categories including; process implementing which comes first and technology and resources that come second.

Keywords: Building Information Modeling · Saudi construction industry · Waste reduction

1 Introduction

Saudi Arabia's market share in construction industry consider to be the highest with 43% within Gulf Countries Council (GCC) [1]. According to a report published by Deloitte in 2013, new contracts awarded in 2012 were worth about $24bn and are expected to go up to $52bn in 2015, about 10% of Saudi Arabia's Gross Domestic Product (GDP). However, construction activities generates abundance amount of waste on a yearly base that cost a fortune. According to market research, 75% of waste in the SA comes from construction, and buildings are responsible for 40% of carbon emissions. Therefore, a slight improvement to this sector could have a considerable impact on capital expenditure and environment. To elaborate more, a 10% saving on contracts could save $5bn a year, resulting in efficient executed projects. This is where Building Information Modeling (BIM) can deliver immense benefits to the building industry, especially by cutting capital cost on construction projects, reducing risks occurrence and delivering sustainable construction projects in line with the Saudi Arabia's Vision 2030. Applying a methodology such BIM, the SA's building industry could be better

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off by as much as $5–10bn (a 10–20% saving on construction projects) and have a digitally empowered sustainable infrastructure and environment [2]. However, implementing BIM in SA is not taking a fast base for many reasons. This paper is considered the first step toward establishing a framework to implement BIM in public projects. Therefore, the author is aiming to investigate barriers for implementing BIM via developing and administrating a questionnaire to BIM professionals with related work experience in GCC. In addition, this paper will investigate and summarizes a case study for a BIM project that constructed in Jeddah, Saudi Arabia. Finally conclude with recommendations for successively implementing BIM for better results.

The construction industry is known for its traditional non-collaborative work practices [3]. Moreover, sustainable development and smart cities are not possible without significant multidisciplinary efforts from the construction industry [4]. Even the legislation stipulating sustainable design and development is perceived as secondary by project teams, in comparison to the primary goals of time and budget in construction projects. Old construction practices based on competition only promote self-interest, forcing stakeholders to make decisions that reflect their own interests and adopt methods that offer the best solution to their organizational business stability instead of energy performance and environment sustainability [5].

In order to translate sustainable concepts into sustainable infrastructure, there is a need for innovate technology and collaborative working, such as BIM, to connect the different levels of the industry (decision-makers, urban planners, economists, architects, contractors and construction supply chain), from strategic urban and infrastructure planning to maintenance and operation of the built assets. Therefore, a slight improvement to this sector could have a considerable impact on capital expenditure and environment. To elaborate more, a 10% saving on contracts could save $5bn a year, resulting in efficient executed projects. This is where Building Information Modeling (BIM) can deliver immense benefits to the building industry, especially by cutting capital cost on construction projects, reducing risks occurrence and delivering sustainable construction projects in line with the Saudi Arabia’s Vision 2030. Applying a methodology such BIM, the SA’s building industry could be better off by as much as $5–10bn (a 10–20% saving on construction projects) and have a digitally empowered sustainable infrastructure and environment [6]. However, implementing BIM in SA is not taking a fast base for many reasons. This paper is considered the first step toward establishing a framework to implement BIM in public projects. Therefore, the author is aiming to investigate barriers for implementing BIM via developing and administrating a questionnaire to BIM professionals with related work experience in GCC. In addition, this paper will investigate and summarizes a case study for a BIM project that constructed in Jeddah, Saudi Arabia. And then conclude with recommendations for successively implementing BIM for a better results.

1.1 Building Information Modeling

Building information modeling (BIM) is a revolutionary technology and coordinated process to create intelligent and information-rich 3D representations for stakeholders to cost-effectively design, construct, operate and manage construction projects [7]. BIM has been proven to significantly reduce construction cost (10–40% of total project cost) and improve project delivery [7]. For example, BIM assisted the UK Government in saving approximately $1.7bn in construction costs in 2013–2014, paving the way for the Digital Built Britain strategy for fully BIM-driven construction and procurement in the UK [8].

Another inherent potential of BIM is its capability to lower the environmental impact of the construction sector, by reducing waste, cutting carbon footprint, and improving energy performance and life cycle management of built assets. BIM is a key enabler for the technology step change towards achieving smarter cities and sustainable developments, for example in energy management, waste reduction, sustainable design and better management of infrastructure and environment. BIM's potential for sustainable development and infrastructure hinges on collaboration and integration of reliable, up-to-date, research-based information and accurate, re-useable data. BIM can be used as a decision-making tool to visualize and optimize multiple design options early in a project stage. A fully coordinated BIM model stores information about components and materials of a project, which can be used to select most appropriate materials and check compliance against sustainable ratings and grades.

Visualization is a key strength of BIM which helps stakeholders see in a virtual environment how a particular development will fit within the surrounding environment, evaluating its interaction with and impact on people, culture and the existing urban landscape. BIM captures accurate design and construction data, which is useful throughout the life cycle of a project, enabling faster, safer, less wasteful construction, and more cost-effective, sustainable operation and maintenance of building and infrastructure projects.

2 Method

A questionnaire was designed to validate the list of barriers to implement BIM that finalized from an intensive literature review and multiples interviews with professionals in the field of construction industry in Saudi Arabia. Some of the participants shows a great experience of BIM background and their feedback scored high than the others with no BIM previous experience. All barriers were fallen under two categories including; process barriers to business including legal and organizational issues and technology barriers related to readiness and implementation. The questionnaire has two sections; the first one for acquiring general information of the respondents to be used for further evaluation. For instance, the participants were asked questions like if they had involved with BIM projects, and if they do so, what was the role they represent. The Likert scoring system was applied to each identified BIM implementation barriers consisting of five categorize of agreement–disagreement. In result, the low total scoring would represent the least impact barrier to implement BIM in Saudi Arabia, and the high total score would represent the major barriers in the area. The Likert system was applied to each identified BIM implementation barriers consisting of five categorize of agreement–disagreement. In result, the low total scoring would represent the least impact barrier to implement BIM in Saudi Arabia, and the high total score would represent the major barriers in the area. The Likert system was as follow 5 points worth for strongly agree, 4 points for agree, 3 points neutral, 2 points for disagree, and 1 point for strongly disagree.

3 Results and Discussion

The questionnaire results showed that main barriers of BIM construction were classified into two fundamental aspects. First, process barriers counted for the most to BIM projects in Saudi Arabia. Barrier B1 Claiming that the Saudi construction market is not ready to adopt a business model like the one BIM is considered to be a major cause to adopted BIM practices in Saudi Arabia with 39% strongly agree, and 54% agree. Furthermore, many owners believe that if they change the contracts to require new types of deliverables, specifically 3D or building information models, they will not receive competitive bids, limiting their potential pool of bidders and ultimately increasing the price of the project. Barrier B9 came second as a major cause for not implementing BIM. Integrating multiple disciplines requires multi user access to the building information model. This does require technical expertise, establishment of protocols to manage updates, edit of the model, and establishing a network and server to store, and access the model. It is also provides an excellent context for new users to learn from more experienced one. Barrier B6 ranked third, which indicated that BIM projects demanding more direct owner involvement, and input, which should be seen as a benefits and not a drawback. However, owners need to establish clear roles, responsibilities, and methods to communicate with the project team and ensure that an owner representative is available as needed. Looking at Barrier B3, it is obvious that cost was a main aspect to implement or adopt BIM business model in Saudi construction market according to respondents' feedback. 80% of respondents were agree while 10% were natural or undecided and the remaining 10% did not see that cost should be an issue. Implementing new technologies such as BIM is costly in terms of training and changing work processes and workflows. Having workers, that familiar with BIM technology was very important to majority of the participants, especially for the contractors. This is will avoid losses in resources, deliver on time, and do it right.

Participants' showed high agreement that barrier B4 could be crucial to implement BIM successfully. It is often difficult to ensure that all project participants have the knowledge and willingness to participate in the creation or use of the Building Information Model. According to the questionnaire, a good number of respondents agreed that government should put more efforts to speed up the movements of green buildings. Furthermore, there is not much of governance and legislation driving the change combined with a lack of knowledge of modern methods such as BIM in the region driven by no requirement for continual professional development for architects and consultants such as American Institute of Architects (AIA). Barrier B2 which was ranked four in overall barriers showed no disagree neither strongly disagree from all participants. Barriers B7 and B8 were least importance under the shortage of resources category according to the questionnaire see Table 1.

The respondents also provided some additional barriers to implementing BIM technology that were not listed in the questionnaire based on their relative experience. For example, local design schools programs are lacking of design computing

Table 1. Summarized of most important barriers to BIM projects in Saudi Arabia according to the questionnaire and the case study

Barrier	Descriptions
B1	The market is not ready
B2	The project is already financed and design is complete – It's not worth is to implement BIM
B3	Training Costs and the learning curve are too high
B4	The difficulty of having everyone on board to make BIM effort worthwhile
B5	Too many legal barriers exit and they are too costly to overcome
B6	Issues of model ownership and management will be too demanding on owner resources
B7	Designers or Architectural Engineering firms do not usually prove empirically the benefits of BIM to customer
B8	Construction Insurance companies do not have BIM projects risk specific policies
B9	Technology risk and barriers technology is ready for single-discipline design but not integrated design
B10	BIM is not having a full support of upper management or decision makers

knowledge in terms of architectural design and that led to high shortage in work force with related backgrounds in GCC region. Moreover, companies are not willing to train their staff because investment in software and hardware is typically exceeded by the training costs and initial productivity losses.

3.1 Case Study

Rabigh Community Centre (RCC) is scheduled to start construction mid 2018 in Rabigh city, Saudi Arabia. Rabigh is small city close to main oil refineries and major schools like Aramco and King Abdullah University for Science and Technology (KAUST), on the west cost of Saudi Arabia with a small community in population of 41000. However, this number is been increasing lately due to the number of people are moving to Rabigh to settle in to stay close to their jobs. The government of Saudi Arabia has allocated 2500 sq2 property in the Rabigh city Centre for the RCC project where the large number of citizens are living. A team consists of faculty members from college of engineering in Rabigh campus, King Abdulaziz University volunteered to develop the design works for the RCC project. The project budget is 80% covered by the government while the remaining, the project team mainly Rabigh Society for Family Development has to secure it. The RCC will provide many services that related to family including but not limited to; training, marriage counselling, shopping plaza, recreation, and kids club. The use of Building Information Modeling was introduced due to the limited budget and the short time is given to complete the design works and select the construction team. Level of details 02 is what the team decided to reach with BIM model due to the team background in BIM, where not everyone knows how use the technology. After a short period of using BIM, the team was able to finish the feasibility studies and got the stakeholders approval earlier than it was scheduled with one month. The reason for that is the using of BIM to present studies to decision makers such as cost estimation, project scoping, early and accurate visualization, optimize energy efficiency and sustainability. However, the team faces many obstacles at the beginning, and yet still have some in progress to be resolved. Implementing BIM for the RCC is challenging due to many reasons including; lack of owner's vision, trained staff, appropriate technology, and stakeholders' BIM knowledge. These issues might reflect the limited resources and stakeholders' assistance to the project team members. In addition, not all team members are enough trained and ready to get involved with BIM projects. To solve this, a weekly meeting that includes all team members along with the stakeholders is scheduled for a month to discuss, train, and identify the BIM level of details and align them with the project main objectives. In the meantime, the project team members' success to bring more experts on board which next will develop a process map and highlighted all required resources like work force. The final design will be wrapped soon and send for the final review. The upper management will evaluate the final results and decided if BIM fulfil the requirements to approve a further BIM implementation. To conclude, the Saudi's construction market is not fully ready to embrace a powerful technology like BIM due to the lack of the fundamentals resources to successfully complete a BIM project and meet the designed objectives.

4 Conclusion

This paper develops a questionnaire to investigate the barriers to implement Building Information Modeling technology in Saudi building industry. The questionnaire was made using a specialized website and an invitation were submitted through emails and in personal. All groups counted in this study showed considerable relative experience of BIM technology and construction industry overall in the area. Total of 195 surveys were included in this study out of 230. The results analyzed results showed that barriers classified under BIM technology implantation process aspect were totaled first followed technology and the appropriate resources. These findings were mainly similar to studies were develop in the area [9–13]. Some additional barriers were discussed in addition to some suggestion were exposed by the respondents that might help accelerate the implementing of BIM technology. For future work, the author is planning to act on the questionnaire and the case study findings to develop a framework that would help stakeholders to adopt the practice of BIM technology and overcome the major related barriers.

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Developers Knowledge and Compliance Towards Development Control Regulations in the Bolgatanga Municipality

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Abstract. Urbanization is a global phenomenon and if not regulated or controlled pose a great challenge to sustainable factors particularly the environment. The rate of urbanization in the Bolgatanga municipality in the upper east region of Ghana is a worrying situation and one that requires immediate attention to enhance sustainability of the environment. Private Individual and public developers failed to adhere to development control measures whiles the municipal assembly has also reneged on its duty to enforce development control regulations resulting in several unauthorized and unplanned development in the municipality. The paper examines the knowledge and compliance level of developers towards development control regulations in the Bolgatanga Municipality. This was achieved through the review of relevant literature on development controls and the use of open-ended questionnaires to elicit data from individual private developers in six (6) urban and peri-urban areas of the municipality. The study further reviewed the concept of development control and permit acquisition in Ghana. The implication of the study is to stimulate strict enforcement of development control regulation to promote efficient and sustainable development in the municipality. It is anticipated that the findings reported in this paper would be imperative for future strategies and guidelines for development in Ghana.

Keywords: Bolgatanga municipality · Development controls · Ghana · Sustainable development · Building permit

1 Introduction/Background

Development control in most African and sub-Saharan Africa countries have been described as not yielding any benefit to the masses [1]. Arimah and Adeagbo [2] indicated the poor compliance of plot coverage ratio in high quality residential neighbourhoods, violation of zoning regulations by medium class neighbourhood and

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zero compliance to plot coverage ratio for low class neighbourhood in Nigeria. An indication by Mosha [3] suggest a total disregard to planning and building control regulations by households in Botswana. The numerous violations and non-compliance have however been attributed to the low-income levels, large family size, cultural practices and unrealistic land use regulations [1].

One should recognize however that the situation of poor development control management is not immune to Ghana. Enforcement of development control is a major problem in Ghana [1]. Development control practices in most metropolitan, municipal and district assemblies (MMDA's) have generally been less effective and efficient [4]. Some communities in the Kumasi Metropolis were reported to have a greater percentage of developments without permits [4]. Also, a study by Boamah [5] on housing affordability in Ghana with focus on Kumasi and Tamale revealed that about 39% and 74.6% respectively of dwellers had no toilet facilities in their housing units. This shows a clear violation of the building regulation that makes it compulsory for every housing unit to have a toilet facility. In the Wa municipality, the story is no different as enforcement of land-use regulations are flouted [1]. The least said about the Accra metropolis the better which has resulted in slum situations, unapproved siting of structures with consequential severe flooding in most parts of the metropolis resulting in several deaths and loss of property [6].

Urbanization in the Bolgatanga municipality is fast growing and accounts for about thirty percent (30%) of urban dwellers in the upper east region of Ghana [7]. It is further affirmed by the Ghana statistical service report of 2005 [8] that Bolgatanga municipality as the regional capital of the upper east region is among other regional capitals that saw a growth in housing development in the regional capital. The positive correlation between urbanization and development in the municipality leaves no doubt of a future adverse repercussion of development activities and practices on the socio-economic and environment of the municipality and therefore the need to check and control development.

The Metropolitan, Municipal and District Assemblies (MMDAs) under the 1993 Local Government Act 462 [9], section 46(1) are the planning authorities for their areas of jurisdiction empowering them as the sole authority in the country to prepare, implement and enforce development arrangements in the various MMDAs. Sections 52 (3), 52(4) and 55 of the Local Government Act 462 of 1993 [9] ascribes powers to the MMDAs which includes; issuance of an enforcement order to immediately halt unauthorized developments, secure court sanctions for developers who violates enforcement orders and to instantly prohibit, abate, alter, remove or demolish any unauthorized development that encroaches or will encroach upon community right of space or interfere with the use of space respectively [10].

Notwithstanding all these powers and authority under the provisions of the Local Government Act 462 [9] of 1993, social, economic and environmental sustainability is far from reach because of the alarming rate at which unauthorized development are springing up in the Bolgatanga municipality of the upper east region of Ghana. The study considering this alarming rate of uncontrolled development seeks to examines the knowledge and compliance level of developers towards development control regulations in the Bolgatanga Municipality.

2 Concept of Development Controls and Permit Acquisition in Ghana

Development Control (DC) is the practice or process, entrenched in legislation that regulates development and the effective and efficient use of land and building [1, 11, 12]. Development control practice includes the approval for development of new structures as well as the extension and modification of existing structures and the allocation of land for the rightful purpose which is an integral part of the planning practice [13]. These development control measures are undertaken with the aim of maintaining building standards, ensuring compliance of physical developments to development code and guidelines and to generate revenue for development projects in the MMDA through the collection of building permit fees [14]. Development Control serves as a way, whereby, policies are implemented and unauthorized growth prohibited. It stimulates local authorities to prevent incompatible land uses [11]. The effective implementation of development control is critical in dealing with land use problems such as flooding, conflicting land uses, unclean living environment, slum situations, overcrowding and congestion as alluded by Aribigbola [12] and cited by Baomah *et al*. [1]. It is therefore imperative to effectively and efficiently implement development control within the socio-economic situation and interests of the several social groups in achieving sustainability of the environment [2].

In Ghana, development control is the responsibility of the MMDAs provided under the local government Act, Act 462 [9], 1992. The basic requirements for authorization of development by the MMDAs are listed below as outlined by the Ghana town and country planning department [15]. This is the primary documentation developers require to kick start the process of permit acquisition for development purposes.

a. 4 Stets of Architectural drawing duly signed: (Three copies of a block and site plan to a scale of 1/20 or 1/40 showing the position of the building(s) and other work on site; Three copies of plans showing the elevation and design of the building at an appropriate scale).
b. 4 Sets of Structure drawings of the building at appropriate scale and duly singed
c. Land Title Certificate or a Deed Certificate or Clearance Form duly signed by appropriate authority i.e. Lands Commission of Land Title Registry. (Copies of clearance forms are available at submission desk. Applicants with clearance forms are to attach two copies of site plans on the scale of 1:12500/1:2500 to the appropriate authority for their action and recommendation). Proof of development and permit fee paid.
d. Building permit application form duly completed.
e. Town and country planning development application form.
f. Five (5) self-addressed envelopes.

Badu and Amoah [16] confirmed a three-stage process professed by Hohoabu [17] in the acquisition of permits as been same as that used by the Kumasi metropolitan assembly (KMA) and other MMDAs across the country. The Bolgatanga municipality assemble also follow a similar procedure in the acquisition of permits. However, this study outlines four (4) elaborate stages to be followed in the acquisition of development permit.

Stage One – Requirement

At stage one, applicants must ensure they meet all the requirements given above as the basic requirement for authorization of development by MMDAs. This applies to both applications for ***new structures*** that have never secured a development permit. Contrary, for ***Multi-User*** and ***Multi-level development***, fire report and appropriate fire engineering drawing duly vetted and approved by Ghana Fire Service, Geo-Technical (Soil investigation) report, Structure Integrity Report (SIR) where vertical extensions are proposed on existing building, Traffic Impact Assessment report and Hydrological report and appropriate drawings must be submitted alongside the basic requirements listed above. Application requiring Permission in Principle (AIP) would be required to submit three (3) sets of Sketch drawings, three (3) copies of brief outline of project covering the location, and design, activities and operational characteristics and Evidence of Neighbourhood consultation and comments. Also, for applications seeking Change of Use of existing permit, submission of the previous permit on existing building, proposed amendments to drawing if relevant and evidence of Neighbourhood consultation and comments for the new use of premises must be made.

It is instructive to know that development and building permits are valid for five (5) years. Applicants who are unable to complete developments within permit validity period are required to seek permit for extension of Time. Application for Extension to Existing Building should however comprise previous permit, three (3) copies of a block and site plan to a scale of 1/20 or 1/40 showing the position of the building(s) and other works on site.

Stage Two – Purchase, Completion and Submission of Application Forms

After obtaining all necessary documents (*listed in stage one*), acquisition of building permit and Town and country planning form 1 from the MMDA works department, or the Town and country planning department offices are done at this stage.

Complete in full, both the Building Permit Application Form and the town and country planning Form 1. The District Town and Country Planning office or the District Assembly Woks Department offers assistance and advice when challenged in filling the form.

Submit completed forms with all other attachments as specified in the Building Permit Application and Town and Country Planning Form 1 to the Town and Country Planning Office in your District or Region. On submission, you shall be informed of any corrections to be made or additions if any, the processing fee, and the date for inspection of project site (if necessary).

Stage Three – Processing

The secretary of the statutory planning committee (SPC) and the Planning officers process the application within two weeks of receipt of application. The technical sub-committee meets to evaluate the application, visit the site if necessary and makes recommendation to the statutory planning committee (SPC) within a month of receipt of application. The SPC considers the development application within nine (9) working days of technical subcommittee meeting. The secretary of SPC submits to the district assembly works department approved plan for the issuance of the building permit.

Stage Four – Collection of Permits
Pay approved building permit fee to the District Assembly's Works Department on receipt of approval letter. Collect building permit from the District Assembly within three (3) months after submission of development application. Applicants may seek further instructions for commencement of building project from the Works Department of the District Assembly.

3 The Study Area

The Bolgatanga Municipality was established in 2004 by Legislative Instrument (LI) 1797 (2004). Located in the centre of the Upper East Region, approximately, between latitudes 10°30′ and 10°50′ North and longitudes 0°30′ and 1°00′ West, it is also the regional capital. Bolgatanga Municipality is bordered to the north by the Bongo District, south and east by the Talensi and Nabdam Districts, and to the west by the Kassena-Nankana Municipality. It covers a total land area of 729 km^2. It was the first of three municipalities to be established in the Upper East Region (the others are Bawku and Kasena-Nankana Municipalities) [7]. A total of thirteen (13) MMDAs constitute the Upper East Region of Ghana. Figure 1 shows the map of the Bolgatanga Municipality. There is a proliferation of unauthorized developments, especially temporary kiosks in the central business area of Bolgatanga Township as well as unauthorized permanent developments elsewhere in the municipality.

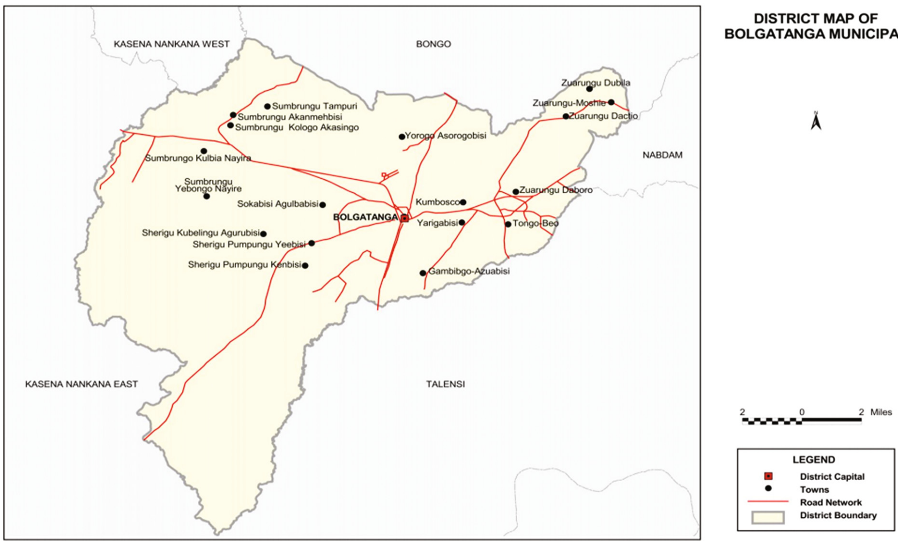

Fig. 1. Map of the Bolgatanga Municipality (Source: GSS, 2014)

4 Effectiveness and Challenges in the Implementation of Development Control in the Bolgatanga Municipality

Implementation of development control must be seen to be effective. To ensure effective implementation of DC, the Bolgatanga Municipal assembly (BMA) must be seen to enforce all regulations in their favor on one hand for appropriate compliance by residents and developers on the other hand. It was however recommended by Boamah [10] to promote strategies to facilitate voluntary compliance and less enforcement since it is clear from literature that developers treat such enforcements with great contempt. Ineffective implementation of development controls has been attributed to several challenges however, these challenges are a matter for both parties to address. Ignorance and lack of enlightenment of people towards development control regulations are categorized as citizen or developers' factors to effective implementation of development controls [18] whereas poor logistics, lack of human resource and political will to enforce development control regulations have been attributed to the metropolitan, municipal and district assemblies across the country. Elsewhere globally, challenging factors such as logistic and capacity gap, multiple sale of land, litigation over land, corruption and high cost of enforcement, lack of public private partnership in development control, lack of punitive sanctions against offenders, overlapping institutional roles and responsibilities, bureaucracy and unrealistic zoning, high rent, ignorance on planning and building regulations, unwillingness to comply with regulations, population growth, high rental cost, lack of political will to enforce building regulations, inadequate policy on housing, and nature and location of lands have been postulated [19–25].

5 Methodology

The paper reviewed literature on development controls and specifically outlines the concept of development control as well as the processes in acquiring development permit in Ghana. Open-ended questionnaires were used to elicit data from private individual developers in six (6) peri-urban areas of the Bolgatanga municipality (Kumbosogo, Yikene, Tindonsolbgo, Zorbisi and Zuarungu). These communities are fast growing with infrastructure development and concerns regarding their compliance to development controls is necessary. Randomly, each peri-urban community was distributed with fifteen (15) questionnaires. Respondents for each urban and peri-urban community included both owners of completed and uncompleted structures. A total of ninety (90) questionnaires were distributed which received a response rate of eighty-three (83%) (see Table 1). Data was analyzed descriptively.

6 Results and Discussion

Towards achieving effective implementation of development controls for sustainable development, parties or stakeholders are enjoined to cooperate in realizing its successful implementation. Local Government Law, Act 462 [9] of 1993 has entrusted enough power to the town and country planning department of all MMDAs in Ghana to

Table 1. Distribution of respondents for the study

Urban/Peri-Urban Area	Questionnaires distributed	Questionnaires received	Responds rate (%)
Bolgatanga	15	14	93
Kumbosogo	15	12	80
Yikene	15	13	87
Tindonsolbgo	15	10	67
Zorbisi	15	13	87
Zuarungu	15	13	87
TOTAL	**90**	**75**	**83**

Source: Author's construct (2015)

enforce and punish developers who fail to adhere to development control and building regulations, [26]. To compliment the effective enforcement by MMDAs, commitment by developers will be much appreciated since their non-commitment results in reprisal attacks on the enforcing departments. In view of this, the studying the compliance level as well as knowledge, awareness and willingness of developers towards development control and building permit acquisition is significant.

6.1 Enforcement and Compliance to Development Control and Building Regulation

An indication of high level of non-compliance towards development control and building regulation is presented in Table 2a. Bolgatanga and Zuarungu had the greatest numbers of development (10 each) without permit as per the response. These included

Table 2a. Profile of completed and uncompleted development project in the municipality with or without development permit

Level of completion with or without development permit	Bolgatanga	Kumbosogo	Yikene	Tindonsolbgo	Zorbisi	Zuarungu	Total
Completed **with** Permit	2	3	5	1	4	2	**17**
Completed **without** Permit	6	4	4	5	1	3	**23**
Uncompleted **with** Permit	2	0	1	1	2	1	**7**
Uncompleted **without** Permit	4	5	3	3	6	7	**28**
Total	**14**	**12**	**13**	**10**	**13**	**13**	**75**

Source: Author's construct (2015)

Table 2b. Enforcement of development control and building permit regulation by MMDAs

Has staff of MMDA ever visited your site or marked your structure "**Stop work and Produce Permit**"							
	Bolgatanga	Kumbosogo	Yikene	Tindonsolbgo	Zorbisi	Zuarungu	Total
Yes	3	1	5	1	3	2	**15**
No	11	11	8	9	10	11	**60**
Total	**14**	**12**	**13**	**10**	**13**	**13**	**75**

Source: Author's construct (2015)

developments which had been completed and that which were still ongoing. At the time of the study, completed and ongoing development which had no development permit and no sign of "**Stop Work and Produce Permit**" or never recorded the visit of MMDA staff as should have been the case was evident (Table 2b). Eighty percent (80%) of developers had never sited MMDA staff at their sites or have their structures marked to stop work and produce permit. This is an indication of a poor enforcement which could be blamed on lack of adequate human and financial resource as well as logistics for enforcement. The cumulative rate of non-compliance is rated at sixty-eight percent (68%). This is a great worry particularly when laws were being flouted at the heart of the municipality. The results are no different from other studies undertaken across the country.

6.2 Knowledge, Awareness and Willingness of Respondents to Comply with Development Control Regulations

Knowledge and awareness of development control is very relevant in assessing one's willingness to comply or otherwise of a regulation or law. Table 3 below indicates a

Table 3. Respondents' knowledge and awareness of development control

Knowledge of development control	Bolgatanga	Kumbosogo	Yikene	Tindonsolbgo	Zorbisi	Zuarungu	Total	%
Yes	14	9	13	10	13	13	72	96
No	0	3	0	0	0	0	3	4
Total	**14**	**12**	**13**	**10**	**13**	**13**	**75**	**100**
Willingness to comply with development control regulations	Bolgatanga	Kumbosogo	Yikene	Tindonsolbgo	Zorbisi	Zuarungu	Total	%
Yes	11	11	13	8	13	12	68	91
No	3	1	0	2	0	1	7	9
Total	**14**	**12**	**13**	**10**	**13**	**13**	**75**	**100**

Source: Author's construct (2015)

greater majority of respondents' knowledge on development control and willingness to comply with development control regulations which was rated at ninety-six percent (96%) and ninety-one percent (91%) respectively. This gives a good indication of a bright future for the development control regime in the Bolgatanga municipality. However, respondents were quick to note that even though they were prepared to comply with the procedure in acquiring development permits, challenges such the high cost involved, bureaucracy and frustration in the application process, difficulty in meeting permit requirements made it difficult to obtain such development permits. Strangely, respondents hold a wrong perception **(ignorance)** that developing on one's own family lands do not require permit which contributes to a high non-compliance rate of respondents in the municipality. On the other hand, the minority nine percent (9%) gave no reasons for such response but it is construed to be because of lack of knowledge and understanding of the subject matter (development control). It is therefore imperative for sensitization of residence on appropriate documentation and processes involves in permit acquisition for development. Ignorance and lack of awareness of development control procedures accounted for the poor compliance to development permit acquisition in the Bolgatanga Municipality which sinks well with other studies such as Somiah [18] and Somiah [26] which identified poor knowledge of the law and ignorance on planning and building regulations as the major reasons for poor siting of building as well as poor compliance to building regulations.

7 Conclusion and Recommendation

In conclusion, development control has been recognised by the study to curb the negative consequence of urbanization such us overcrowding and congestion to promote environmentally sustainable development regime. However, the Bolgatanga Municipal Assembly (BMA) of the upper east region of Ghana is yet to fully achieve the desired compliance by developers. Strategies such as public-private partnership towards development control is important. Until then the evidence is poor enforcement and non-compliance to development control and building regulations. It is however imperative to note that, there is a positive indication that the challenges professed by respondents which influenced its non-compliance to development control and building regulations such as high cost involved, bureaucracy and frustration in the application process, difficulty in meeting permit requirements, and wrong perception by some respondents regarding the "no need for permits" to develop on one's own family land, when pragmatically addressed will help improve the compliance level within the municipality. It is therefore, recommended that, sensitization of residents on the processes and importance/benefits in acquiring approval to commence development in the municipality and finally, to adopt innovative strategies to promote voluntary compliance with development control and building regulation with little enforcement. The study was undertaken to study the knowledge and compliance level of developers towards development control regulations in the Bolgatanga Municipality. This was achieved through the review of relevant literature on development controls and further, the concept of development control and permit acquisition in Ghana.

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A Conceptual Building-Block and Practical OpenStreetMap-Interface for Sharing References to Hydrologic Features

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Abstract. Disaster related scientific data is multidisciplinary by nature, and comprises data entities from observations, experiments, surveys, simulations, models, and higher-order assemblies, along with the associated information to describe and interpret the data. One of the essential elements of life on this planet is freshwater. Sustainable development with disaster preparedness therefore demands sustainable management of the world's limited freshwater resources. However, water resources cannot be properly managed unless we know where they are, in what quantity and quality, and how variable they are likely to be in the foreseeable future. The present work with AGORA's SDI-NODE focuses on connecting dispersed disaster-relevant data to enable easier and faster discovery and access of disaster-related data. The technical framework of environmental data aggregation and unified data sharing method is explored for distributed data integration with a "LOD-enabled SDI-node".

Keywords: Natural risk management · Flood risk model · Spatial Data Infrastructure (SDI) · Metadata · Semantic Web · Interoperability · WikiData · OpenStreetMap (OSM) · Citizen Science (CS) · Volunteered Geographic Information (VGI) · Ontology · Controlled vocabulary

1 Introduction

Observations about the state of one or more properties of geographic phenomena, such as the height of a stream, may be available from datasets. Such Information can be represented in multiple ways. Additionally, features change over time, their representations use different spatial scales and different aspects of them are of concern to different stakeholders. We propose the use of Linked Data to describe the relationships between them. We describe standard-based approaches how different resources can be discovered and accessed. As it regards to Citizen Science, Volunteered Geographical Information (VGI) and OpenstreetMap (OSM).

The overall envisioning objective is to enable the virtual navigation between "compatible" observational dataset on hydrological connectivity [1–3].

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1.1 Data Vocabularies

Vocabularies define the “concepts” and “relationships” (also referred to as “terms” or “attributes”) used to describe and represent an area of interest. They are used to “classify” the terms that can be used in a “particular application”, characterize “possible relationships”, and define “possible constraints” on using those terms. Several near-synonyms for Vocabulary have been coined, for example, “ontology”, “controlled Vocabulary”, “thesaurus”, “taxonomy”, “code list”, “semantic network” [4]. There is no strict division between the artifacts referred to by these names. “Ontology tends however to denote the Vocabularies of classes and properties” that structure the descriptions of resources in (linked) datasets. Ontologies are the “key building blocks” for inference techniques on the “Semantic Web” [4].

1.2 Related Work – Hydrological Features

1.2.1 Standardized Data Sharing in Hydrology

During their Thirteenth Congress (Cg-13) the World Metrological Organization (WMO) there was widespread consensus that the exchange of hydrological data at the local, national, regional and global levels was absolutely essential to enhance the shared and sustainable management of water resources, coping with floods and droughts, and improving the capability of nations to provide essential hydrological forecasting and warning services.

In this context, the WMO Executive Council invited the Commission for Hydrology to provide advice and assistance on technical aspects of the implementation of the practice on the international exchange of hydrological data and products [3].

Hydrologic features are units of hydrologic information [1, 2] required to convey identity of real-world water-objects through the data processing chain from observation to water information and identified under the umbrella of the joint WMO-UNESCO Glossary of Hydrology [3, 5].

Knowledge representations with logical models and physical model of hydrological systems. According to the authors in [2, 3], Water Management Ontologies can be specified using logical models, which constitutes the basis for the analyses performed by the water resource manager.

A logical model is the representation of the managed water supply system components and relations that acts as interface between the water manager and the water management ontology.

Any logical model has a correspondence to a physical model. A physical model is a collection of real elements that match a structure consisting of a geographical positioning component and other associated information (geodata). These elements define how things work in real life.

As such, the user can obtain information from specific ontology as well as recommendations based on applying a rule-based analysis based on expert experience. According the authors, this allow to distinguish between the elements’ interactions and the specific information available in each of the physical elements involved.

In Water Management Ontologies, the inclusion of such logical models allows parts of the water supply distribution system to be grouped or detailed as needed in function of the quantity and quality of existing information and the decisions that must be made [2, 3].

Knowledge representations with logical models and physical model of Hydrological systems: Standardized Data Sharing. According to the authors in [2, 3], Logical and physical models contain information to be provided through Water Management Ontologies to the water resource manager, such as observational data that will be used as input to decision-making processes. This information is based on time series, and these series are within the scope of hydrology.

There have been several efforts to standardize the exchange of this kind of information, these efforts have concluded in the specification of WaterML2.0, which is an OGC encoding standard for the representation of hydrological observations data with a specific focus on time series structures [2, 3].

1.3 Related Work – Linked Open Data (LOD)

Facilitating the discovery of public datasets: Search engines, Google and Schema.org. National and regional governments, scientific publishers and consortia, commercial data providers, and others publish data for fields ranging from social science to life science to high-energy physics to climate science and more. Access to this data is critical to facilitating reproducibility of research results, enabling scientists to build on others' work, and providing data journalists easier access to information and its provenance [6]. For these reasons, many publishers and funding agencies now require that scientists make their research data available publicly [6].

Due to the volume of data repositories available on the Web, it can be extremely difficult to determine not only where is the dataset that has the information that you are looking for, but also the veracity or provenance of that information. Yet, according to the authors in [6], there is no reason why searching for datasets shouldn't be as easy as searching for recipes, or jobs, or movies! These types of searches are often open-ended ones, where some structure over the search space makes the exploration and serendipitous discovery possible! On one the hand, to provide better discovery and rich content for books, movies, events, recipes, reviews and a number of other content categories with Google Search, we rely easy on structured data that content providers embed in their sites using "schema.org" vocabulary. On one the hand, facilitate similar capabilities for datasets, Google [7] recently published new guidelines to help data providers describe their datasets in a structured way, enabling Google and others to link this structured metadata with information describing locations, scientific publications, or even Knowledge Graph, facilitating data discovery for others.

The "schema.org" approach for describing datasets is based on an effort recently standardized at W3C (the Data Catalog Vocabulary https://www.w3.org/TR/vocab-dcat/), which Google expect will be a foundation for future elaborations and improvements to dataset description: "While these industry discussions are evolving, we are confident that the standards that already exist today provide a solid basis for building a data ecosystem [6]."

Facilitating the discovery of public datasets - Technical Challenges presented by Google. According to the authors [6], while Google has released the guidelines on publishing the metadata in [7], many technical challenges remain before search for data becomes as seamless as we feel it should be [6]. The authors details the following issuers in the same report under chapter “Technical Challenges” [6]:

- Defining more consistently “what” constitutes a dataset: For example, is a single table a dataset?
- Identifying datasets: Ideally, datasets should have “permanent” identifiers conforming to some “well-known” scheme that enables us to identify them uniquely, but often they don’t.
- Relating datasets to each other: When are two records describing a dataset “the same” (for instance, if one repository copies metadata from another)?
- Propagating metadata between related datasets: How much of the metadata can we propagate among related datasets?
- Describing content of datasets: How much of the dataset content should we describe to enable support for queries similar? Where license terms allow, of course?

Linked Open Data (LOD). In the present work, we explore LOD related technologies to improve feature-level queries over distributed datasets. The task of public administration is to publish structural data including spatial data, but in a LOD approach this occurs in a way that supports the ability to integrate data from multiple heterogeneous sources using Semantic Web technology, particularly RDF [8]. Linked Open Data offers the unique chance of accessing vast amounts of machine-readable, semantically annotated data. However, according to [9] access is still limited by additional knowledge required for data discovery. Data consumers have to know where datasets of interest are located, what kind of data they contain, where to access them in which formats, as well as the terms of reuse. To date, some parts of this important metadata can be found in various repositories, datahub.io being the most accepted one, although various domain-specific repositories exist. Data models of these repositories vary and none of them offer enough granularity to sufficiently describe complex datasets in a semantically rich way. For example, datahub.io partially implements the Data Catalog Vocabulary (DCAT) W3C Recommendation, but only describes all resources associated with a dataset superficially, be it an ontology, a single example file, a diagram or a data dump as a distribution of the dataset [9]. Experience gained so far shows that efficient data exploration is one of the key problems that the community faces [10]. Existing linked data exploration techniques are trying to exploit linked nature of data to search/provide/visualize data [10]. As a result, focus has shifted towards datasets exploration instead of data exploration [10]. For example, DCAT metadata speak about distributions, publishers and records. The only DCAT properties partially representing the dataset meaning are DCAT:keyword and DCAT:theme [10]. Bruemmer et al. argue in [11] that the DCAT vocabulary as well as the established VoID vocabulary only provide a basic interoperability layer to discover data.

The Data Catalog Vocabulary (DCAT), a W3C recommendation. Maali et al. introduce in [12] a standardized interchange format for machine-readable representations of government data catalogues. The DCAT vocabulary includes the special class

Distribution for the representation of the available materialisations of a dataset (e.g. CSV file, an API or RSS feed) [11]. These distributions cannot be described further within DCAT (e.g. the type of data, or access procedures). Applications which utilize the DCAT vocabulary (e.g. datahub.io) provide no standardized means for describing more complex datasets either [11]. Yet, the basic class structure of DCAT (Catalog, CatalogRecord, Dataset, Distribution) has prevailed. Range definitions of properties provided for these classes are general enough to make this vocabulary easy to extend.

1.4 Objective, Challenges, Contributions and Limitations of the Present Work

The broader objective: Opening Accessible and Comprehensive Environmental Risk Data - A General Open Data Strategy. In 2011, the European Commission published its Open Data Strategy defining the following six barriers 14 for “open public data”:

1. lack of information that certain data actually exists and is available,
2. lack of clarity of which public authority holds the data,
3. lack of clarity about the terms of re-use,
4. data made available in formats that are difficult or expensive to use,
5. complicated licensing procedures or prohibitive fees, exclusive re-use agreements with one commercial actor or re-use restricted to a government-owned company.

The broader objective: Opening Accessible and Comprehensive Environmental Risk Data - An example concerning water related datasets for Environmental Modeling.

The current situation seems to be that datasets for water related risks are gradually being made available (especially from developed countries) but are not easily discovered and not easily accessible (remotely searchable, re-usable). The existing platforms and catalogs have of course improved the situation and help in finding relevant datasets for water management related applications.

However, there are still tough challenges in making datasets really discoverable and re-usable (e.g. https://ijabe.org/index.php/ijabe/article/view/1765).

Challenges: A standardized, semantic representation of the conceptual model “Hydrologic Cycle” - compatible with the terminology endorsed by WMO and UNSECO. As it regards to interoperability of logical models in the field of hydrology, a significant effort for a standardized, semantic representation is undertaken by the World Meteorological Organization (WMO) [3].

However, at present there is not yet an WMO [3], UNESCO [5] and/or OGC standard for this and its technology is not enough mature to use it at this moment.

The development of a future standard for semantic representation in the water domain is (still) ongoing; nevertheless, it is being considered by the present paper and will be tracked in future steps [5, 6].

Challenges: Facilitating the discovery of public datasets (Google). According to the authors in [6], while Google has recently released the guidelines on publishing the metadata Last updated March 28, 2017. ([7], last updated March 28, 2017), "many technical challenges remain before search for data becomes as seamless as we feel it should be" (Sect. 1.3). Interestingly, in the same report we can read regarding DCAT: "The structure is very close to that used in the W3C DCAT specification. We expect to add a DCAT example in a future revision of these guidelines." (The DCAT-Standard was developed by W3C and the European Union for describing public sector datasets. Its basic use case is to enable cross-data portal search for data sets and make public sector data better searchable across borders and sectors.).

Contribution: Linking standardized hydrologic observations and features. This paper describes approaches how observational datasets may be linked to (and "contextualized" with) specific hydrological features. We show further how domain models can be used to standardize links between different features. Authors use "standardized" terms directly as OSM-TAGS describing POIs inserted by volunteer citizens to represent "Surface Water Features" controlled by an abstract ontology. We use hereby standard W3C - vocabularies, including the DCAT, CSVW, VoID, PROV, DQV and Schema.org to describe the datasets and cross-references between them [13]. Authors illustrate challenges when mapping W3C's DCAT, and highlight potential design issues/improvements in the target vocabularies (e.g. PROV, CSVW and SCHEMA.ORG's Dataset vocabulary), The authors use the PROV ontology to describe the provenance.

2 Methodology

2.1 Approach: Knowledge Representations with Logical Models and Physical Model of Hydrological Systems

A physical model is a collection of real life elements that match a structure consisting of a geographical positioning component and other associated information. Any logical model has a correspondence to a physical model. That the introduction of logical models does "not" mean that the system removes any reference to geographic elements or temporal scope of decision. Each element of the logical model corresponds to one or a set of physical elements. That each element of the logical model has its corresponding temporal scope. That there may be other logical elements containing the same information but with a different temporal scale [2].

2.2 Approach: System Architecture and Implementation

We use the DCAT vocabulary to describe the available datasets, groups of datasets and catalogs. The interlinking is modelled by a linkset (void:Linkset) that describes relationships between hydrological features and monitoring points, described using WaterML2.0. A linkset in VoID is a subclass of a dataset, used for storing triples to express the interlinking relationship between datasets. This modelling enables a flexible

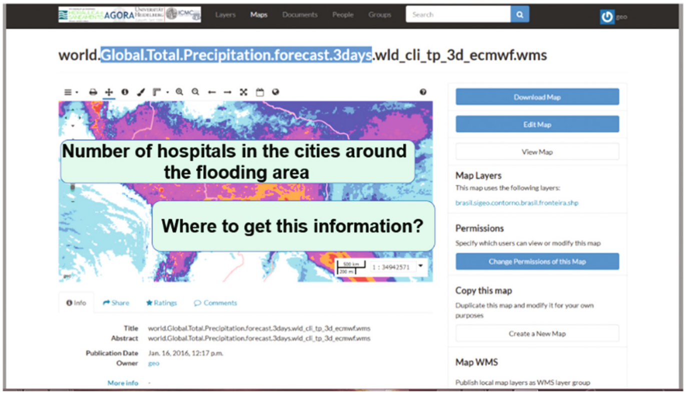

Fig. 1. Number of hospitals around the flooding area: where to get this information?

and powerful way to talk in great detail about the interlinking between two datasets, such as how many links there exist, which kind of links (e.g. owl:sameAs or foaf:-knows) are present, or stating who claims these statements. This provides the data backbone allowing navigation between specific features (e.g. rivers) and observations (e.g. height, flows, water quality) [13] (Fig. 1).

2.3 Approach: Combining PROV-O and DCAT to Attend Provenance Related Demands

We use the following approaches to attend provenance related demands:

- An detailed description of repositories is mandatory.
- A clear specification of involved agents and their responsibilities is needed.
- Making further use of PROV-O promotes to meet the requirements with flexibility.

2.4 Approach: Integrating the Players of Data Ecosystem - Data Providers and Data Consumers - The Schema.org Initiative

We stress the orientations in [6], where authors emphases that, as any ecosystem, also a data ecosystem will thrive only if a variety of players contribute to it: For data providers, both individual providers and data repositories: publishing structured metadata using schema.org, DCAT, CSVW, and other community standards will make this metadata available for others to discover and use.

For data consumers (from scientists to data journalists and more): citing data properly, much as we cite scientific publications (see, for example, a recently proposed approach). For developers: to contribute to expanding schema.org metadata for datasets, providing domain-specific vocabularies, as well as working on tools and applications that consume this rich metadata [6].

2.5 Approach: Proof of Concept Implementation

The present research work is guided by the research questions (see chapter introduction) and applies the following methods and approaches: The proof of concept implementation of AGORA's LOD-enabled SDI-Node as practical use case and research platform [14]. The close cooperation with the National Centre for Monitoring and Warning of Natural Disasters CEMADEN (http://www.cemaden.gov.br/): This means our academic research work is inspired by practical real-life challenges faced by CEMADEN in its daily work; The consideration and use of existing web-2.0 based SDI-state–of–art solutions by exploring and completing them – where possible: This means especially where data and data services are freely available. Prominent examples are at federal level, INDE (the Brazilian SDI), ANA (the Brazilian Water Agency), INDE (The Brazilian Institute of Geography and Statistics), and INDE (National Institute for Space Research), and CETESB (Sao Paulo State environmental agency) at São Paulo State level (see Fig. 2).

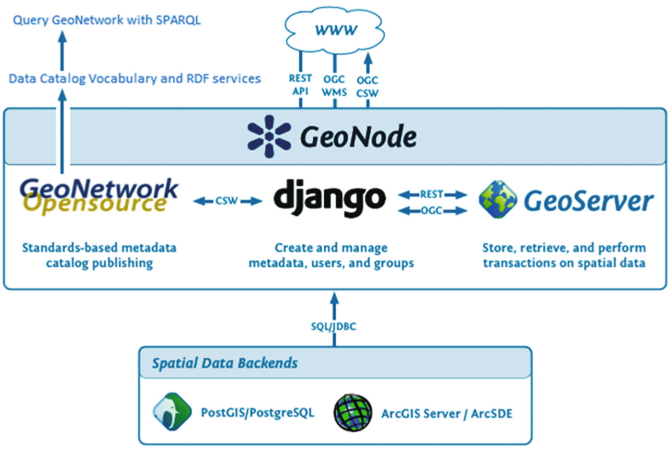

Fig. 2. GeoNode: AGORA's LOD-enabled SDI-Node [14].

3 Results

3.1 Results: Standardized Data Sharing in Hydrology

Surface water land cover plays a major role in a range of geographic studies, including climate cycles, landform generation, and human natural resource use settlement. Surface water is a primary concept of human experience but captured in cultures and languages in many different ways. An abstract ontology of surface water features based only on those physical properties of landscape features has the best potential for serving as a foundational domain ontology for other more context-dependent ontologies. The Surface Water ontologies design pattern were developed in literature for both, domain knowledge distillation and to serve as a conceptual building-block for more complex or specialized surface water ontologies.

The effective exchange of hydrologic data containing references to hydrologic features requires standardized semantics of the concepts that allow identification of these features. To this end, we implemented within the volunteered geographic information (VGI) platform OpenStreetmap (OSM) an interface by using "standardized" terms directly as OSM-TAGS describing POIs inserted by volunteer citizens to represent "Surface Water Features" controlled by an abstract ontology of surface water features based only on those physical properties of landscape features. This Common hydrologic feature model uses as far as possible the term and definitions endorsed by WMO applying the "UNESCO/WMO International Glossary of Hydrology" as key reference [1].

The advantages of this "standardized approach" are the facilitation of a reliable "VGI/OSM-Information Model for Surface Water Features", that serves for both, as a practical interface and a conceptual building-block for more complex or specialized OSM-based surface water applications. Expressed in a platform-independent form, the "VGI/OSM-Information Model for Surface Water Features" can be used as a general basis for referencing hydrologic features that have persistent identity across multiple data systems: e.g. Citizen Scientists may link sampling features to the water body intended to be observed, and practitioners and modellers may describe the unit of study or reporting they share.

3.2 Results: Combining PROV-O and DCAT to Attend Provenance

The Data Catalog Vocabulary (DCAT) is used to describe datasets in catalogs, but does not deal with the issue of dataset evolution and versioning. The Provenance Ontology (PROV-O) is used to capture information about entities, activities, and people involved in producing or modifying data. There are plenty of demonstrations of the use of ontologies such as DCAT, being used with PROV-O. Combined PROV-O and DCAT ontologies can be stored in RDF databases and accessed together using SPARQL queries.

3.3 Lifting Data to the Web of Data

Table 1 displays the different components and the integration of the overall system (Fig. 3).

3.4 Results: Text Mining and the Spatial Mining Workflow

On the one side, we face the challenge that the majority of the world's knowledge remains locked up in unstructured text. On the other side, as text mining matures, it is increasingly possible to extract this knowledge automatically; however, most people, even within the highly-specialized domain community, do not have the skills and resources to perform this work.

Table 1. Lifting data to the web of data with W3C-standards (https://www.w3.org/standards/semanticweb/)

Actions	W3C-standards	Tools
(1) Mapping to standard Vocabularies	DCAT	DCAT export of metadata from datasets in CKAN
(2) Mapping to standard Vocabularies	Schema.org	Mapping of DCAT to Schema.org's dataset vocabulary (to promote the integration into knowledge graphs of major search engines)
(3) Enrich the datasets	CSVW	CSV on the Web vocabulary – Dialect properties: (dcat:mediaType, csvw:encoding, csvw:delimiter)
(4) Enrich the datasets	CSVW	CSV on the Web vocabulary - Schema properties: (csvw:name, xsd:datatype)
(5) Enrich the datasets	PROV-O	Provenance ontology
(6) Enrich the datasets	DQV	Data Quality vocabulary
(7) Enable access	SPARQL	Discovery, Access, Semantic Integration

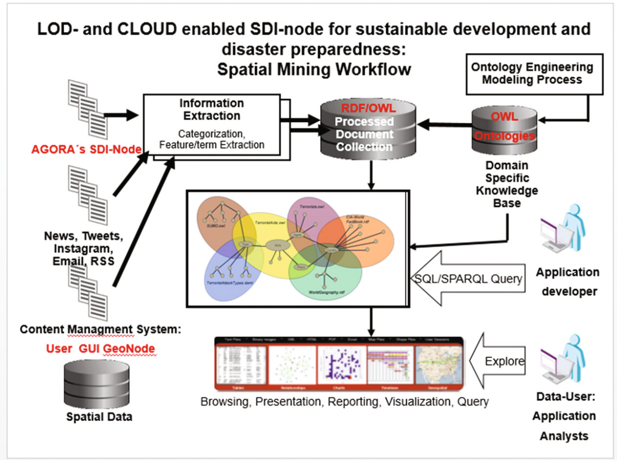

Fig. 3. Spatial mining workflow

4 Conclusion

The effective exchange of hydrologic data containing references to hydrologic, physical features requires standardized semantics of the concepts that allow identification of these features. To this end, we implemented within the volunteered geographic information (VGI) platform OpenStreetmap (OSM) an interface by using "standardized" terms directly as OSM-TAGS describing POIs inserted by volunteer citizens to represent "Surface Water Features" controlled by an abstract ontology of surface water features based only on those physical properties of landscape features.

The interlinking is modelled by a linkset (void:Linkset) that describes relationships between hydrological features and monitoring points. This modelling enables a flexible and powerful way to talk in great detail about the interlinking between two datasets, such as how many links there exist, which kind of links (e.g. owl:sameAs or foaf:-knows) are present, or stating who claims these statements. This provides the data backbone allowing navigation between specific features (e.g. rivers) and observations (e.g. height, flows, water quality).

Adding provenance annotations: Allow users to judge the trustworthiness of data, and, Making data traceable to Interoperability. Apart from generating mappings, quality measurements and enrichments of the metadata alone, in order to make data traceable and allow users to judge the trustworthiness of data, it is import to record the provenance of our generated/published data.

The PROV ontology is a flexible approach which provides an ontology to annotate all kinds of resources with provenance information and allows tracking of provenance of resource representations. On a high level PROV-O distinguishes between entities, agents and activities. Entities can be all kinds of things which are created or modified. Activities are the processes which create or modify entities. An agent is something or someone who is responsible for an activity (and indirectly also for an entity).

Additionally, PROV-O also allows to tag certain activities with time, for example a timestamp when an entity was created.

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Child-Friendly Kindergarten Bathrooms – Design Ideas

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Abstract. Creating a child-friendly hygienic and sanitary space refers not only to area that is associated with a bathroom at home. The toilets in kindergartens are one of the most important rooms in these institutions. They have a significant impact on the well-being of children, as well as their health and safety. As it turns out, the preschoolers often avoid using the bathrooms in kindergarten due to both unfavorable sanitary infrastructure and discomfort associated with various psychosocial factors, including the lack of a sense of privacy. Such reactions can cause serious health effects. Therefore, the planning and design of bathrooms and selection of sanitary equipment for the children at the kindergarten should be done with great care and attention to the needs and requirements of this age group. Designing a functional, safe bathroom for kindergarten requires knowledge of the rules, regulations and references to the needs of children in terms of their physical skills. However arranging the child-friendly bathroom requires something more. It needs consideration of the requirements and expectations of children in terms of their relationship with the environment and the widely understood friendliness, coziness and attractiveness of the surrounding conditions. The work will be discussed the examples of creating and arranging kindergarten bathrooms, taking into account the above aspects. Specific models will show the possibilities of functional and aesthetic formation of bathrooms.

Keywords: Ergonomics · Architectural design · Interior design · Bathrooms design · Toilets design · Preschool children · Kindergarten · Accessibility · Safety · Comfort · Hygiene · Health · Privacy · Child-friendliness

1 Introduction

Bathrooms in kindergartens are some of the most important rooms in these institutions. These facilities have a significant impact on the well-being and health of children. Therefore, both the design of bathrooms and selection of sanitary equipment for children should be done with great care, attention and consideration of the needs of this age group.

Among the requirements for the bathrooms in the kindergarten above all we can find expectations in relation to their hygienic-sanitary conditions and health conditions. Further demands include issues related to accessibility and adequacy of bathroom equipment for comfortable use by children, taking into account their needs and the spatial-motor abilities. Aesthetic criteria are another important issue that should be

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considered in the process of creating a child-friendly bathroom. The demands also include expectations for favorable conditions for children for the acquisition of specific knowledge on hygiene and the cognition of proper use of sanitary facilities. The kindergarten bathroom should encourage children's independence with regard to toilet training and other hygienic activities. Another important issue concerns the requirements for the care and supervision of children, with particular emphasis on their protection and safety. Other criteria, including requirements to provide a sense of privacy of children also turn out to be necessary. Psychosocial criteria are studied more and more often in the context of use kindergarten bathrooms, mainly due to the fact that preschoolers are not protected in this respect by any rules and regulations. Given the importance of health, safety and wellbeing of children, all of these criteria should be considered in detail during the design and realization of kindergarten bathrooms, the more that not all are equally defined by legal requirements. Planning a functional bathroom for kindergarten requires knowledge of the rules and regulations, but they do not define all the issues and they are not always clear, accurate and precise.

2 Criteria for Accessibility, Safety and Comfort of Use

The location of the kindergarten bathroom should be convenient both for children and for caregivers. Small children have poor bowel and bladder control, therefore they cannot wait long when they need to use the toilet. They must be able to get to toilet facilities quickly. Kindergarten teachers and caregivers also need to have easy access to bathrooms, to combine the use of sanitary facilities and supervision of the children.

Bathrooms should be available from the rooms of activities and playrooms and should be connected to these rooms in a way that allows staff to supervise children both in the rooms and in the toilets. The bathrooms should be located near the entrance to the rooms of groups and exit to the outdoor play area. If both are located close to each other, one bathroom is sufficient. Between the exit outside and the bathroom should be a vestibule to prevent cold [3, 8].

Regulations define the amount of necessary bathroom equipment and its location. Bathrooms should implement the specific standards. For children of preschool age from 3 to 6 years should be provided (in accordance with Polish regulations) [1, 13]:

- 1 children's toilet bowl with a height of 32–35 cm for every 15 children,
- 1 washbasin at a height of 55–65 cm for every 15 children,
- 1 shower with shower tray.

Using the bathroom equipment designed for adults by small children presents numerous difficulties. Due to the smaller size of the child, its physical, motor space is also reduced. The limitations include particularly space of handling - space of reach and grasp. For this reason, using the standard equipment of bathroom and full-size sanitary devices is uncomfortable and unsafe for the child, and usually requires a additional supporting elements and assistance of kindergarten teacher or caregiver, what in turn results in limited development of the child self-reliance and independence.

The project of bathrooms in kindergarten should include fit of mounting height of washbasins to the height of preschoolers. This is an essential issue especially among the youngest children. Mounting height is also important for additional equipment associated with the use of washbasin: mirrors, dispensers for soap, clothes hangers, dispensers for paper towels. Also the dimensions of the washbasin are crucial for preschoolers. Smaller devices are much safer for them. Today, many manufacturers of sanitary facilities have in offer products designed to meet the needs of small children, for example, the small-size washbasins. Suitably shaped a small-size washbasin (e.g., with dimensions of 49×42 cm or even smaller with dimensions of 40×33 cm) should be installed at a level corresponding to the child's height allows the child to comfortably and safely use of it. Recommended installation height of washbasin is 55–65 cm above the finished floor [1].

The kindergarten toilets design should take into account the needs and requirements of preschoolers. Therefore, installation of small-size toilet bowls and fit of their height to the height of children should be included in the projects. Small-size toilet bowl (e.g. with a width and a height of 30–33 cm and a length of about 40 cm) provides comfort to use of it even for the smallest child. Small toilet bowl can eliminate the necessity of a child climbing on standard toilet bowl and reduce the risk of falling child into the "adult" toilet bowl. Location and mounting height of the toilet paper dispenser should be convenient for small children (approx. 75 cm above the floor). Solutions in the form of wall-hung toilet bowls that are installed on the in-wall support frame, work perfectly in this kind of establishments, as in other public institutions. They allow installation of equipment at any height and provide comfortable use and ease of cleaning [1].

Children should be able to easily open every toilet door from the inside, and caregivers should be able to easily open toilet doors from the outside. Doors that can be opened easily will prevent entrapment of children inside toilet cabin and will allow easy access to them in case of adult assistance necessity. Inside latches that children can easily operate can allow the child to ensure privacy when using the toilet. The latch or lock available for use, must be of a type that the caregiver can easily open from the outside in situation when a child requires adult help [3, 8].

Properly equipped kindergarten bathroom should include a safe and aesthetic shower cabins, taking into account the number of kids. Cabins and spouts should be adapted to the height of users (lower than for adults). The standard size of shower cabin for preschoolers set out in the technical requirements are: width 80 cm, height 140 cm, depth 120 cm. They should be equipped with a special lock, which opens the door from the outside, in case the child locks himself in the inside [13].

All elements of the kindergarten bathroom equipment should meet ergonomic standards for sanitation.

3 Criteria for Health, Hygiene and Safety

According to the polish regulations on safety and hygiene in public and private educational institutions, every kindergarten is committed to providing adequate sanitation for preschoolers [10–12]. This means easy access to hot running water, soap, paper towels, toilet paper. Taking into account the sanitary and epidemiological requirements with respect to the bathrooms in kindergartens, selection of materials is also subject to regulations. The project of bathroom in kindergarten should use materials designed specifically for public bathrooms: safe materials, that are easy to clean and materials with a smooth surfaces, which do not collect dirt, antimicrobial surface materials. The mirrors and other glass elements of kindergarten bathroom equipment should be made of shatterproof and safe glass. The use of waterproof, non-slip floor finishes, for example in the form of tiles with a special texture and non-slip mats can be an effective way to reduce slips and falls of children and caregivers. If a platform or children's stool is used, it should have slip-proof steps and surface. Sanitary equipment should be provided as safe and easy to keep clean. These requirements also apply to additional hygienic and toilet accessories, such as soap dispensers, paper towels dispensers or hand dryers, toilet paper dispensers and holders, waste bins and toilet brushes [5–7, 13].

Transmission of many infectious diseases can be prevented through hand washing, so it should be a habit of preschoolers not only at home but also at kindergarten. Unfortunately, children often avoid using washrooms, due to unfavorable and unfriendly infrastructure. Hand washing is essential to prevent many infections that are typical for this environment. Caregivers should pay attention to the fact that children have to wash their hands always after coming to the kindergarten, after sports, before and after a meal, and always after using the toilet. The location, access to washbasins and supporting elements to enable adequate hand washing are important to the successful facilitation of this key routine [3, 13]. The application of electronic touchless faucets controlled by a photocell and automatic liquid soap dispensers are preferable because they minimize hand contamination during and after handwashing and should be considered in order to improve the hygienic use of washbasins in kindergarten bathroom.

In addition to the use of sensor faucets and dispensers, we can consider the possibility of application of the automatic flushing toilets in order to minimize the amount of touch points in the kindergarten bathroom [8]. But flushing toilets should not be a surprise during toilet use, because it can discourage a child to this function [8]. The innovative rimless toilet bowls "no collar" turn out to be more "hygienic" [9]. They are designed without an inner rim, thus there is no place for dirt and limescale to hide. Therefore we should consider the use of such solutions in the kindergarten bathroom.

Solution in the form of recessed washroom accessories is indicated if possible in order to minimize loss of floor space and risk of injuries by bumping into projecting corners [8].

In order to avoid accidental burns of children, washbasins for preschoolers should be equipped with thermostatic faucets that control the temperature of the water and thus prevent burns. The temperature of the water in these taps can be controlled in the range of 15–65 °C with a precision of one degree. The ideal water temperature, which is used by small children is 48–50 °C. Therefore, setting the water heater to a maximum temperature of 40–55 °C is the easiest solution to prevent burns children, because every time the temperature of water has the same value [7, 13].

Storage of cleaning supplies should be lockable and protected from the reach of children [6, 13].

Preschoolers need to feel well and safely all over used space. In order to minimize the risk of possible accidents, it is necessary to provide adequate conditions to stay in the kindergarten bathroom and to its use. Avoiding delicate injury is almost impossible, but a well-planned organization of the interior of the kindergarten bathroom can provide a safe activity of the child in its area, without unnecessary restrictions.

4 Aesthetic Criteria

Preschoolers often avoid using the bathrooms in kindergarten, mainly due to the unfavorable and unfriendly infrastructure. This behavior can cause not only serious discomfort, but also negative health consequences. For this reason, the creation of appropriate conditions for comfortable and safe use, as well as proper aesthetics and child-friendliness of these rooms is so important. This action seeks to provide protection of children from the unpleasant impressions, feelings and experiences associated with the use of bathrooms and toilets. On the other hand, friendly sanitary spaces in kindergarten should encourage to take care of personal hygiene and health from an early age.

The child should feel good in the kindergarten bathroom, therefore this space must not only be safe, functional, adapted to its motor abilities, but also attractive and curious, taking into account its needs, interests and psychophysical activity characteristic of that stage of development. Preschool children pay special attention to shapes, patterns and colors. Development of a child's imagination is stimulated by external impulses and incentives. Appropriately designed kindergarten bathroom can satisfy the curiosity and cognitive needs of preschoolers. Child development is actuated, motivated and inspired by fairytale stories and characters. Fun can be the key - in this way the children should be encouraged to use the bathroom and train proper hygiene habits. Colors, shapes, patterns provide joy and can be inspiring for the children's fantasy. To create a child-friendly bathroom we need some thoughtful treatments aimed at the practical use of this room, without depriving the children the opportunities for fun [2, 5–7].

Shaping of the child-friendly aesthetic is a great challenge for designers of kindergarten bathrooms. In this respect, the kindergarten bathrooms usually do not have any restrictions, because among users are practically only children and too colorful interiors are not burdensome to the eye of adults. There is no risk that the colors, shapes, patterns, decorations will be boring for children. The main objective of the design and implementation is to create a child-friendly, cozy interior that encourages the use of sanitary facilities and minimizes anxiety.

5 Psychosocial Criteria

Using the kindergarten bathroom by children is not only standard processes aimed to maintaining personal hygiene and implementation of physiological functions, but also includes the acquisition of knowledge on hygiene, learning the principles of care for hygiene and proper use of toilets, shaping the habits and behavior of children associated with the use of bathroom in general, but also as a public toilets, the acquisition of knowledge regarding contacts and social relations in such situations and shaping individual, personal attitudes towards the body, its functions, physiological processes, personal hygiene, gender, privacy, modesty and toward private and public bathrooms. These aspects are important, because preschool children have a special interest in the environment and are particularly sensitive to what happens around them. From all possible cognitive sources preschoolers absorb knowledge and information, that shape their personality and attitude. For most of them, the kindergarten is the only institution in addition to home, where they spend most of time and where they experience long-term and intense social contacts. Therefore, all the experiences, incidents, impressions from kindergarten, also from kindergarten bathroom, can have a crucial impact on both their functioning in this place and their further psychosocial development and behavior.

The "open" nature of the kindergarten bathrooms, which may result from the lack of legal regulations in this regard, can arouse particular anxiety. These concerns focus on issues such as the lack of privacy in toilets, dysfunctionality of toilets, insufficient safety and protection of children [4]. Many shortcomings and inconveniences regarding these matters are the result of inadequate organization of kindergarten bathrooms. Improper functional organization of the whole kindergarten and individual rooms can cause intense psychological and physical discomfort of children and at the same time can negatively affect their efficient functioning in this environment and their social relations.

Special importance of the kindergarten bathroom in everyday lives of children is undeniable. Children's skills about hygiene practices (the proper way of hand washing or use of toilet paper after using the toilet), that should be taught at home, appear at that place. Of course, differences between preschoolers in this regard are noticeable and perceptible by both peers and caregivers, which causes a strong emphasis on the need for training related to personal hygienic activities. The need for care and control of children, the necessity to assist and support them in some actions and encouraging them to be independent should be balanced. Another problematic issue is the limited control or lack of control over urination by some children, which also causes "marking" them, at least for a while, until a change of clothes [4]. It happens that some kids avoid using the toilets in kindergarten [4]. The reasons may be different: inadequate sanitation infrastructure, inadequate equipment, the lack of functionality and convenience, the lack of sense of privacy, security, the lack of gender segregation of toilets, but also the lack of self-reliance of children, the modesty of children or other psychological and social factors. In any case, this is a significant problem, because avoidance using the toilet in kindergarten by preschoolers can have negative health effects. Therefore, consideration of the solution possibility of this problem and improvement of conditions for the use of toilets in kindergarten has evident social importance.

According the regulations, the use of separate vestibule in kindergarten toilets is not a necessity. Also, individual toilet bowls do not have to be separated by partitions [11]. This stems from the need to control children by kindergarten teachers. However, taking into account the need for privacy during physiological and hygienic functions, which is revealed by preschool children in varying degrees, we should think about how to organize the preschool bathroom, on the one hand ensuring the necessary privacy for children, on the other providing control and protection by caregivers. The need of staff supervision, visual connection and privacy of children should be balanced. Bathroom should be visually and acoustically connected with playrooms [8]. This allows children to be assisted by caregivers individually rather than all together. It also encourages and supports independent toilet use by preschoolers [8]. In order to increase privacy only small perforations or light transparency of the walls dividing bathroom and playrooms should be provided. Also the use of half-size walls or other partial dividers between toilets is advisable [8]. Supervision and assistance are necessary for small children, but if a child has the ability to self, proper use of toilets and demands of privacy, we should provide it to him. The issue of gender segregation in the bathrooms at kindergartens should be considered in a similar way. If a preschooler, girl or boy, shows the need to use the bathroom among children of the same sex, we should enable him such conditions of use. Planning gender-segregated kindergarten bathrooms can be the right solution. Although cultures differ in needs of privacy, gender-segregated use of the toilet among people who are not relatives is the norm for adults. Children should be allowed the opportunity to practice modesty and shape social behaviors [3].

Another issue worth discussing, is associated with the organization and management of time and tasks in the kindergartens. Many of these institutions practice certain customs and procedures, in order to regulate their activities and ensure the efficient functioning [4]. Adaption of actions, including hygienic and physiological functions, to certain times and the imposition of a time regime could mean training routine, exercising discipline and shaping habits of children, but the stimulation of regular activity can also exert intense pressure, causing stress, irritability of children and other negative effects.

These considerations indicate that not only the criteria for functionality, health, safety and aesthetic criteria are crucial in shaping the bathrooms in kindergartens. Also psychosocial conditions and requirements are essential. They are undeniably associated with the other criteria, and should be carefully considered.

Ergonomic actions are intended to protect children from the inconvenience and discomfort during use in hygienic and sanitary spaces. They can prevent certain improper behaviors, but also allow shaping attitude of children to their gender, body, personal hygiene, privacy, modesty. It is particularly important in terms of psychological, social and cultural conditions.

6 Final Results and Conclusions – Design Proposals

The analysis of regulations and criteria related to availability, spatial-motor requirements, comfort, safety, hygiene and aesthetic of using kindergarten bathrooms by preschool children and additional observations related to the psychological and social requirements allowed to draw conclusions, which were the basis for the formulation of design assumptions and for the creation of design concepts showing arrangements bathrooms in kindergartens. The students of the Faculty of Architecture from Wroclaw University of Science and Technology in Poland have created conceptual designs of kindergarten bathrooms using by children aged 3 to 6 years. The projects were made in the academic course *Ergonomic Design of Hygienic-Sanitary Spaces and Rooms*. Development of graphic projects was preceded by numerous pre-design analysis and studies. Ergonomic criteria were considered, examined and taken into account during development of the design assumptions.

6.1 Design Assumptions

The following design assumptions were specified based on ergonomic criteria for the design of kindergarten bathrooms:

- compliance with the rules and regulations,
- ensuring the health, hygiene and safety of children,
- ensuring the availability, ease and comfort of using sanitary facilities for children,
- taking into account the functionality and aesthetics of the interior,
- ensuring the protection of children and their sense of security,
- providing a sense of privacy and intimacy of each child,
- creating an atmosphere of child-friendliness,
- encouraging children to take care of hygiene from an early age,
- teaching children the proper use of bathrooms and the principles of taking care of hygiene,
- shaping the habits and behavior of children, associated with the use of bathroom in general and use of the bathroom as a public facility.

6.2 Design Ideas and Suggestions - Examples

Two distinctive design concepts are selected from several completed projects, because they present the most optimal and creative solutions of kindergarten bathrooms taking into account the design assumptions.

The first of the chosen projects *The Meadow* (Figs. 1 and 2) is based on the idea of a centrally located large bathroom separating two playrooms, each of which is intended for use by 20 children. Sanitary facilities are accessible from both rooms. The equipment of bathroom includes 6 small-size washbasins and 4 small-size toilet bowls. The dimensions and mounting height of sanitary devices are adapted to the spatial-motor skills and requirements of preschoolers. Privacy of children while taking into account the need to control and care, is ensured by the use of lightweight sliding doors in the toilet cabins

Fig. 1. *The Meadow* - example of shaping the kindergarten bathroom, floor plan and perspective view (Source: student project depicted by K. Kepka, tutor - A. Jaglarz)

with the possibility of opening from the inside and from the outside. The shower with shower tray is placed in a separate room with an extra washbasin. Individual toilet with washbasin is designed for preschool teachers and caregivers.

Fig. 2. *The Meadow* - example of shaping the kindergarten bathroom, wall elevation views and perspective views (Source: student project depicted by K. Kepka, tutor - A. Jaglarz)

The leitmotif of the concept is *the meadow*, to which refers a centrally placed, simplified form of the tree, images of insects on the wall with mirrors over the countertop with washbasins and pictures of dandelion clocks among the grass on the door of toilet cabins. Equipment, materials, patterns and colors used in the project conduce to creating a child-friendly bathroom. The cozy atmosphere of the interior has a positive effect on the psyche of children and relaxes them. Therefore, the use of the kindergarten bathroom is a pleasure, not a necessary evil.

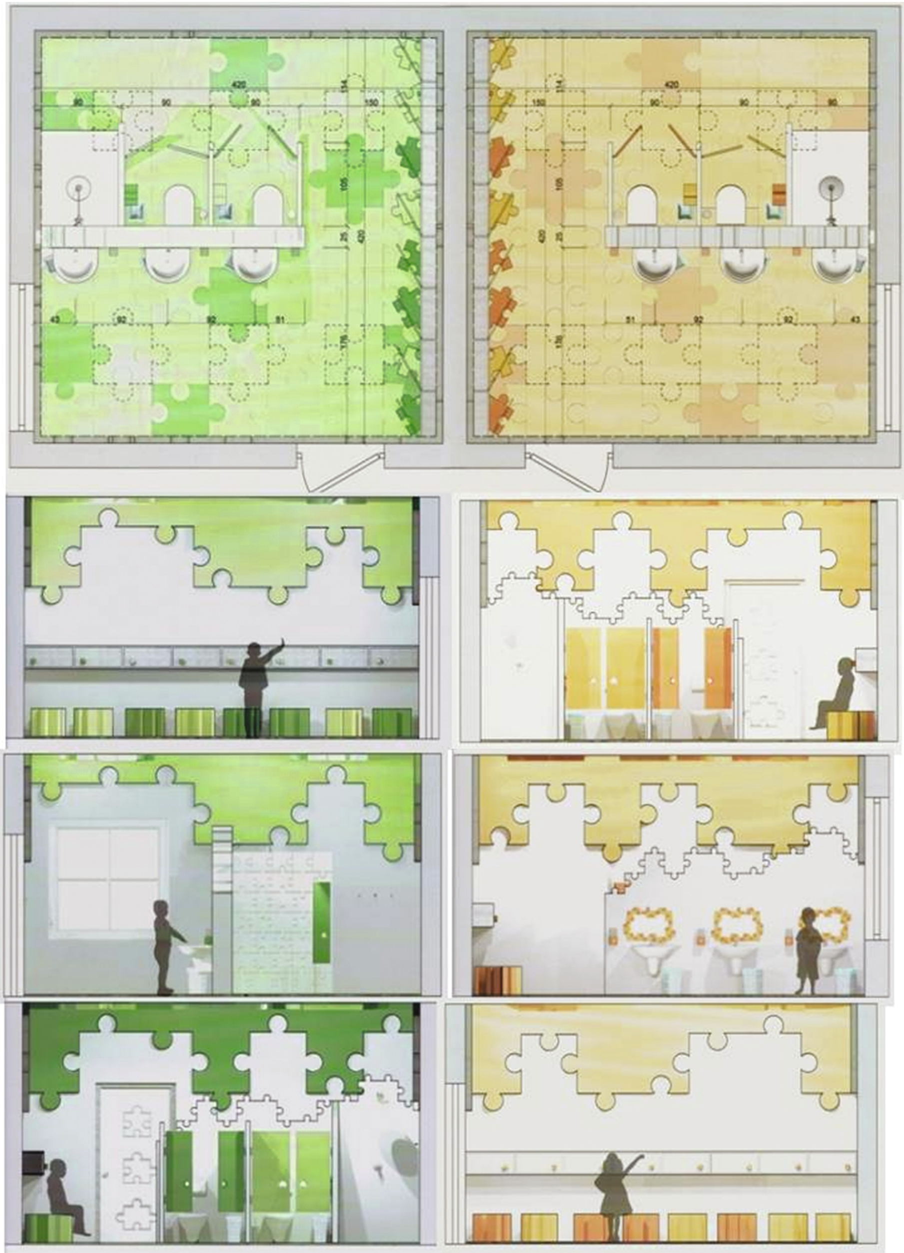

Fig. 3. *The Puzzles* - example of shaping the kindergarten bathroom, floor plan and wall elevation views (Source: student project depicted by A. Kieliszek, tutor - A. Jaglarz)

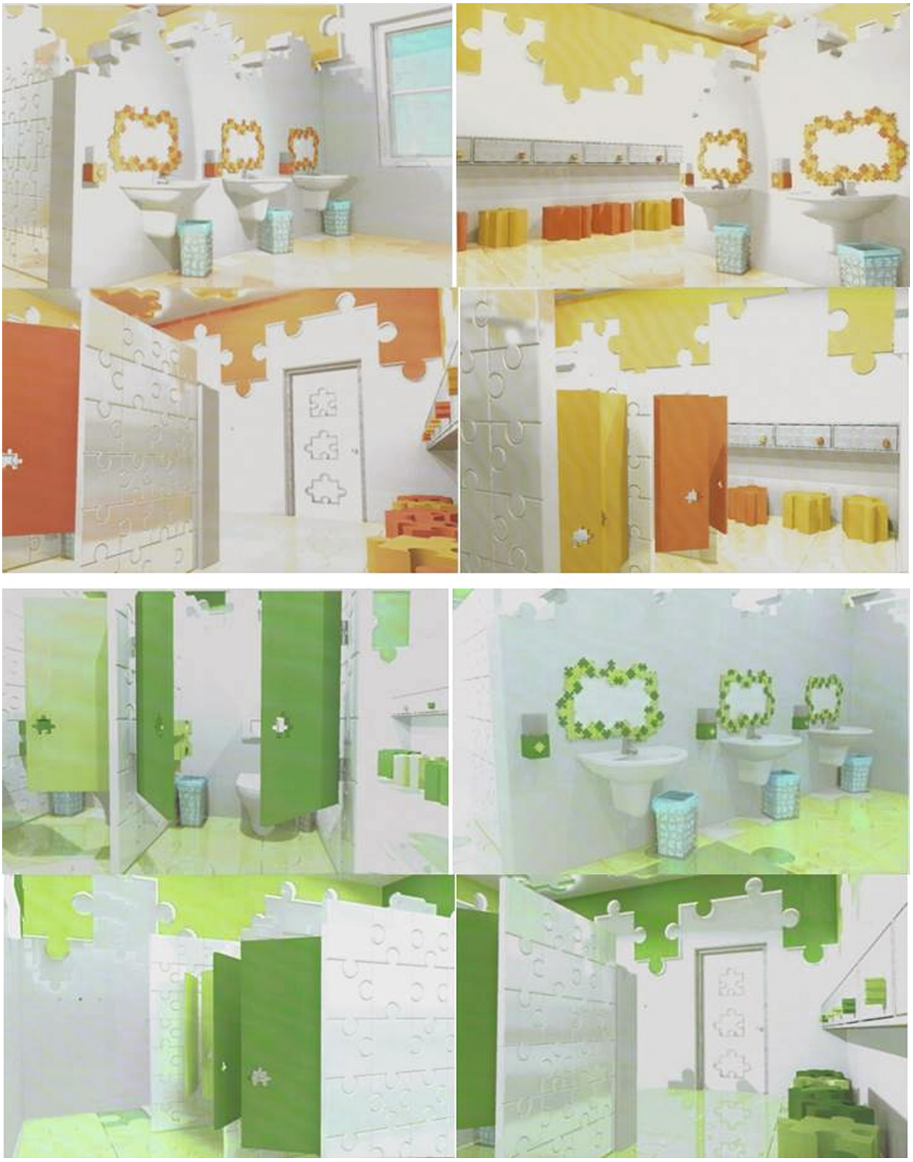

Fig. 4. *The Puzzles* - example of shaping the kindergarten bathroom, perspective views (Source: student project depicted by A. Kieliszek, tutor - A. Jaglarz)

Elements of *Puzzles* are creatively used in another selected project (Figs. 3 and 4) that combines functionality and aesthetics. The concept includes 2 separate (gender-segregated) kindergarten bathrooms, accessible from the playrooms, which are intended for use by 40 children. The bathroom in tones of yellow is for girls, while the green bathroom is for boys. Each of the rooms is equipped with 3 small-size washbasins, 2 small-size toilet bowls and 1 shower. Lockers are provided for storing the necessary hygienic and toilet accessories. Overall dimensions and mounting height of all sanitary facilities and additional pieces of equipment such as mirrors, hangers, etc. are adapted to the spatial-motor abilities and needs of preschool children. The possibility of partial closure of the toilet stalls provides a sense of privacy of children while allowing control by caregivers.

Puzzle elements of different sizes and in various configurations appear on the floor, ceiling and walls. Compiled puzzles are used as mirror frames, light fixtures, covers of waste bins and decorations on the door. This motif also appears in the form of additional accessories. Large spatial elements of the puzzles can be used as seats or helpful children's stools. Such attractive and interesting interior, which was created thanks to the ingenuity of the designer, may encourage children to use the bathroom in the kindergarten and at the same time affect the development of children's interest in taking care of hygiene from an early age.

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Ergonomics in Public Building and Urban Design

Smart Street Furniture: Innovation in the Concept Design Process

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Abstract. The prospective of replace the traditional street furniture with smart ones, in which digital technologies are integrated, is fascinating many cities all over the world. Many cities are today in a dichotomous situation: on the one hand, some "smart" street furniture are installed with less success than expected, on the other hand, in many public spaces the "traditional" street furniture are still not sufficient or not integrated, with problems of effective usability, or they are in worrying degraded conditions. The research group of Department of Architecture and Design (Politecnico di Torino) participates to a demonstrative project called "Smart square meter, looking the city meter by meter" where a partnership of companies intends to test smart street furniture in the city of Turin and Milan. The paper describes the role assumed by the research group in the demonstrative project and the contributions in terms of service design, integration in the built environment, analysis of citizens and public administration's needs.

Keywords: Street furniture · Smart city · Accessibility

1 Introduction

Sm²art is a research project supported by the Italian Ministry of Research Education and University aimed at the design of innovative street furniture, in which digital technologies are integrated. The research project partnership sees the collaboration between research partners and private enterprises in both the fields of street furniture design and production, and smart technologies. Two Italian cities gave their endorsement to the research project: Torino, supported by Politecnico di Torino, and Milano, supported by Politecnico di Milano. All the partners are coordinated by Telecom Italia, the Italian main telecommunication company.

The research project is built on two pillars:

– The creation of a series of smart and sensitive objects and street furniture, scattered on the city;
– The development of a platform to manage them and provide services, information, inbound and outbound data from/to the citizens and from/to the public administration.

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The *Sm^{2}art* solutions are meant to renew the public space, also aggregating existing functions, and generating an "offer" of wellbeing, which, in turn, stimulates a further "demand" for increasing the efficiency of urban services.

Sm^{2}art integrates the design of an innovative furniture and the design of an ICT platform, aiming at:

– Optimizing existing networks (public transport, bike sharing, water supply, etc.), currently not integrated with each other, by gathering them into a multi-purpose hub where street furniture can be installed.
– Deliver innovative services, widely accessible and available to all citizens, with a widespread distribution, focused in disadvantaged, under-served areas, where social inclusion and urban security issues are crucial;
– Evolve through an open approach to offer simple on-demand services.
– Provide the city with "tangible" and "intangible" tools, to better meet current and future citizens needs.
– Reduction of the "digital divide" with increased accessibility of computer services, offered in Public Administrations.

The project service network concept comes from the traditional telephone box: a small urban furniture, scattered all over the cities in a sort of network, useful to the citizens to communicate. *Sm^{2}art* urban services therefore, have been developed on a square meter, the original telephone box dimension, replaced nowadays, by large smartphone diffusion. The concept at the base of the research project was investigating citizens' actual needs that could lead to a new "telephone box network" service: a small urban smart furniture scalable system, increasing citizens' urban well-being, through the implementation of public services efficiency, accessibility and functionality.

One of the main reason the project was founded, was its open structure: nevertheless, many possible kind of urban furniture and smart technologies where presented in the candidature dossier, the services design supplied by *Sm^{2}art* was leaved as an "open issue". The research partners have the task to define the service design through a participative process involving the public administration (the municipalities of Turin and Milan), as the other partners of the project.

2 Meta-design

If the mentioned "open issue" can be considered the strength of the demonstration project – considering the number of failure installation of supposed smart objects in our cities - the role of the research group in the service design is crucial and really delicate, because of the numerous stakeholders which must be involved (from the citizens to the project partners themselves) and because it makes the fundamentals for the executive design and test phases.

All the activities developed by the research group in order to support the ongoing demonstrative project go over the name of "meta-design", considered as the systematic work which comes before ("meta") the "design" in order to give to the design team all the instructions needed to satisfy all users' needs in terms of safety, usability, and management.

Considering the *Sm²art* demonstrative project, the research group decided to face the challenging task with the development in parallel of three activities:

- a methodology for managing the debate with the local administrations about the definition of services, in order to guide the "open issue" to some more specific topic;
- a modular scheme of elements called "*Sm²art* Abacus", in order to make the partners able to prefigure in their design sessions some possibilities of compositions and integrations between urban furniture and digital technologies;
- the analysis of the urban environment and of the existing urban furniture stock in a test area of Turin, in order to make more evident the problems and the opportunities for the integration of the new *Sm²art* objects;
- a methodology for the development of the services design, in order to complete the meta-design phase.

The expected result of the meta-design phase is a specific composition of the "*Sm²art* Abacus" with the definition of all the requirements asked all its elements, meeting the user's needs, which come out from the service design.

3 Defining the Services Scenarios

The first activity developed by the research group to support the demonstrative project, was the debate management with the local stakeholders, around the service scenarios. A list of 18 possible scenarios were designed and organized in a matrix in which 3 possible basic actions (to communicate, to take objects, to play activities in public space) were crossed with 6 topics (wellness, security, free time, mobility, tourism, infrastructures), generating 18 possible services supplied to the users by the *Sm²art*. The scenarios were then presented in a public event, in which the municipal administration of the city of Turin, experts representing all the public and private enterprises managing the local municipal services (public transports, water distribution, wastes management, public lighting and district heating) and citizens were involved in a debate, asking them to vote the services considered prior for increasing the community welfare.

During the Smart City Week promoted by the Municipality of Turin, all the scenarios were presented in public with a short description and a sketch. The scenarios were also published on the facebook profile[1] of *Sm²art* project, in order to involve the communities in the open debate about the services, as better as possible.

The 18 scenarios matrix, presentation and vote permitted the research group to establish a very first involvement of the stakeholders and to stimulate, the innovation of their service delivery and management with the integration of smart technologies. The engagement in the debate of all the stakeholders, about the service scenarios, permitted to identify some priorities and basic concept used in the next phases to develop the service design.

[1] https://it-it.facebook.com/sm2artpeople/.

4 The Flexible "Abacus"

In parallel to the services debate, the research group supported a design activity organizing two workshop sessions between the partners. The workshops aimed at finding a match between services, the different typologies of urban furniture and digital and technological equipment.

A simplified exercise was proposed to the *Sm²art* partners in order to guide the discussion and definition of a shared framework to be used as a base for the executive design of *Sm²art* urban furniture.

Starting from some of the most voted service in the Smart City Week public event, the research group stimulated the partners discussing how to deliver the service to users, choosing the more appropriate "structures" (spatial objects: cabin, totem, ground, pole) and listing the necessary technological equipment (screens, sensors, cams, printers, nfc, cloud lte, wifi, bluetooth, pos,…). Different composition of service/structures/equipment have been developed in order to test the more suitable solutions. As a result of the workshops, an Abacus of elements based on the urban lighting pole structure, was designed. Beyond the service design, which is still non-already completed, the "toolkit" based on a pole, as main structure, and a list of possible equipment called "rings", designed for specific single functions (ex. covering is the cover which protect from sun and rain, monitoring which includes all the sensors for the air quality and acoustic noise…). The pole was chosen as a base structure to have, not only the opportunity to install a new *Sm²art* infrastructure, but also to consider the possibility to use the existent poles for public lighting as nodes of a *Sm²art* network, installing a different kit of technological equipment, for different services. The flexible Abacus of pole+equipment is an "open" design which should be adapt to the different declination the service design can assume in the ongoing research activity (Fig. 1).

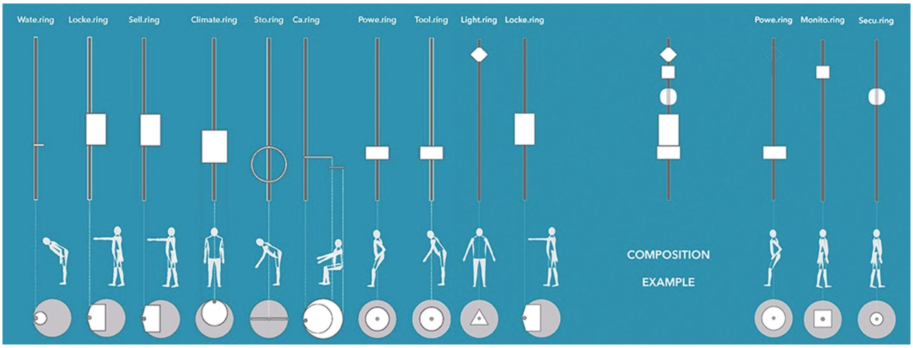

Fig. 1. *Sm²art* flexible "Abacus"

5 Territorial Analysis

The main scope of the present analysis proposed in *Sm²art* is to share a spatial description method, in order to modify urban space features above citizens needs, giving designers and planners a lecture of space made by layer, that will help them in the reading of urban phenomena and make decision about possible changes or implementations of urban services.

As for experimental purpose, the analysis has been focused on Risorgimento square, a public area in Campidoglio district, Turin.

As stated in the previous chapter, one of the project main concepts was to associate new tools and services to poles connected to the urban power network. According with this vision, analysis first step was to define poles and urban furniture coordinates, in order to build a proximity map, based on Voronoi diagram and define a cellular division of the square area, where, a cell is associated to each relieved pole.

To better define critical issues and service needs related to each cell area of the square, six specific analysis layers' maps have been realized and then overlapped to the proximity map. Each layer, displayed on a 3d model, outlines specific features about public space usage, concerning two main aspects:

- Urban space configuration, further developed in Elements, Functions and Irradiance layers' analysis.
- Users behavior, developed as Mobility, Paths and Seats, Motion tracking layers' analysis.

5.1 Elements Layer

The map is defined reporting square space actual configuration and urban furniture disposition coordinated, into a digital model. Each point in the 3d model space correspond to a 2d item schedule, giving a complete urban furniture description. Overlapping the proximity map to elements layer, quantitative data about each cell are shown, allowing direct observations about services provision uniformity within the whole square area. Figure 2 shows as many of the experimental area cells are in lack of furniture. Moreover, if obtained data are compared with data from other user behavior and

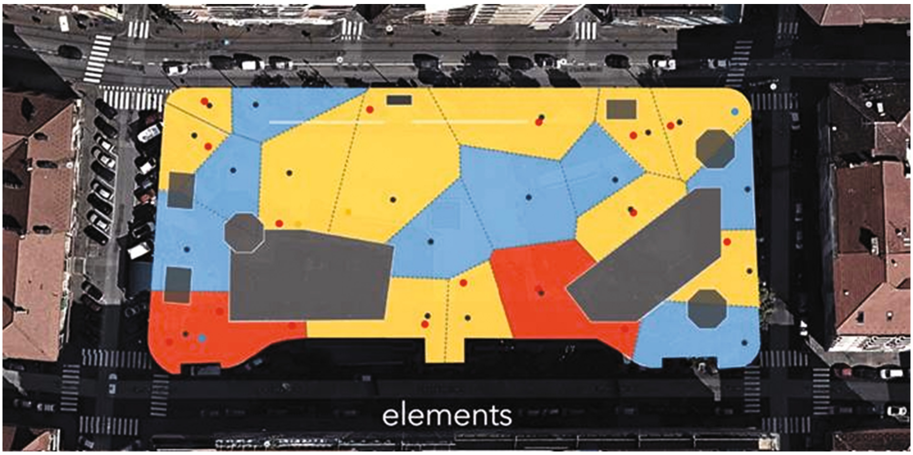

Fig. 2. Existing elements map and Proximity map overlap

space configuration maps, more complex issue can be revealed, e.g. the presence of architectural barrel preventing furniture use or making it difficult.

5.2 Function Layer

As squares and parks are generally preferential outdoor urban meeting-place, they often host many different function. The first step of a function analysis is to determinate every function footprint; in this case, fenced areas, a local bar and two highly crowded news-stands, useful to define most common user profiles in the square, have been considered. Once the overlap of the proximity map allows to establish on which cells, such functions insist, and determine the closest poles, to be a reference to test smart functions suitable to the identified neighboring functions. Function analysis turns of great importance to identify areas, in need to be re-arranged, and that could also extend beyond the square boundaries when required.

Furthermore, user behavior investigation, related to the number of people and frequency they make use of each specific function within the square, can greatly help to ensure the services provided to be adequate.

5.3 Solar Radiation Layer

Solar radiation plays a role of large impact in the fruition of public space, so that function and services distribution optimization, according with this issue is a key strategy in smart project design. During *Sm²art* project a flexible solar radiation analysis method have been studied. An algorithm including several steps have been assessed: define surfaces and context to be analyze, run the simulation, and export a grid with results. This kind of approach is able to let input data to be modified easily, when required, giving planners an accurate analysis tool for the entire design process; moreover such analysis is able to give interesting suggestions not only about services most suitable distribution, but also allows remarks about materials to be employed. In Campidoglio main square, child and playgrounds areas, take place at southeast, a protected area from sun rays during the whole year: a useful feature in summer but maybe a problem in winter. Solar analysis show the area twenty meters away from its actual position, as a more interesting one for kids to play; thanks to autumn leaf fall, it presents comfortable values of radiation during the whole year.

5.4 Outer Mobility Layer

This is the first "users group" analysis layer and prevents to describe how citizens can reach the Campidoglio square. It starts from pedestrian mobility, defining the gates of the surface -normally matched with street cross stripes- in other words every starting point for a trip across the square or on its perimeter. These areas are the most crossed part of the city, the key points for administration to monitoring urban phenomena and guaranty the safety of streets. The bus stop on northern side and the bike sharing exchange station represents other important square gates where a *Sm²art* city tool, like an info-ring, could be installed. In conclusion, outer mobility layer results as a useful tool for designer and partners, such as administrations and public services, to define a network of connected hotspots in the city, where additional smart services could be installed to increase safety, information and citizens' wellness.

5.5 Paths and Seats Layer

The mobility topic within an urban area is crucial to understand its accessibility degree. Paths and seats analysis describes users' displacements and pauses within the square; the layer also merge together information about floor patterns, seats, walls, and barriers presence. Every people main paths accessibility degree inside the area, has been assessed and outlined in the map design, varying path lines thickness. Seats disposition and shape also has been reported in the map. Overlap of the proximity map allows to outline each cell prevailing function, marking it as a passing through cell or a resting cell (Fig. 3). The resulting map gives an early suggestion in order to associate to each pole useful services to moving or sitting activities (Fig. 4).

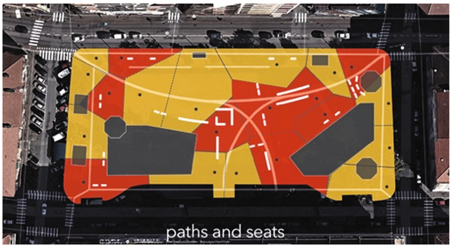

Fig. 3. Path and Seats-proximity map overlap; Motion tracking-proximity map overlap

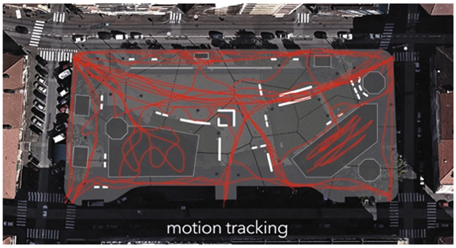

Fig. 4. Path and Seats-proximity map overlap; Motion tracking-proximity map overlap

5.6 Motion Tracking Layer

The last layer of the analysis process is an experimental tool proposed by *Sm^{2}art* to identify and tracking people and vehicles movements during their journey into the public space network, further supporting information collected during previous analysis but giving back data about occupation and use profile during daytime.

Basically, there are two different method to monitor passages, the traditional one needs a large amount of sensor, the experimental one require only a wide view camera, a tripod and a software of video editing. The first step is to catch 1 photo of the entire square, as vertical as possible, every second for a determined time. Once many (maybe 1000 or more) images are taken, they had to be merged in a single video, exporting a time-lapse of urban mobility. The tracking function will underline movements, giving designer a different image for each analysis period they choose. The relevance of this type of analysis is that it gives a precise idea of how people usually use the space during a specific hour or day, probably one of the most important information for the development of a smart project.

The formal results of the analytic *Sm²art* process is an urban multilayer evaluation map which will give back important data during and after the entire design process. Thanks to its adaptive capacities the same method can be easily replied, monitoring the city thus evolve by itself.

Once data from analytic layers have been collected, a territorial land map, listing its own characteristics in a cell mode, can be provided. Studying every single cell, using the analysis described above, a schedule of specific features can be built: suitable user profiles, usage hours and frequency, related specific climate conditions, which serves as guidelines for urban public space design, functions re-distribution, as for the most appropriated and needed services installation.

6 Service Design Development

Starting from the hypothetical scenarios assumed during the Smart City Week Public Event with partners, two services were chosen to be proposed and further developed into a specific urban context area. Furthermore, one of them has been further detailed as to be prototyped and experimentally installed in a considered interesting area for the specific users. Prototype will be monitored for a given time lapse, in order to gather useful feedback from urban context and users, to be re-entered into the design process as to further improve the design proposal, in a "trial and error" approach.

6.1 Detailed Services Design

Proposal to be implemented were chosen, on one hand, as a result of reflections based on an on-line inquiry, engaging citizens to give opinion on the issue, in an effort to listen at local voices. On the other hand, observation of particular social phenomena and current transformations of working urban society led us to consciously engage in confronting a topic/scenario, we considered as an opportunity, sensible to citizen social context [1,2].

The two proposed services to be implemented were:

- A neighborhood social network; an informing and interactive totem in a significant neighborhood point gives people the opportunity to leave announces and be informed about neighborhood activities. It also represents, a landmark, a meeting point, where joining the community activities proposed through the network.

- An outdoor working station: gives the user the opportunity to work, connecting to the network and download digital documents, to connect and recharge his own devices, to visualize multimedia contents, for a limited time lapse.

The outdoor working station was chosen to be further developed and experimented in a city area, determined by agreement with the Municipality.

Due to increased pace of life and work activities, an increasing number of people are forced to move during the day, within or outside the city; great number of these people make use of its notebook or personal electronic devices for working, studying or leisure activities, and need to make use of these devices outdoors, especially while waiting to displace for work or during pauses between different daily activities. In this regard, a suitable outdoors working environment, within the urban fabric, to be used for a brief time lapse, using your own portable devices, reload and connect them to the network, eventually enjoying the surrounding environment, appears quite an interesting opportunity.

Once the principal service to offer, and the related scenario, was identified, possible users' profiles were defined through a storytelling text and a storyboard concerning each of them activities was built, as to differentiate the offered services.

Moreover, for each user profile, a map of interesting sites for service installation, inside the considered urban area, has been defined, taking into account the related storyboards and further analysis related to user profiles needs, described in the next paragraph.

In order to assess an overview of user's interaction with the provided service, and to define a complete user experience path, a *Customer journey map* also was designed. Through a graphic visualization it is shown how, during the different phases of user's experience, the relationship between needed devices, service managers and other stakeholders involved in the design process, is assured to make the service properly work. The touchpoints defining the user main path can have great impact in the whole service building process and have been carefully outlined starting from the storyboard.

Afterwards an *Offer map* was built in order to define the macro-categories of standard and essential services provided by the outdoor working station and pointing out an overview of relationship between user needs and requirements the service must accomplish with, through the associated devices.

The four macro-categories directly related to the main service declined as *Seat, Connect, Power* and *Visualization* are defined as users needs; each user need is than declined in different related sub-functions the working station would offer.

As a further step an *Upgrade Offer map*, including a further secondary level of additional services macro-categories, was designed in order to satisfy specific needs, mostly concerning with specific users' profiles and related to location where the working station service will be installed (Fig. 5).

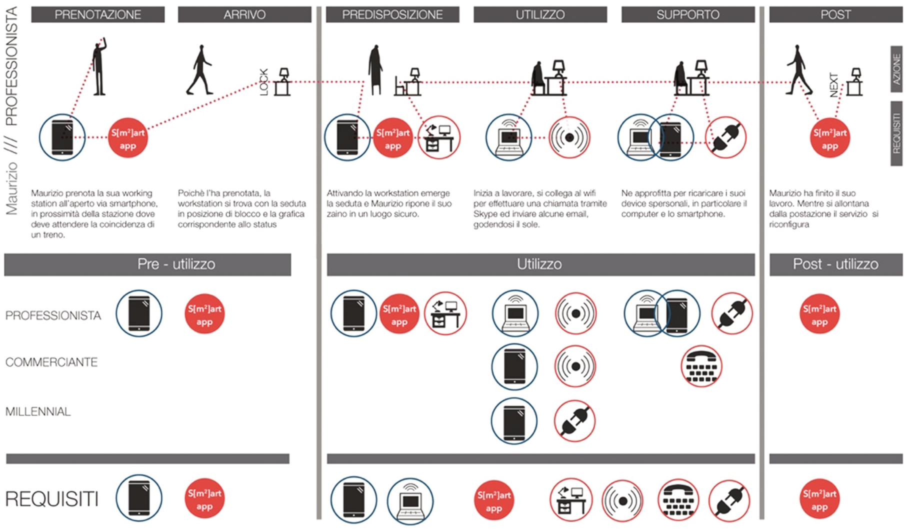

Fig. 5. Professional user Customer Journey map

This way each proposed workstation type has its own *Upgrade offer map* associated, showing the specific offered services and functions (Fig. 6).

The three structure of the map will help to identify the project requirements that the attached devices, composing the whole workstation system, should satisfy. So, each Working Station will be provided with the standard services macro-categories, with certain sub-function adjustment, while the additional macro-categories will be included depending on the related user profile and the installation site.

For example, the upgrade offer map associated to the "millennial" user will show the *Monitoring*, *Store* and *Cover*, as additional services macro-categories needed, while Light and Green Energy will not be provided because of the day-hours use of the service and the reduced time range use. Each macro-category with its linked sub-functions is associated then, to a specific *ring* contained in the previously designed abacus, identifying services able to satisfy the related macro-category/needs.

Cover macro-category e.g., with its linked requirements, sun & rain protection and anti-glaze, will be directly associated to the *Covering* in the abacus, where service needs, requirements and performances are described.

The *Upgrade offer map* result this way as a useful tool for designer partner, suggesting which kind of devices to be associated to the needs and function shown for each working station typology.

All described information is collected in design guidelines to be used by partner Metalco, to develop the prototype.

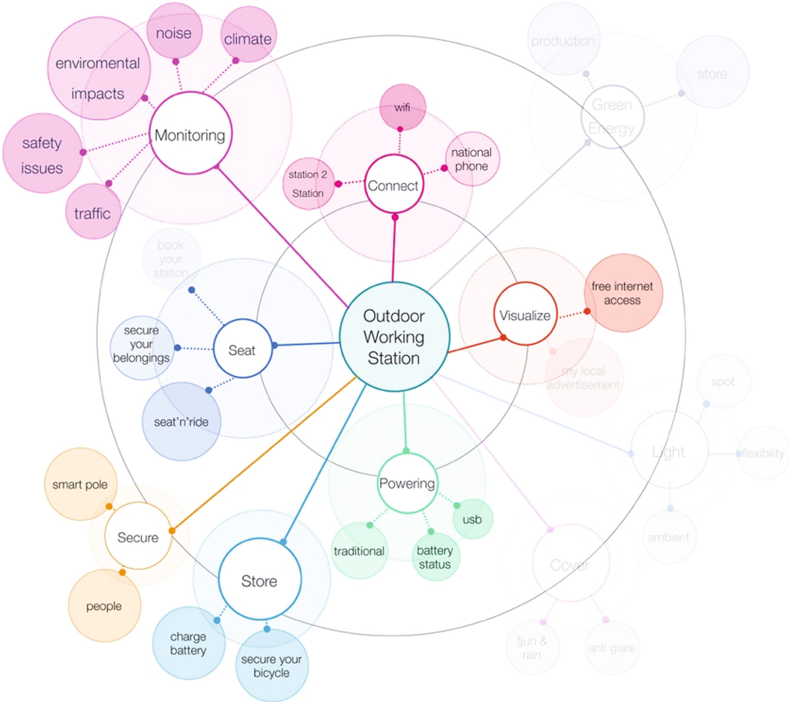

Fig. 6. Working station service Millennial user Upgrade Offer map

6.2 Specific Users' Profiles Need

As the project is developed within the field of social inclusion including all social categories and considering people needs from a physical, psychological and social point of view. Tools and services offered therefore, will be designed according to actual expected user's needs.

Particularly for the outdoor working station service analysis, three user profiles were assessed and a specific scenario was outlined for each of them:

- The professional: he is interested in using the working station while waiting for one of his many daily business metro or train travels; he books the working station and uses the space for an hour work, read and send job e-mail, recharge his own devices;
- The merchant: during breaks from his work, he makes use of the connection offered by the outdoor working station and the screen for video calls his family;
- The student: She just moved in Turin to study and the working station allows her to meet new friends from the same neighborhood. She uses the working station service to connect to the net and download needed studying documents and papers and read it enjoying the sunny day; her smartphone is always out of power, so she can also take the opportunity to charge it.

7 Further Steps: Prototype Design - Monitoring Activity

Users interaction with prototype will be monitored once installed, in order to verify its effectiveness and how to eventually improve the provided service.

As for this purpose, it would be necessary to develop measurable and effective Key Performance Indicators, together with the partners and stakeholders involved in the process, that would allow to measure provided service performance.

During installation period, of great importance would be to verify if provided service, effectively meets user's specific needs, in every step of their experience, described in the relates Customer Journey map.

User profiles will be further detailed, paying particular attention to usability and accessibility for everyone and referring to two different types of approach: the knowledge-based and the behavioral-based ones. The first includes the use of questionnaires, interviews and focus groups to involve the users themselves.

The second approach instead, is based on user categories behavior analysis within the study area through spatial analysis methodology Space Syntax[2]. These techniques aim to observe the movement flows and usage patterns in complex buildings or urban contexts, in order to bring out data that will lead to an objective reading of how a space is experienced by users [3]. Static snapshots and traces [4] are considered the most appropriated techniques for the project purpose.

Through these techniques, user profiles, previously outlined, will be improved; moreover, according with users' needs and characteristics of the area, they will lead to detect the most suitable places for the service to be installed, as well as to add more information to the territorial analysis useful to rethink the urban space, as by reallocating existing services or adding new ones. Moreover, in order to assess the possibility to accomplish with different users' profiles needs with a single working station type to be installed in area of users' common interest will be assessed: users' profiles usage frequency and length will be monitored and confronted. Also, others potential user profiles interest in the proposed service could be monitored.

8 Conclusions

The research group contributed to the demonstrative project development through the adoption of methods and tools aimed at making more effective both the service and the furniture design. It played a strategic mediation key role between private partners and public administrations, with the mission of shaping the "supply" to the real "demand" and real needs of the community. The smart furniture installation in our cities, by private subject's initiative, demonstrated, in many cases, less success than expected, as they couldn't meet citizens' real needs. The research group activity in the "meta-design"

[2] Space Syntax is a set of techniques for the analysis of spatial patterns and behavior of human activities, used in buildings or urban areas. Its main objective is to understand how people move through space, how they adapt to it and at the same time modify it.

phase made evident some crucial questions which the ongoing demonstrative projects must deals with:

– the installation of new urban furniture must be associate with a rationalization of the existing ones, improving their integration in urban spaces;
– the service design [5, 6] must be developed in a participative work with public administration and citizens, otherwise it will not be accepted by the local community;
– smart technologies can't be considered the aim themselves, they are innovative tools to supply the new services required by the contemporary society.

The lesson learnt since the very first steps of the activity have been that the innovation of products (smart street furniture) is not enough as a driver for the improvement of urban space quality. It should be always accompanied by the same level of innovation in process, without forgetting the importance of the meta-design development.

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The Requirements of Human Factors and Ergonomics for the Safe and Comfortable Stairs Versus the Escalators

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Abstract. The contemporary public spaces such as train stations, airports, subway stations or great shopping centres requires vertical displacements of the great human masses. The common means used for this kind of transportation are the new inventions such as elevators, moving ramps and primarily escalator systems. The analysis on these systems in terms of compliance with requirements of the human factors, ergonomics and safety indicate a need for their further improvements. Dimensions of standard escalator steps differs much than the steps of normal comfortable stairs and in result the escalators in the stop state cannot be used as the evacuation stairs. The mismatch of escalator's geometry and the human motoric capabilities can result in an increased risk of an accident during the specific behaviours of users, inter alia in a state of panic. The basis of presented research are author's practical and theoretical experience in the designing of stadiums and arenas.

Keywords: Human factors · Ergonomics · Escalators geometry · Comfortable stairs · Evacuation stairs

1 Introduction

The functional arrangement of the public space requires both horizontal as and vertical displacements of human masses. The new inventions, such as escalators, horizontal and sloped moving walks and elevators complement in our times, used for this purpose since the dawn of history, stairs and ramps. Escalators have become a popular means of public transportation. They are used both in the form of equipment installed in the interiors as well as in the open spaces outside. Most often, they apply in areas with the flows of a large number of people, characteristic for the nodal zones of public spaces such as railway stations, airports, metro stations or major shopping centres. Analyses of these systems in terms of the requirements of ergonomics, as well as the safety of users, indicate the need for their further improvement. The article presents the results of research, considerations and conclusions, based on the experience of the author's many years of didactic activity and architectural practice on the field of stadiums and arenas designing.

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Fig. 1. Escalators in MBK Centre (Mahboonkrong), Bangkok, Thailand (Photo: Christian Henrich (own work) [CC BY-SA 2.5 (http://creativecommons.org/licenses/by-sa/2.5)], Wikimedia Commons, https://commons.wikimedia.org/wiki/File%3AMBK_Bangkok_2.jpg, admittance 2017-02-11)

2 Research Problem

The dimensions of movable steps of escalator are drastically different from those required by the normal stairs geometry. This causes that the escalator steps in the stop state cannot fulfill functions of the normal stairs. It also means that they cannot properly act as the evacuation stairs. This maladjustment to human motoric capabilities may lead to an increased risk of an accident during a failure of the drive system of escalators, as well as the unusual behavior of users, particularly in the state of panic [1, 2]. The aims of undertaken research are analyzes of the differences occurring in the applicable standards between normal stairs and escalators and resulting from these differences consequences for users, as well as the definition of such a geometry of the escalator steps, which meets the standards of normal comfortable stairs. Described assumptions of research tasks complement the comparative analysis of widely used escalators solutions and models with postulated by the author, corrected geometry of the escalator steps.

3 Theoretical Fundamentals of the Normal Stairs Design

Stairs accompanied humankind since time immemorial, but pioneering research on the geometry of the comfortable stairs occurred only in the mid-seventeenth century. We owe it to François Blondel, director of the Royal Academy of Architecture in Paris, who defined in the year 1672, applied until now, method of determining the proper relationship between the height and depth of the stair steps, depending on human step length. When designing the stairs, the main problem is to determine the depth and height of the step, and thus the inclination of the flight of stairs. Commonly used for this purpose, is the above mentioned Blondel's method known as so called "algorithm of comfortable stairs": $2R + G = LHS$, which is the algebraic equations, wherein R is the height of a step, G is the depth, LHS is averaged length of men and women step. Stairs representing such geometry of steps are adjusted to the anatomy and motoric abilities of man, and walking down and up the stairs is accompanied by the most economical use of energy with sense of psychological and physical comfort. Basis of this equation are shown graphically in Fig. 2. Man has the natural ability for movement in the space by three types of gait: walking on the horizontal plane, using the so-called. "horizon-talstep", vertically, climbing the ladder by using the so-called "vertical step" and walking down and up the slope terrain, ramps or stairs, thanks

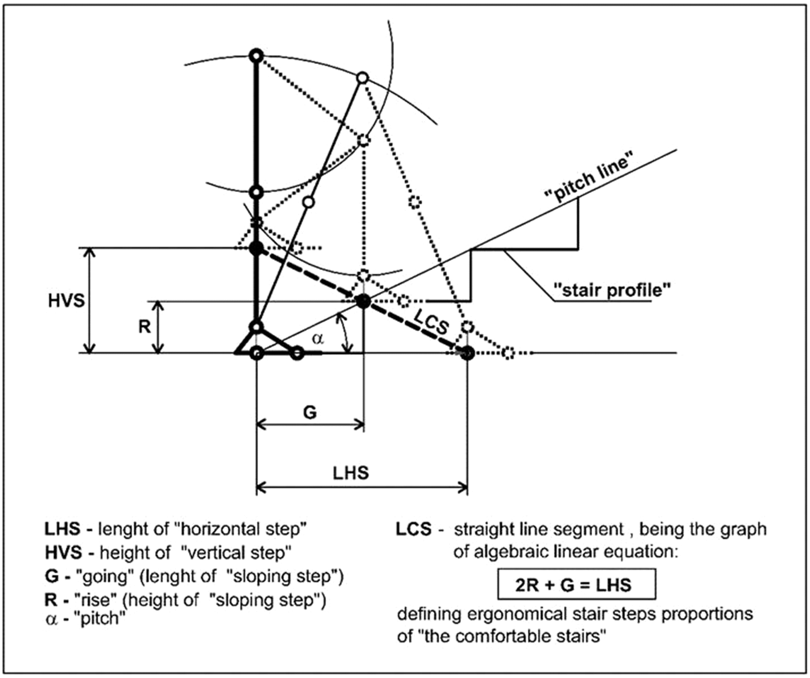

Fig. 2. The theoretical basics of the stairs designing (Source: author)

to the so-called "sloping step." In the first case body movement occurs in a horizontal direction, vertical in the second and the third one simultaneously in the horizontal and vertical directions [3].

The anthropometric and ergonomic studies indicate that the normal average horizontal step of male and female is equal to 630 mm and reached in the same way value of the vertical step, being the half of it, measures 315 mm (Fig. 3). The relationship between the height (*rise*) and depth (*going*) of the step of comfortable stairs establishes a mathematical linear function which graph on the plane in the Cartesian Coordinate System is a straight line (*LCS*) given by the equation: $y = ax + b$, where *"y"* is step height (R), *"x"* refers to the step depth (G). Intercept *"b"*, setting the intersection point at the axis *"y"* (when $x = 0$) has a value equal to the height of the vertical step, i.e. $R = 315$ mm. Angular coefficient *"a",* setting the slope and the intercept *"x"* should have such a value that when $y = 0$, x has a value equal to the length of the horizontal step, i.e. $S = 630$ mm. This is achieved when: $a = -0.5$. After applying the notations used in the stairs design, the equation takes the form: $R = -0{,}5G + 315$, which after transformation obtains commonly known image of this equation: $2R + G = 630$. Each "pitch line" of normal stairs led out from the zero point of the coordinate system when intersecting the line of comfortable stairs designate a point which coordinates *"x"* and *"y"* determine the appropriate values of the height and depth of the step of comfortable stairs. Each "pitch line" of normal stairs led out from the "zero point" of the coordinate system when intersecting the line of comfortable stairs designate a point which coordinates *"x"* and *"y"* determine the appropriate values of the height and depth of the step of comfortable stairs [4].

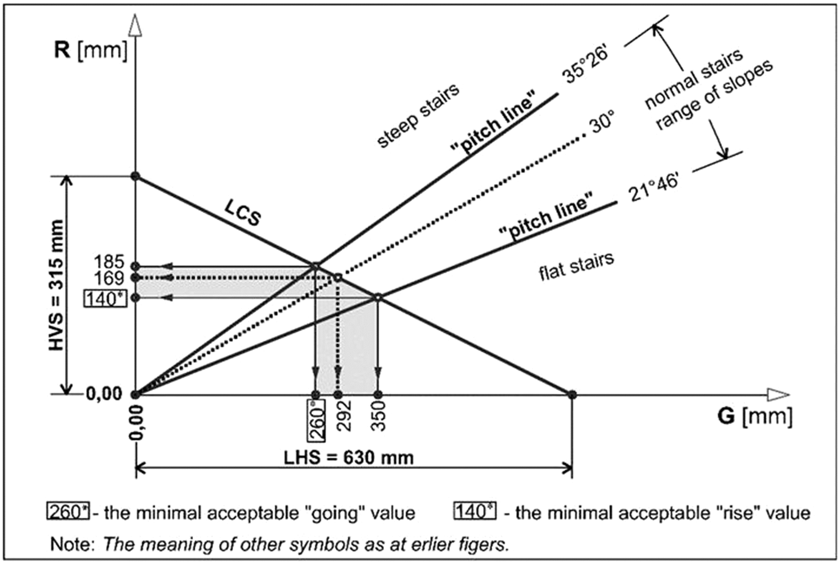

Fig. 3. The graphic method of designing the ergonomic stair steps) (Source: author)

4 Analysis of the Body Movement Sequences While Walking the Stairs

The ability to walking down or up the stairs results from biomechanical characteristics of the human locomotive apparatus. From the point of view of the biomechanics the human gait is a spatial, cyclical movement act, rely on performing the steps. A single step is the sequence of movements, which consists in changing the position of the center of gravity of the trunk over the supporting leg, while simultaneously moving in space, separated from the substrate rear foot ahead of the supporting leg and instantaneous recovery of balance at the time of putting it on the substrate. Moved to the front rear leg becomes the supporting leg and the whole cycle repeats itself until the next time to recover the balance, or temporary support body weight on both legs simultaneously. This definition corresponds also with walking by the stairs (Fig. 4). The most essential for the undertaken research problem is fact, that while descending the stairs, each step consists of a long sequence of movements during which the body is supported by one leg. Even a small horizontal external force can cause loss of body balance and fall as the consequence in this moment. While descending the stairs the displacement of free of load rear foot to its front position amounts two goings forward (horizontally) and two rises down (vertically). When walking the stairs muscles of legs work much more than in gait on the horizontal surface. Particularly large load is taken over by muscles of the single leg carrying weight of the entire body. In summary should be stated that walking

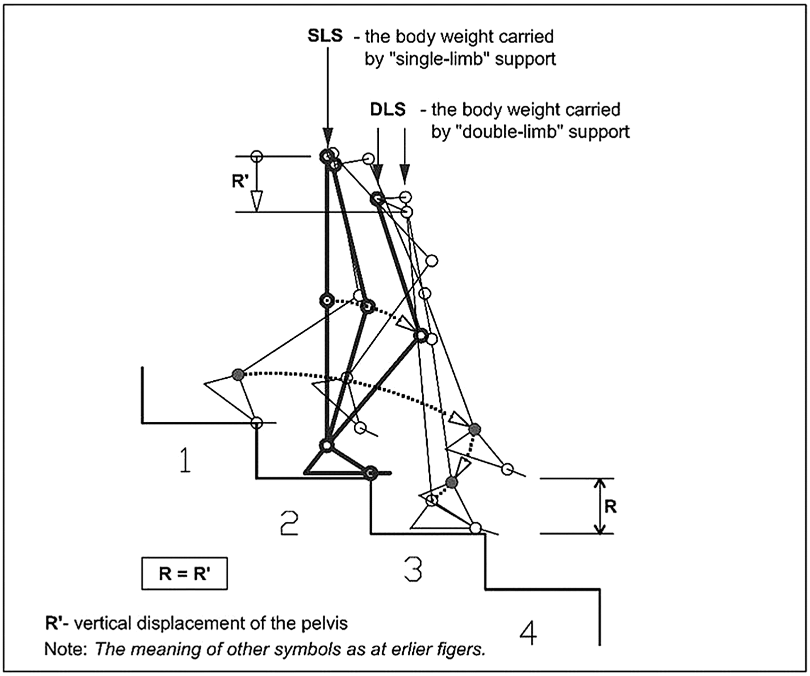

Fig. 4. The sequences of body movements while descending the stairs (Source: author)

up and down the stairs as compared to walking on a horizontal surface, is much more physically complicated task, much more involving the musculoskeletal system and carrying a serious risk of falling and injury. The main threats while descending the stairs arise from the fact that when in last phase of the step, free of load foot, hangs over a tread of the below stair step there is no longer possible support. These issues play an important role in particular while the large masses of people move at the stairs because the specific displacements conditions in the dense crowd completely eliminates the sense of sight in controlling the shape of treads.

5 Geometrical Discrepancy Between the Escalators and Comfortable Normal Stairs

Dimensions of the steps and the inclination of escalators defines the European Standard EN 115-1 “Safety of escalators and moving walks - Part 1: Construction and installation” [5]. According to the findings of this document, step height of the escalator cannot be larger than 24 cm, and its depth must be equal to or greater than 38 cm (Fig. 5). The nominal speed of the escalators must not exceed 0.75 m/s for the slope of the flight equal to 30° and 0.5 m/s for slopes greater than 30° - but not to exceed the maximum allowable slope of flight equal to 35°. In practice, the most common type of escalator used by leaders in the field of implementation, are escalators with a slope of 30° and steps of the height 20 cm and the depth of 40 cm. The main problem that hinders the application of the comfortable normal stairs standards for the escalators lies in the functional duality of mobile steps (Fig. 6). At the beginning and the end of the flight of steps have to act as a horizontal moving walkway, which then becomes inclined stairs in the shape of moving conveyor belt or chain with steps. Depth of the steps in this phase results from the need to provide the right platform at the most difficult moment of entry on the escalator when a user takes a first step. The difficulty lies in placing the foot exactly within the tread surface of the first moving step. During the movement by the sloping guides, treads retain the horizontal position. Thanks to the curved shape of risers, the neighbouring treads overlap of each other by a value of about 5 cm. The result is that the profile of the escalator in the stop state reminds a profile of the classic stairs with characteristic elements such as tread, nosing, rise and going. The proportions between dimensions of rises and goings however are far different from the ergonomically correct proportions of the comfortable stair steps.

Figure 7 presents the results of the analysis of these discrepancies. The vertical dotted line sets the minimum dimension of going equal 330 mm, resulting from the smallest standardized tread depth ($T = 380$ mm). The intersection points of this line with the pitch lines, reflecting the slopes of analysed escalators, determine appropriate for them values of goings. As can be seen in the graphs all the points corresponding to the commonly used escalator profiles are situated significantly above the *LCS* line. This means that these profiles drastically differ from the requirements of the comfortable stairs profiles. The fulfilment by these profiles the conditions of proper adjustment to the capabilities of human motoric apparatus would require the length of the horizontal step of well above the average of anthropometric values characteristic for contemporary populations. For

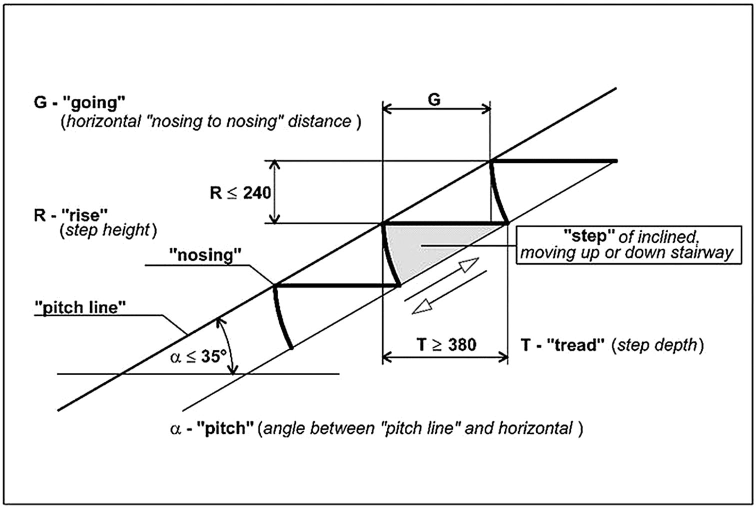

Fig. 5. Normative boundary geometric parameters of the escalator steps (Source: author's elaboration based on the European Standard EN 115-1)

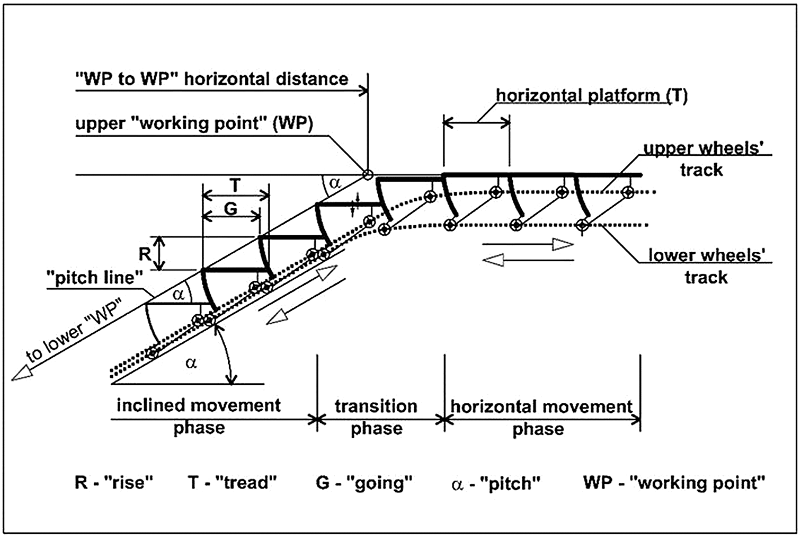

Fig. 6. General operating principles of the escalators (Source: author)

example, for the escalator with slope of 35° the average stride length should have to be 792 mm, which significantly exceeds the current applied value equal to 630 mm. The only escalator profile which respects the minimum dimension of going $G = 330$ mm and belongs in the same time to the set of ergonomic profiles defined by the algorithm $2R + G = 630$ mm, is profile in which the value of the rise (R) equals 150 mm, and the inclination angle $\alpha = 24°27$.

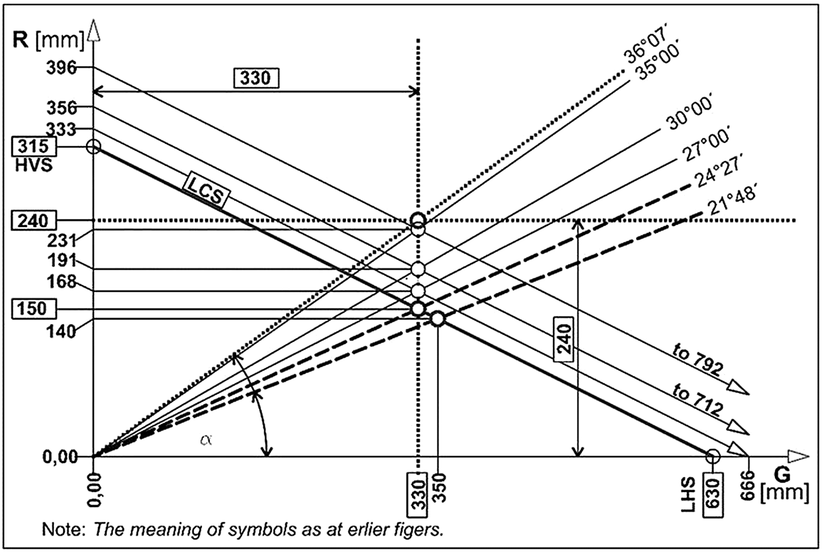

Fig. 7. The analysis of discrepancies between the normative escalator step geometry and the ergonomic geometry of the comfortable stair step (Source: author)

6 Postulated Ergonomic Profile of the Escalators

The only escalator profile which respects the minimum dimension of going $G = 330$ mm and belongs in the same time to the set of ergonomic profiles defined by the algorithm *2R + G = 630 mm,* is the profile in which the value of the rise (*R*) equals 150 mm, and the inclination angle α = 24°27 (Fig. 7). The geometry of this profile is defined by the coordinates of the point of intersection of the vertical dotted line of the minimum value of going with the inclined *LCS* line, which is a graph of the equation of "comfortable stairs" (Fig. 3). Commonly used for this purpose, is the above-mentioned Blondel's method known as so-called "algorithm of comfortable stairs": *2R + G = LHS*, which is the algebraic equations. The Fig. 8 shows the difference between a standard escalators profile and the profile postulated as ergonomic. As is clearly visible all nosing points of the ergonomic profile lie on the corresponding to them lines *LCS*, while their counterparts in the standard profile (*NP′*) are substantially offset from the theoretical points fulfilling the ergonomic requirements (*NP*). The proposed ergonomic profile of escalators meets the requirements of the in force European Standard EN 115-1 EN, because the dimension of tread $T = 380$ mm is equal *Tmin* and rise $R = 150$ mm is much below *Rmax* = 240 mm. Furthermore, it should be emphasized that the dimension of rise $R = 150$ mm meets specified by standards adopted in most countries of the world, the demands for stairs used in public buildings.

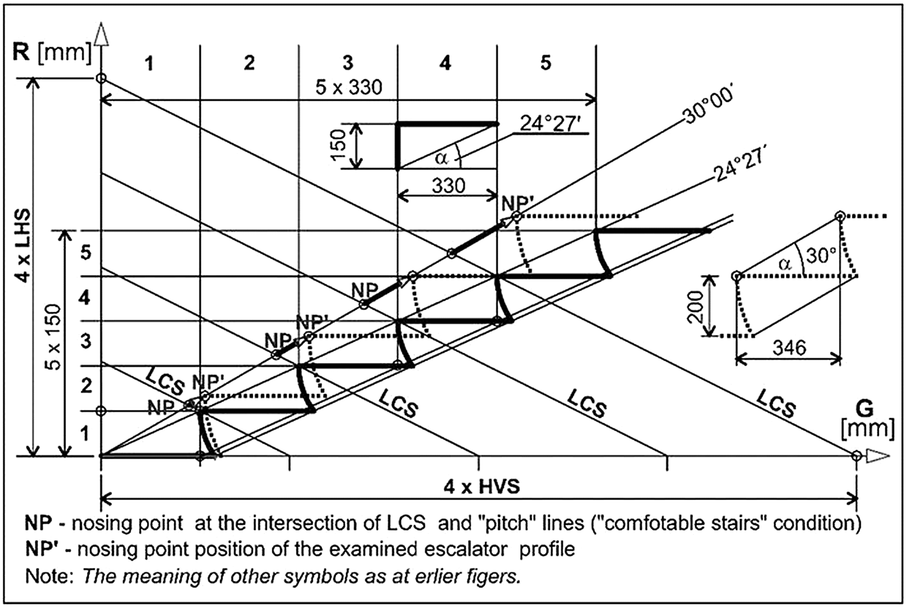

Fig. 8. Postulated ergonomic profile of the escalator flight of steps in comparison with the typical one (Source: author)

To investigate the spatial effects resulting from the application of the proposed ergonomic profile of the escalators applied a simple comparative method (Fig. 9). In place of a typical escalator used for communication between two theoretical utility levels introduced postulated escalator with the ergonomic geometry adapted to the requirements of the comfortable stairs. The theoretical elevation of the upper level (*H*) is the same for both cases.

The lower working points of escalators flights (*WP-A*) and (*WP-A′*) are identical and lie on the same vertical axis. As a result, it was found that the difference in length of both studied flights of escalators projected on a horizontal plane is $\Delta Lb = H \times 0,4675$. For example, for values of $H = 6000$ mm, the length of ergonomic escalator, projected onto a horizontal for values of $H = 6000$ mm, the length of ergonomic escalator, projected onto a horizontal plane increases by 2805 mm. For just such the value moves the upper working point (*WP*) - moving from position *B* to position *B′*.

The length of the stair flight of typical escalator, measured horizontally, is given by the equation $Lb = Hb \times 1{,}732$ and adequate equation for the proposed ergonomic escalator takes the form of $Lb' = H \times 2.1995$ or $Lb' = Lb + \Delta Lb$. As is apparent from the analysis, adapt the profile of the escalator to the requirements of comfortable stairs, taking into account the human psychomotor capabilities, results in the elongation equal to 27% of the flight of steps of examined above, typical escalator.

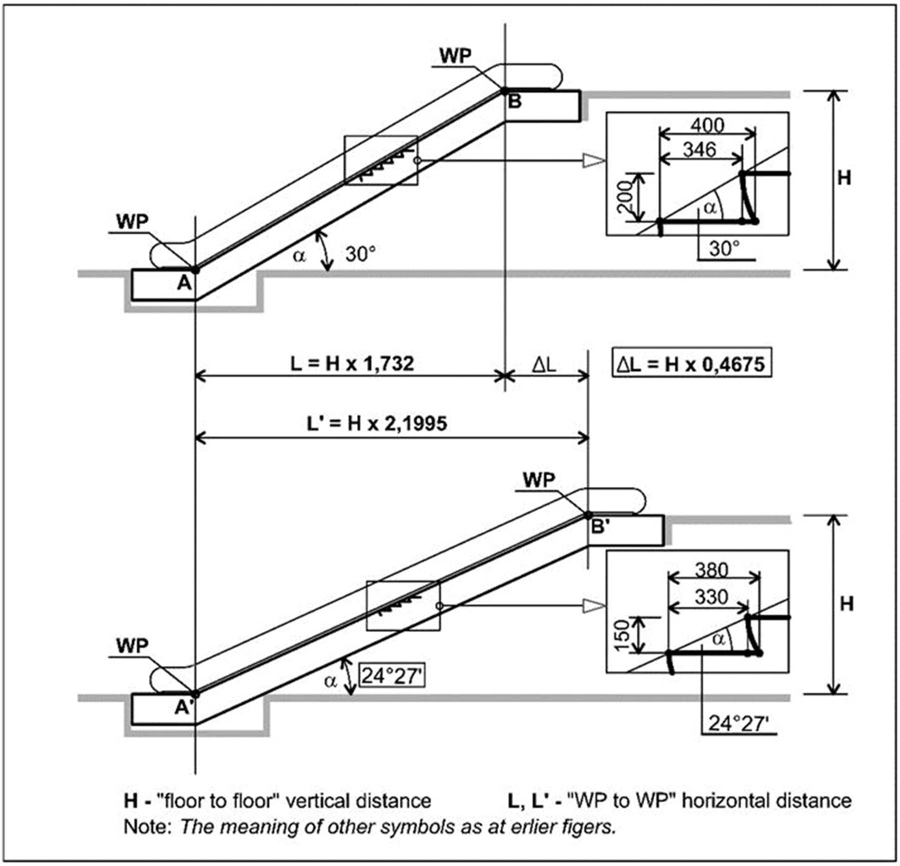

Fig. 9. Comparative analysis of the general geometric parameters of the examined profiles of the escalator flights of steps (Source: author)

7 Summary

The results of undertaken research have shown that it is possible to adjust the geometry of the escalator flight of steps to the requirements of “the algorithm of comfortable stairs”, while meeting the findings of the European Standard EN 115-1 with regard to the dimensions of height and depth of the escalator steps. The postulated model of escalator fully deserves the name of the “moving stairs”, because in state of stop can be used as a comfortable, and therefore safe, normal stairs. This very ergonomic profile can be obtained by reducing the slope of commonly used escalators just by about 6°. In addition, the ergonomic profile of stair steps would treat them as a supplementary emergency stairs. The use of the proposed profile in practice would contribute to increasing the safety of this mode of transportation, which would affect its more extensive use in serving the public spaces. All these features would favour reducing the number of accidents among users of the escalators, which is increasing from year to year in direct proportion to the growing number of active escalators all around the world.

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Evidence Based Design of Scooter Parking Space in Taiwan

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Abstract. This study engaged in the following endeavors: (a) conducted questionnaire surveys to determine scooter riders' parking awareness and experiences; (b) observed scooter riders' parking behavior to identify problems related to the six common parking grid types in Taiwan; and (c) proposed and assessed new parking grid designs. The questionnaire surveys revealed that 37% of the respondents believed that the parking was legal even if a tire touches the boundaries of the parking grids. Non-participant observations showed that users would move other parked scooters to park their own scooters. This study proposed new parking grid designs such as leaving space on the left for scooter operation, increasing height differences to lower the likelihood of scooters crossing the parking grid boundaries, and adding barriers that prevent parked scooters from being moved. After introducing the new designs to the six parking grid types and making subsequent observations, this study found that overall parking conditions improved significantly.

Keywords: Evidence based design · Scooter parking space · Post-occupancy evaluation

1 Introduction

From 2005 to 2010, the total number of scooters in Taiwan increased from 6.5 million to nearly 15 million. Considering that Taiwan only has a population of 22 million, the demand for scooters has evidently become saturated in Taiwan. Because of Taiwan's small geographical size, dense population, and high degree of urbanization, the scooter has become the most cost-effective option for transportation because of its mobility and fuel economy, which enable rapid travel between destinations.

According to statistics released by the Ministry of Transportation and Communications [1], of all public and private means of transportation, the scooter is the most frequently used in all cities and counties in Taiwan (Department of Statistics, Ministry of Transportation and Communications, 2011). Its dominance can be attributed to the following factors [2]: (1) Because Taiwan is a small and temperate island, roads do not ice over and become restricted in winter. The limited space in urban areas also makes the intermixing of residential and commercial spaces fairly common, resulting in a condensed sphere of activity for most people [3]. (2) Since 1988, traditional heavy motorcycles were gradually replaced in the Taiwanese market by light scooters, which

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quickly became highly popular under the influence of the global economy [4]; the transition was further accelerated by the government's industrial protection policies, such as subsidies for purchasing scooters. (3) The light weight and small size of scooters grant them a small turning radius and excellent agility, as well as noticeably greater acceleration from low speeds than that of normal passenger cars. Considering that the sale price and maintenance cost of scooters are also quite affordable, their advantages in both economic efficiency and mobility have made them a necessity for mid- to short-range transportation.

According to the Design Directions of Urban Roads and Accessory Works issued by the Ministry of the Interior in 2009 [5], parking areas for scooters can be designed as either zones or grids. When designed as zones, the length allowed for a vehicle should be at least 2 m; and when designed as grids, each section should be at least 0.8 m in width and at least 2 m in length. Whereas Western countries advise that 1 car parking space be allotted for 3–5 scooters or motorcycles, most Asian countries advise 4.5–10 scooters or motorcycles instead. This contributes to frequent violations of parking regulations in Taiwan. In addition, other than handicapped parking spaces, which are identifiable by a conspicuous symbol, the markings for ordinary parking zones or grids often become blurred or indistinguishable because they can easily wear out after long use. Furthermore, for parking grids with sections of similar sizes, misunderstandings of the intended manner of parking can often occur when there is no guidance from an established policy or intuitive visual directions. The "critical mass" [6] of parking violations is also a key factor in cramped scooter parking areas; an ill-designed and misleading parking area can result in parking behaviors that are not allowed by regulations, which will in turn induce more violations and problems. However, a study [7] on parking management policies in Asia suggests that the premise of an effective parking policy is exercising sufficient control over parking violations. Therefore, to alleviate current usage problems with parking grids, this study engaged in the following endeavors: (a) conducted questionnaire surveys to determine scooter riders' parking awareness and experiences; (b) observed scooter riders' parking behavior to identify problems related to the six common parking grid types in Taiwan; and (c) proposed and assessed new parking grid designs.

2 Method

The present study consisted of two parts. The first was a questionnaire to investigate the parking behavior of scooter riders in terms of their parking habits, awareness on parking violations, and experiences of parking-related injuries. A total of 105 questionnaires were returned.

The second part involved observation of parking areas, namely recording scooter parking behavior through nonparticipant observation at six types of free outdoor scooter parking grids in Taipei (Table 1). The duration of the observations was from 7:30 A.M. to 9:30 P.M., spanning 15 h. To understand how and why the change in time influenced parking behavior, the sites were videotaped by the researchers to analyze the types of scooters parked, the density of parking, and the scooter riders' gender, age, time of parking, direction of parking, and special behavior (e.g., parking

Table 1. Types of scooter parking grids and examples

Type	Location	Measurements	Sample size
Sidewalk surface		990cm X 210cm	58 persons
Sidewalk groove		570cm X 210cm	62 persons
Sidewalk grids		910cm X 155cm	38 persons
Sidewalk groove grids		750cm X 180cm	39 persons
Roadside perpendicular grids		700cm X 177cm	46 persons
Roadside angled grids		1750cm X 155cm	120 persons

the scooter partially beyond the grid boundaries, mounting the scooter on a tilted angle, moving the scooters already in the grid, and reverse parking) (Fig. 1). Subsequently, a new parking grid design was developed on the basis of these investigations and tested on site to assess its feasibility. The resulting conclusions were proposed as recommendations for the design of parking areas.

Fig. 1. Non-participant Observation of parking behavior

3 Results

The results of the questionnaire revealed that 88% of the participants would park their scooters in free public parking areas, 57% of them would park under an arcade and only 22% of them would choose paid private parking areas. This suggests that, because they see scooters as an economical means of transportation, most scooter riders are not willing to pay additional parking tolls, even if it means they run the risk of being fined. This, coupled with the facts that 57% of the participants reported having ever parked under an arcade, 53% of them had parked on or beyond grid lines, and 48% of them had parked in nonparking areas for the sake of convenience, indicates that violations of scooter parking regulations are quite common in Taiwan. In addition, as many as 71% of the participants responded that they had been injured in their efforts to park their scooters, and of the participants who had been fined for scooter parking violations, 43% had sustained parking-related injuries. Additionally, 25% of the participants reported that they had been fined because their scooters were moved out of the parking grids by someone else. That said, 37% of the participants were of the opinion that a scooter could be considered as being parked properly as long as it was in some way “touching” the parking grid, and by that token it would not have to be parked entirely within the grid boundaries; another 35%, however, were completely disagreed with this idea. Therefore, opinions on the definition of "parking properly" appear to be polarized. As an aside, 50% of the participants agreed and only 30% disagreed that the problem of insufficient scooter parking grids can be resolved by allowing scooters to be parked in spaces marked for cars.

The sidestand is a bar that extends sideways from under a scooter, allowing the vehicle to be steadily mounted at a tilted angle (approximately 30° to the left). Because the sidestand is convenient and does not require much strength, many people prefer to use it when parking their scooters for brief periods. However, statistics have suggested that the use of sidestands tends to cause parking-related injuries, particularly in tightly packed parking areas. Conversely, the two-pronged centerstand allows the scooter to be steadily mounted upright, but it also requires more strength to operate. The results of surveys on scooter riders' parking habits have indicated that female riders prefer using the sidestand. In addition, fewer male riders than female riders have reported being injured by a tire running over their feet. Because most riders tend to push and park their scooters to the right side of another scooter, inexperienced riders can be burned by the adjacent scooter when they move too close to its muffler.

When a scooter is parked incorrectly, other scooters are prevented from being parked entirely within the parking grid. Therefore, it can be inferred that as the density of the parking area rises to a certain degree, instances of parking beyond grid boundaries will become increasingly numerous (Fig. 2).

For this type of behavior, the peak densities occur at 8 A.M., 10 A.M., 11 A.M., and 4 P.M. (Fig. 3).

For this type of behavior, the peak densities occur at 7 A.M. and 8 P.M. When instances of parking beyond grid boundaries occur, the static density also starts to rise. When instances of tilted parking occur, parking density rises slightly at 12 P.M. and 3 P.M.

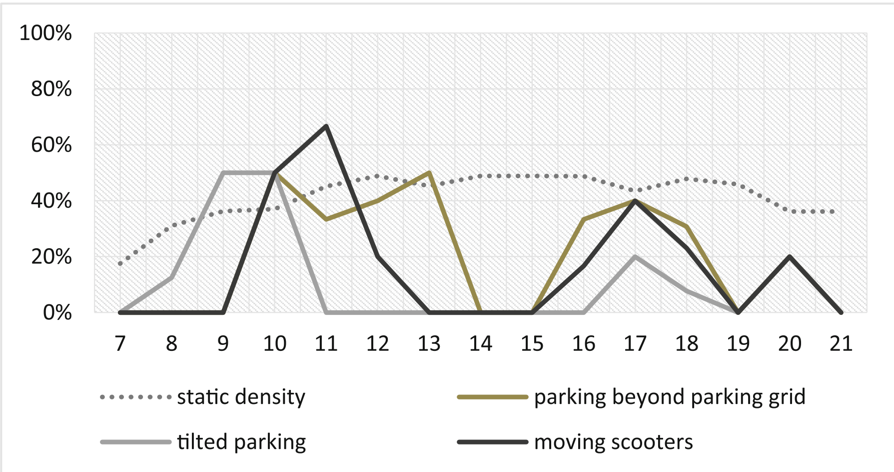


Fig. 2. Type–time distribution of parking behavior for sidewalk surface parking

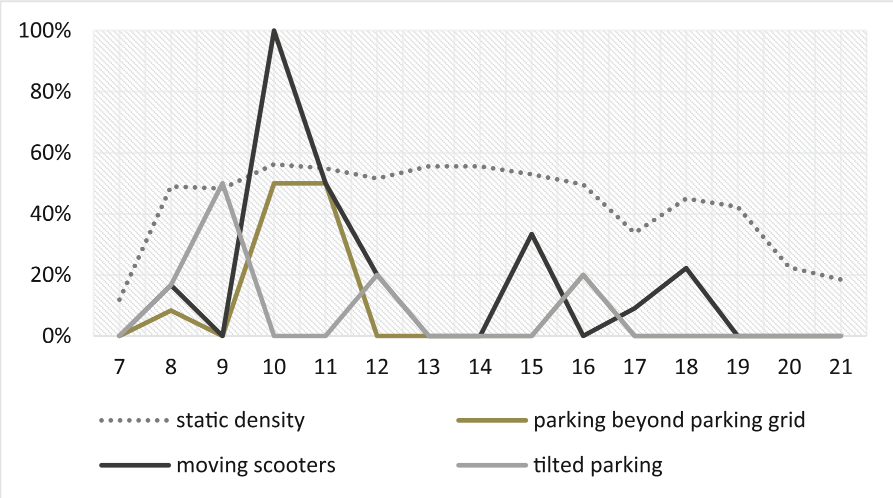


Fig. 3. Type–time distribution of parking behavior for sidewalk groove parking

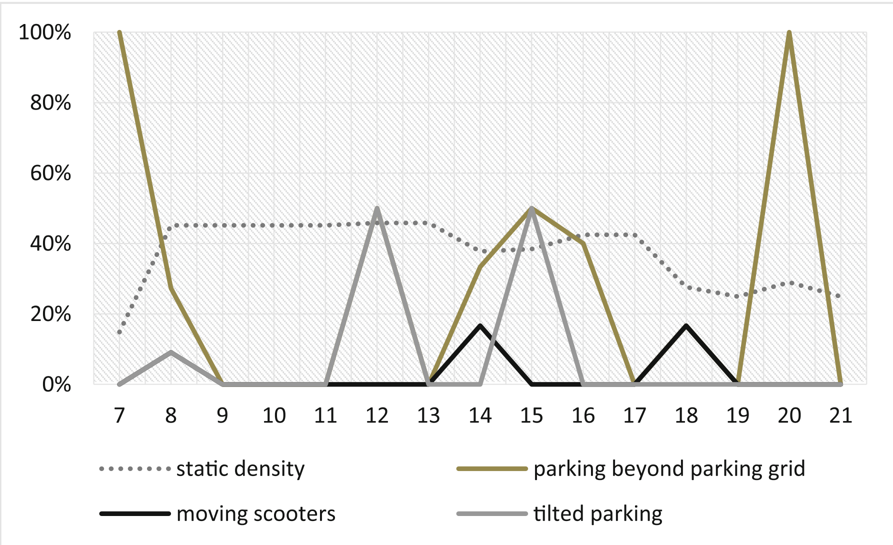


Fig. 4. Type–time distribution of parking behavior for sidewalk surface grid parking

When instances of moving scooters occur, parking density rises significantly at 2 P.M. and 6 P.M. (Fig. 4).

When the static density of this type is at the lowest, the frequency of tilted parking appears to be the highest. It can therefore be inferred that the more spacious the parking space becomes, the more the riders will tend to park their scooters in a tilted manner (Fig. 5).

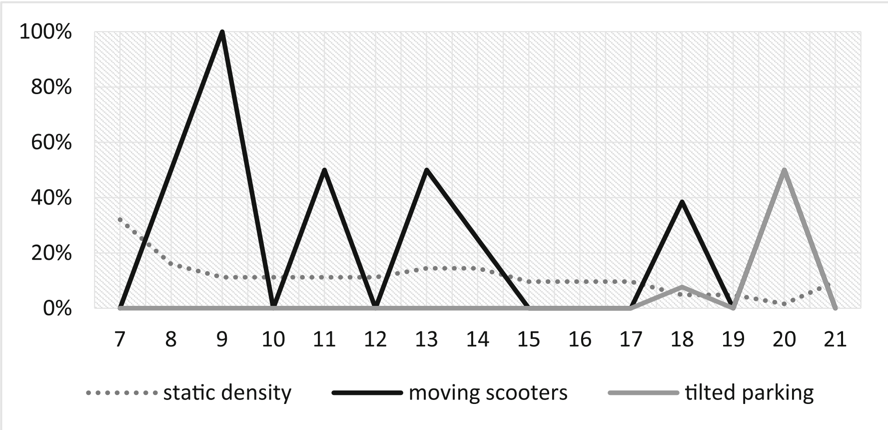


Fig. 5. Type–time distribution of parking behavior for sidewalk groove grid parking

When the percentage of parking beyond grid boundaries exceeds 20%, all parking types show a static density of more 80%. Therefore, parking beyond grid boundaries is correlated with static density (Fig. 6).

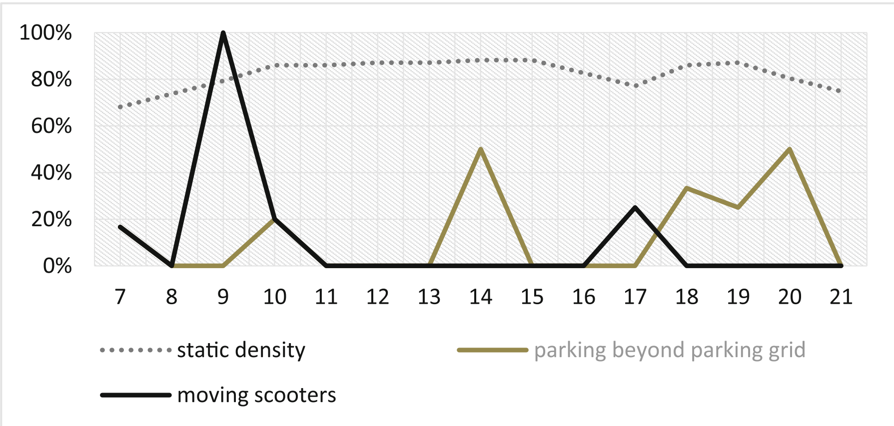


Fig. 6. Type–time distribution of parking behavior for roadside perpendicular grid parking

Given that parking beyond grid boundaries maintains a more or less consistent trend and density except for at 2 P.M., the behavior is directly proportional to the density of parking grids. The relationship between moving scooters and static density can be inferred from the distributions at 7–9 A.M., 11 A.M.–1 P.M., and 5–6 P.M.; the behavior exhibit similar trends (Fig. 7).

According to observation records, 70% of the scooters were of heavy types of 125 cc or above, and the other 30% were of lighter types. Moving scooters induces

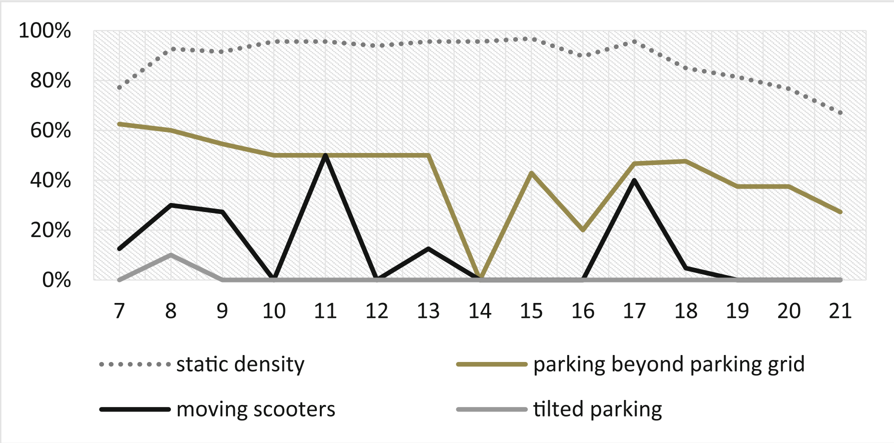


Fig. 7. Type–time distribution of parking behavior for roadside angled grid parking

most parking violations. When a rider insists on parking his or her scooter in a saturated parking grid, part of the scooter will be left out of the parking grid. If the rider tries to fit his/her scooter into the parking grid, he/she will have to "push" the adjacent scooters away (making the scooters on both the left and right sides even more tightly packed). In other words, this behavior involves the rider forcibly moving other scooters for selfish reasons, resulting in those scooters being parked in a tilted manner or beyond grid boundaries. Of the six types of parking grids, the sidewalk groove type had the fewest instances of parking beyond grid boundaries, because the grid's height difference with the sidewalk forms a natural barrier that restricts the space available for parking. According to observations of actual parking grid sizes, the narrower the parking grids, the higher the percentage of parking beyond grid boundaries.

Reverse parking involves the rider parking the scooter in a reversed direction. Observations revealed that when the height difference with the sidewalk is less than 10 cm, reverse parking tends to occur at the area close to the parking grid; conversely, when the height difference is over 10 cm, instances of reverse parking decrease considerably. Because most riders are right-handed, and because the accelerator is located on the right side, nearly 90% of the riders tended to park their scooters from the left side of the vehicle, and only approximately 10% did so from the right side.

Therefore, an ideal parking grid design should leave enough room for the rider to maneuver at the left side of the scooter; by the same token, the width of the parking grid should also take the width of human body into account (Dong et al. [8]). Based on the four physical means of protecting personal space proposed by Gehl [9], namely barrier, distance, height difference, and layout, the results of this study's investigation and those of past studies were examined and the following criteria were drawn up for the design of scooter parking grids:

(1) Space: Sufficient space must be allocated on the left side for the user to maneuver.
(2) Height difference: A sufficient height difference with the sidewalk surface is necessary to prevent scooters from being parked beyond grid boundaries.

(3) Barriers: To protect the rights of the user and prevent parking violations such as moving others' scooters.

4 Discussions

The proposed parking grid design for the roadside perpendicular grid type is a space that is defined by two L-shaped 30 cm × 20 cm × 10 cm angled parking blocks made of four 20 cm × 10 cm × 5 cm bricks held together by cement. Similarly, the parking grid for the roadside angled grid type is a slanted parking grid (at 50° to the road) defined by 27 cm × 25 cm × 10 cm L-shaped parking blocks. The L-shaped blocks should be placed in accordance with existing regulations, at the lower left and upper right corners of a parking grid. Because the observation results confirmed that the behavior of moving others' scooters occurs in all six types of parking grids when a scooter rider wants to park his or her own vehicle in an already saturated parking grid, and because a suitable height difference with the sidewalk can reduce the instances of parking beyond grid boundaries, the study proposed that the height of the blocks should be set at 10 cm, the same as the height of the sidewalk. This will make the blocks for the sidewalk groove grid type and the sidewalk grid type as tall as the average height of the sidewalk. The width of the blocks is also set at 10 cm. The purposes of such features are to cause riders to move their scooters into the parking grid from the right-side entry point, and also to restrict the size of the entry point to 50 cm, leaving a space 10 cm–30 cm wide for the rider to maneuver (Fig. 8).

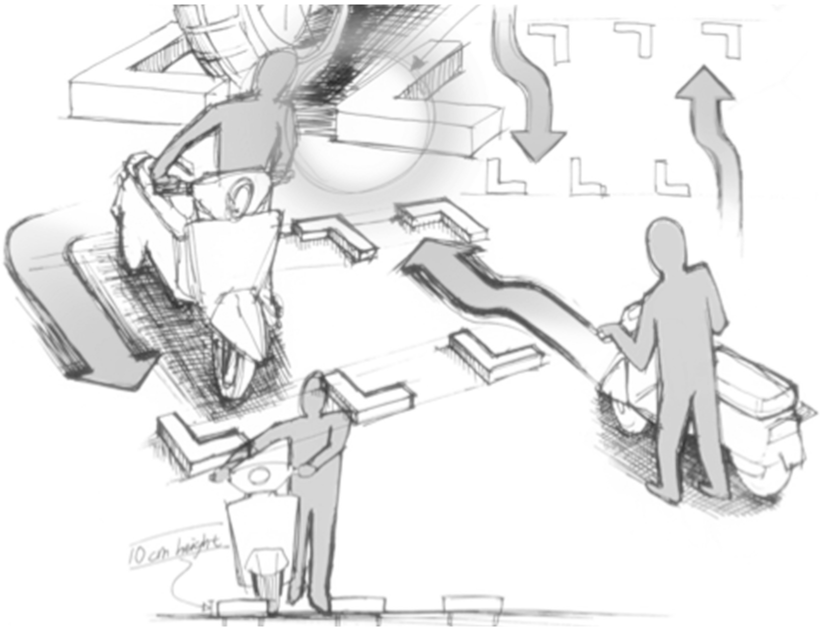
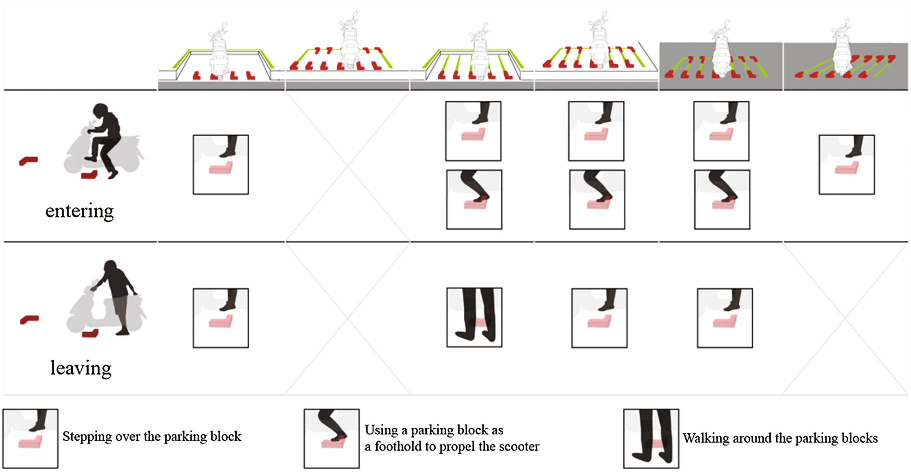


Fig. 8. Design concept of scooter parking space

Observations made after placement of the parking blocks indicated that, although scooter riders felt confused when they saw such arrangements for the first time, the scooters indeed parked in a more orderly manner afterwards. Two styles were employed for maneuvering a scooter into a parking grid: riding and pushing. Those who preferred the riding style would ride on the scooter while entering or leaving a parking grid without hitting the parking blocks. To prevent being tripped by the blocks, they would raise their feet when passing or rest their feet on the floorboard of the scooter. Some were also observed to use one of the blocks as a foothold to help propel the scooter.

Riders who preferred the pushing style would stand beside the vehicle before entering or leaving the parking grid, adjusting the vehicle at an angle that allowed smooth passage. Most of these riders chose to walk around the blocks or walk into the parking grid when doing so (Table 2).

Table 2. Styles of entering and leaving a parking grid



5 Conclusions

As a light and rapid means of short- to mid-long-range transportation, scooters play a critical role in the development of transportation in Taiwan. However, the oversaturation of scooters in urban areas has resulted in a severe shortage of parking grids, which in turn has resulted in tightly packed and disorderly parking conditions that render the parking grids unable to protect the rights of their users. Existing scooter parking areas are defined by grid lines painted on the ground, and the areas can vary in size depending on the conditions in situ. However, the worn-out paint or repainting of the grid lines can make the boundaries ill-defined and lead to misunderstanding or even parking violations. Moreover, problems caused by the painted grid lines becoming

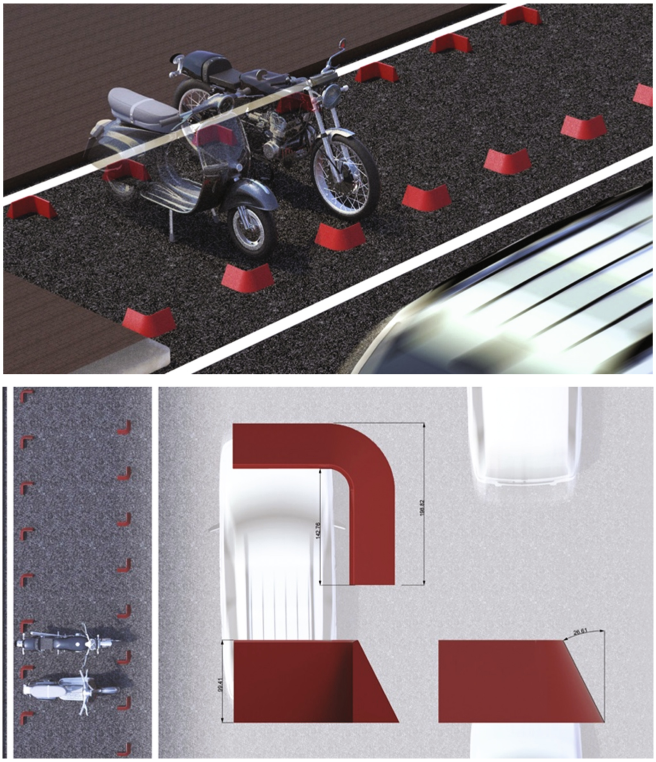


Fig. 9. New design of parking space

slippery in the rain cannot be overlooked. Therefore, this study proposes a parking grid design that forms a grid with unit blocks to prevent misunderstandings resulting from repainted grid boundaries. Because observational results have indicated that some scooter riders invade the sidewalk in their attempts to park their scooters between the sidewalk and the road, the study proposes preventing such behavior through the placement of parking blocks at the exit when the height of the sidewalk is less than 10 cm. The parking blocks proposed by this study can serve as a new approach to improve the orderliness of parking, and an on-site experiment proved that the blocks can maintain the principle of one vehicle per grid and protect the rights of scooter riders (Fig. 9).

Furthermore, some of the scooter riders were found to use the parking blocks as footholds. For this reason, antislippage treatment is recommended to be applied to the surfaces of the parking blocks. It is advisable to introduce the proposed parking blocks in future designs to help scooters riders park their vehicles and maintain order in the parking area.

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Ergonomic Experimentation in the Architectural Design Process – Types of Test Environments

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Abstract. The purpose of an ergonomic experiment in the design of architecture is to adapt the designed environment to human dexterity, particularly taking into account people with impaired motor abilities or those with a vision impairment, the elderly, children and those with temporary disabilities. Depending on the test purpose and scale, one may conduct experiments in small scale test environments; e.g. an ergonomics laboratories, or in large scale environments: architectural mockups, show houses and experimental houses. There are many advantages to real-space experimentation in testing ergonomics of architectural spaces and interior designs, as opposition to experiments conducted with digital tools and virtual reality, which gain on popularity.

Keywords: Ergonomic research · Method · Architectural design

1 Introduction

Assessment of accessibility of interior spaces and their comfort of use is a significant issue in the architectural design process. The purpose of an ergonomic experiment in the design of architecture is to adapt the environment to human dexterity, particularly taking into account people with impaired motor abilities or those with a vision impairment, the elderly, children and those with temporary disabilities. Ergonomic tests in architecture focus on the distribution of partitions and furniture elements in interiors as well as the location of functionally diverse storage compartments inside furniture. Ergonomic tests may also pertain to the perception of space in the context of changing light and colour conditions.

2 Ergonomic Tests - Methodology

Experimental testing constitute the basis of research in ergonomics laboratories. Experimental tests are an important method for testing ergonomics even though the digital tools and virtual reality have been introduced into the research. A real-space experiment as a method to test architectural spaces entails a recreation of the required spatial situation in an ergonomics lab or at another testing space. Experiment

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participants carry out tasks according to a pre-determined script in the arranged environment. Test results assessment criteria may include the time taken to perform the test task, the path an experiment participant travelled to perform the task, the task performance comfort or the effort needed to perform the task. A multi-criteria assessment is also feasible, which combines a number of criteria according to assigned weights. The following are required to perform a real architectural space experiment:

- a test environment, which illustrates the spatial, functional, light and colour characteristics significant for the test objectives
- experiment participants, whose level of physical ability reflects that of the target group which the architectural space is dedicated to
- test apparatus used to record the experiment
- test apparatus used to measure the time taken to perform tasks identified in the script, or used to measure the distance travelled during the performance of tasks identified in the script, or used to measure the effort required to perform tasks identified in the script.

2.1 Test Environment

Setting up a real-space test environment entails a recreation of space or use of an existing fragment of architecture, which exhibits correct spatial, functional, light and colour characteristics. Any fragment of architecture or architectural interior may become a subject to a test: fassade systems with supporting structure, interiors or furniture systems with desired functional distribution, which particularly applies to the design of kitchen furniture. The test result may depend on the precision of the recreated environment, thus it is considered good practice to accurately recreate a design or to use furniture prototypes.

Depending on the test purpose and scale, one may identify:

- small scale test environments; e.g. an ergonomics laboratory, a kitchen furniture laboratory
- large scale test environments: mockup, a show house, an experimental house.

In a small scale test environment or an ergonomics laboratory a spatial situation is recreated, within which the experiment will take place. An approximate layout is often put in place, which provides a general picture of the space. Here, one can focus on the details, which are significant in terms of the test. An accurate duplication of all the elements is not always necessary (Fig. 1).

A large scale test environment, for example a mockup is a 1:1 model, which presents any fragment of the architecture on the basis of the architectural and construction design. Creating a mockup is a practice widely used in high budget architectural projects. On the basis of a mockup, one is able to assess both large architectural elements as well as the quality of the designed architectural details, ergonomics of the suggested solutions and the safety thereof. Ergonomic tests in the form of a real experiment using a mockup are an optimal solution, as the experiment participant performs tasks in an accurate replication of the given environment. The use of mockups

Fig. 1. Small scale test environment: kitchen furniture laboratory, example of BLUM company. Photo A. Bonenberg

in designing architecture, facilitates even major changes and adjustments to be implemented to an architectural design quite quickly (Fig. 2).

To conduct a real-space architectural experiment, the interiors of show houses or apartments created by developers in order to help in selling the real estate may be used. Also in this case, the test environment is an accurate copy of the final version, thus it is useful in the performance of a real experiment. However, as show houses are not part of the design process but a result of it, not all changes which are the result of an experiment can be applied to the design.

A specific type of research environment is provided by experimental houses, which are permanent buildings, where spatial and technical solutions, thus far little known or unknown are applied. In this case the investor – user, together with an architect - researcher execute a spatial or technological experiment concept. In contemporary architecture, issues pertaining to flexibility and multifunctionality of an architectural space, mobile elements in architecture or new functional solutions are often tested in this way. For example, the famous contemporary experimental houses designed by Shigeru Ban, a Japanese architect, employ interesting structural solutions (Paper House 1990–1994) the open plan concept (Wall-Less House 1997), treat the issue of the relation with the spatial context (Curtain Wall House 1995) or flexibility and functional layout of the interior (Naked House 2000) (Fig. 3).

Fig. 2. 2, 3, 4. Mockup of housing development in Trento, Italy by Renzo Piano Building Workshop. Photo A. Bonenberg

2.2 Experiment Participants

A real-space experiment entails people who perform tasks in accordance with a defined test script. The physical dexterity of individuals who participate in the experiment should be adapted to the tested issue. The elderly or those with impaired mobility should also participate in tests, which apply to them.

There is a research tool, which makes it possible to adjust the physical abilities of a fully able person to carry out a test for a person with impaired abilities, and vice versa. Such tools include exoskeletons, which improve the physical abilities of the test subject. There is also the opposite - an overall used to simulate old age is a useful test tool. It features a weights and clamps used to immobilize joints and stabilize the weights, special glasses distort vision and make it difficult to judge distance and tell colours apart. Gloves which make it much more difficult to handle things as well as ear muffs which limit the hearing abilities of the test subject are also part of the overall.

In ergonomic experimental tests of architectural space, which is to be used by individuals with disabilities, results achieved by fully able and disabled persons may be compared. If apparatus in the form of a test suit simulating old age is used, the experiment may be performed in two variants: natural (without the suit), partially suited

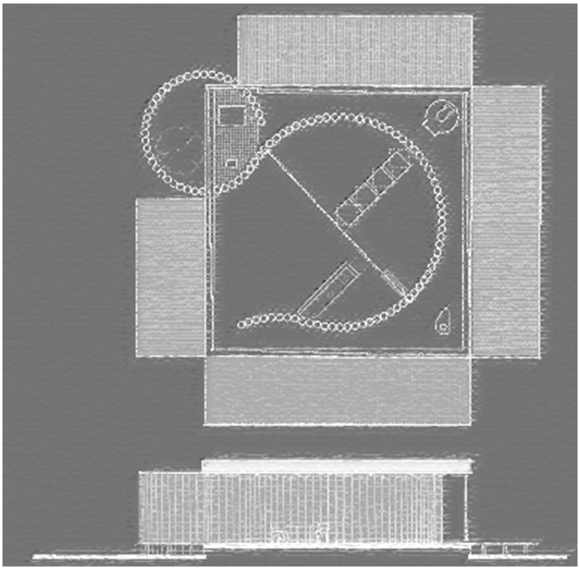

Fig. 3. Experimental Paper House plan and Section 1990–1994 by Shigeru Ban. Drawn A. Bonenberg based on http://www.shigerubanarchitects.com

up (without sight, hearing and touch impairments) and fully suited up with sight, hearing and touch impairments.

2.3 Test Apparatus

To perform a real-space experiment, it is necessary to prepare test apparatus used to record the experiment: video camera and a photo camera. Depending on the adopted test assessment criteria, the selection of measurement apparatus is significant. If the basic assessment criteria entails the time taken to perform tasks defined in the script, the apparatus consists of a stop-watch, if it is the distance travelled in tested premises, the energy expenditure, use comfort, different apparatus has to be selected. The use comfort may be recorded using an assessment questionnaire completed by participants of the real experiment.

Testing architectural spaces entails a formulation of a test script, performance of the experiment, collection of the obtained results and writing up a report. The test script should define the scope, objective and purpose of the performed tests, for example: required effort, precision of the performed actions or the perception and quality of the architectural space. The script should include the main objective, which might constitute a comparison of the usable qualities of different interior shapes, various furniture design options, interior lighting, selection of colours and contrasts. Additionally, it is possible to identify the best heights for handling and storage spaces and the best lighting conditions and colour schemes. Ergonomic experimental tests of architectural spaces may be grouped into:

- Geared towards the analysis of performed tasks
- Geared to effort measurements
- Geared towards testing contrasts and spatial light and colour perceptions
- Geared to measure use safety.

3 The Experiment Process – Performance and Recording

The experiment is based on the performance of tasks in accordance with the script. A list of tasks may include actions, which aim to measure the effort based on furniture usage, for example moving items. A script should include a detailed description of the tasks performed in order, which may be formulated as follows:

- start position - entrance to the premises (time start)
- remove a given item from furniture
- carry the item to a different location
- place the item in a defined spot within the designed furniture system
- end of test (time stop).

A test may be performed by persons with different levels of physical ability in order to determine whether a space is correctly designed for persons with disabilities.

Testing contrasts and perception of colours may be done as comparative experiments. The spatial environment subject to analysis may be painted in a single colour (e.g. white), and then a contrasting of surfaces may be introduced: for example, counters, lower cupboard edges in order to separate them from the floors, etc. If the

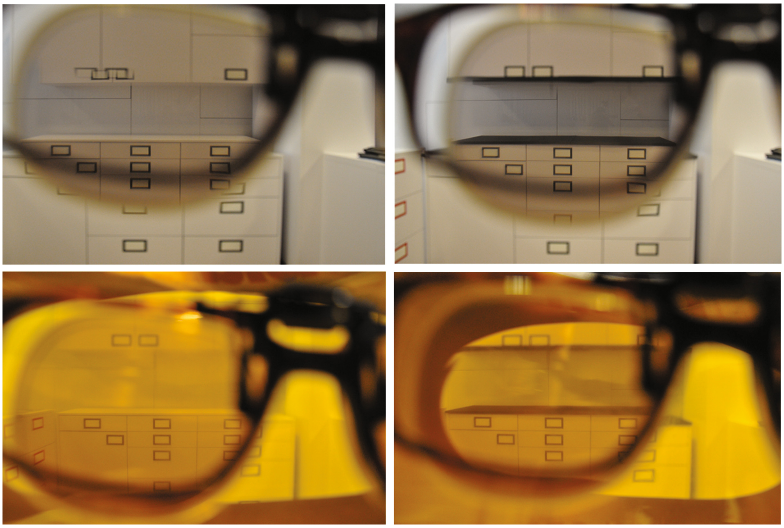

Fig. 4. Testing contrast and perception of colours performed as comparative experiments; example of BLUM company laboratory and use of Age Explorer research tool. Photo A. Bonenberg

purpose of the experiment is to increase use safety and comfort of the space for visually impaired persons, then the contrasting elements should be aligned so as to emphasise the location of furniture edges. Correct contrast also make it easier to locate handles for opening furniture. Glasses which distort image, make it difficult to estimate distances, limit side vision and impair the perception of colours may also be used as test apparatus. Observations and photographic evidence may thus be made in six categories:

- assessment with the "naked eye" (without visual impairments) of a space without contrasts and with contrasts
- assessment of a space without contrasts and with contrasts with the use of glasses which distort image, make it difficult to estimate distances
- assessment of a space without contrasts and with contrasts subject to full visual impairment with the use of glasses and a mask - to impair the perception of colours (Fig. 4).

4 Assessment of the Test Material – Results Analysis

An assessment of the obtained material is performed on the basis of live observations, photographic documentation and a video rerecording. The results and analysis thereof, can be presented in categories where effort, precision, contrasts and light - colour perception of the space or user safety, were tested in variants taking into account the user's physical ability. The compilation of the times for the performance of given tasks may be presented as a table or a bar chart.

Questionnaires completed by experiment participants also constitute a form of documenting the results. The results of questionnaires and opinions of the test subjects document a subjective assessment of the spatial situation. The results of questionnaires should be presented in the form of tables and state, for example, the comfort level experienced in the performance of the task. Detailed comments may be included in the form of a description.

A list of the ability to see results (testing the perception of contrast and colours in interiors as well as light and shadow contrasts) can be presented in the form of tables. An assessment may be made on the basis of a questionnaire or using the expert method. Photographic documentation should be drawn up, which illustrates the legibility level of the space and legibility level of edges and surfaces. Results of ability to see assessment may be presented in the form of photographic evidence.

5 Summary

There are many advantages to real-space experiments in testing ergonomics of architectural spaces and interior designs. The primary advantage within the scope of shaping architecture is the ability to observe the actions of people - users in a real or reconstructed spatial environment. The behavior of a person performing tasks in a real experiment is not entirely foreseeable. That is the main difference between a real experiment and a computer simulation, which maps the behavior of a model human in accordance with the data entered into the computer software. But it is the unpredictability of users, the "human factor" which is the phenomenon which directly or indirectly affects the tempo and efficiency of actions in a spatial environment, the comfort and safety levels and perception of an architectural space. The factors which play a role in the selection of the manner in which a task will be completed may include personal habits, instinct, physical dexterity. A user may omit certain steps in the performance of a test task without being prompted or involuntarily (unless these are steps specified in the test script) and perform the task in a manner which will surprise the tester. This makes it possible to understand the potential and quality of the tested space and suggest original design solutions. The use of real people, rather than computer simulations simplified the performance of complex test tasks, and the ability to perform the test in an actual environment (mockup, show house, experimental house) guarantees meaningful results.

The cons of a real experiment in testing architectural space include limitations stemming from the need to execute the spatial structure, within which the experiment will take place, unless the tester already has an appropriate test environment at their disposal. An approximation of the space, its outline without all the details is a common occurrence. The ability to precisely copy the elements is limited only to general shapes and dimensions. An unbiased assessment of the obtained results may constitute a difficulty of sorts, due to the nature of the test subject, often available only as a subjective description. The ability to measure forces and external loads acting on a body of a test subject during the performance of the test tasks are also limited. To sum up, the adequacy of the selected architectural space test method depends on the objective and nature of the planned test. When it comes to issues within the scope of ergonomics, where it is important to come up with an innovative solution and tests on a larger scale: light and colour conditions as well as heights, a real experiment will provide a lot of meaningful data.

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The Case Study of BIM in Urban Planning and Design

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Abstract. The objective of this paper is to explore the application of BIM (Building Information Modeling) [1] in Urban Planning. Using BIM technology, urban planning and design from the three-dimensional information model to start, making the original two-dimensional drawings of the abstract has become "concrete" and "visualization". In order to achieve the design goals and three-dimensional visualization, such as VR (virtual reality), designers use the three-dimensional planning diagram to communicate the design, discussion and optimization with the customer to be identified ultimately. By using the BIM simulation of the 3D terrain combined with the design to see whether the layout of the building is reasonable, designers guarantee that road and landscape design is up to design expectations. Through building information model, it is reasonable to analyze the sunshine, noise, ventilation and so on so forth. BIM delivers benefits the building project life-cycle in every aspect. For instance, it helps making better design decision, building more efficiently, and managing and maintaining building portfolios more effectively. BIM supports architects throughout the green design. It uses the concept to ameliorate reality with improved quality and efficiency. It ameliorates your creative vision with innovative technology solutions which enable you to impact the green design. This research case aims at identifying the shortcomings of the design through sunshine analysis and ventilation analysis, thus optimizing the design. This not only makes the planning and design more reasonable, but also can meet the corresponding green building standards at the beginning of the design.

Keywords: BIM · Urban planning · Sustainable design

The US National Building Information Model Standard Project Committee has the following definition: Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.

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1 Introduction

The traditional practice is to use computer-aided drawing (CAD) to record the geometric shapes, spatial relationships, geographic information and other graphical information, such as work progress, external environmental conditions, materials, and costs and other non-graphical information is another information System processing. The emergence of BIM not only integrates the graphical and non-graphical data of the above buildings, but also provides a virtual reality model, and incorporates the concept of processes to reduce the information omission of planning, design, construction and operation of the project at all stages.

2 Research Problem

2.1 Our City Need to Be Smarter

With cities as living and working environments set becoming even more complex in the future, urban planners are going to require new technological tools and approaches. But are cities really prepared for this great leap forward? Most cities are too old, too small, too cramped, too loud, not agile enough, and too wasteful of their resources. They are poorly equipped for the future. While back in 1930, most people still lived in rural areas, 2014 figures put the share of the world's population in cities and urban agglomerations at more than 50%. A figure from the United Nations predicts that the share will rise to 66% by 2050. So cities have to be prepared. Construction companies, urban planners, and architects will have to rethink if they want to keep pace with this explosive development and make cities fit for the future [2].

2.2 Our Urban Planning Design Need More Details

In urban planning and design, compared with professional designers, our customers can not read the two-dimensional drawings, and three-dimensional renderings which are only some of the architectural surface of the design, as a result, they may not be able to accurately express the designer's design goals. This communication can't be understood as an obstacle, resulting in accurate grasp and control the quality of the design.

Based on the above analysis, the urban planning and design needs to solve the following technical problems:

- A large amount of planning digital information requires multidisciplinary collaboration.
- Design projects should be easy to adjust and manage.
- The need for a more intuitive, visible process analysis file.
- Predictable simulation of future results.
- Future use and maintenance requires cost forecasting and control.

3 Research Methodology

3.1 BIM in Urban Planning

The city is a complex system, urban planning requires a lot of digital information to support itself. By using BIM, Visualization of urban planning is very important to the macro-grasp and scientific guidance of urban development. Through the visual design, we can correct some errors and deviations at the early stages of design, and effectively promote the entire process of the project.

3.2 Methodology

Key methods of technology:

- Constructing Information Model Based on 3D Digital Technology.
- Simulation of digital information.
- Integrated construction project information.
- For the construction of all aspects of the relevant personnel to provide "simulation and analysis" of the scientific cooperation platform.
- The use of three-dimensional digital model of the project design, construction, operation and management of the whole life cycle assistance.

Important ecological indicators in the planning: sunshine and lighting, micro-environment of the air flow, moderate analysis, and noise analysis.

A. Sunshine time and lighting analysis

The analysis of sunshine involves time, geography, architectural modeling and other complex factors. It is very difficult to combine these mutually influencing factors with artificial precision calculations. But BIM can be easily resolved with visual dynamic simulation, and BIM information model has the project's geographic data, you can analyze in the day during the sun exposure time.

B. Analysis of air flow in micro-environment

With the process of urbanization, the building height not only becomes more and more intensive, but also is getting higher and higher. The interaction between the winds of buildings becomes very important. Through the BIM wind environment analysis, we can calculate the secondary area of the building and the thermal environment and other data, so that architects and planners can better cooperate and adjust the program to the most reasonable state.

C. Visibility analysis of urban planning

Through the visibility analysis of the information model of BIM, according to the demand of landscape visibility of each building, the visibility of each landscape building can be easily and clearly simulated, and the scheme can be adjusted according to the result of the analysis.

D. Project Environmental Noise Analysis

In the BIM information model, some of the existing conditions, such as roads and crowd squares, entertainment places and other noise data generated into the project model for analysis and simulation. Through the analysis of the model, the impact of noise on the building needs to take sound insulation measures. Designers can improve the noise level of the overall project by adding noise walls, planting soundproofing trees, and so on so forth.

4 Case Study

In order to solve these problems, we can use BIM information model to build information platform when the plan starts. Through digital information simulation, integration of various information are related to the project, thus providing simulation and analysis processes and results for all aspects of the project. For instance, important parameter indicators in urban planning, sunshine lighting, moderately, wind, noise, etc., can be modeled and analyzed using BIM's digital information model. In the case study, the first thing to do is collecting information, and then establishing a BIM information model. In the BIM information technology platform, we used the external environmental data, such as meteorological data in the information model for parameterization, thus simulating the planning results of different levels of the city through analysis and evaluation to get the best design method (Fig. 1).

A. Overview project

Project name:	Jinan Riverfront district north lake area conceptual design.
Project Location:	Jinan City, Shandong Province, China;
Planning area:	127.2 hectares;

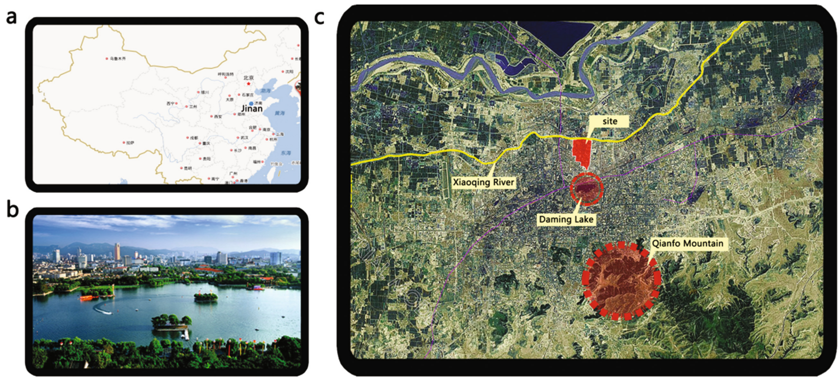

Fig. 1. Jinan Riverfront District North lake area conceptual design. (a) Location in China; (b) Photo of area; (c) Site in Google map.

Urban design requirements: four aspects to consider: highlighting the cultural characteristics, the construction of complex urban sub-centers, promotion of the development of Binhe New District to meet the needs of residents, building a harmonious city. The design aims at building the core area for the service of the northern city of Jinan commercial center and urban public activity center and leisuring tourism and cultural transmission characteristics of the Jinan city center.

The status of urban planning:

- The residence is divided into urban roads that are very messy, small scale, and it is not conducive to the scale of development.
- Commercial and financial plots traffic is not convenient, which requires the west part to have an increase of the number of the city road, thus reducing the net land scale.
- Central landscape belt and pedestrian area are affected by the road, causing landscape green and people being mixed with the car and the deterioration in space quality.

B. Planning concept

Planning and design which ensure that the size of the land area is basically the same under the premise of the land network structure has been adjusted. Transfer the urban roads between the east and west residential sites to both sides of commercial land. Part of the road in Shuitun Road sank through the road. This road network adjustment, the project can be built to increase the construction area of about 2.43 hectares, the utilization of land resources has increased, while the commercial block of the pedestrian and car dealers have become more convenient, the central waterfront landscape with a real high Quality walk open space (Fig. 2).

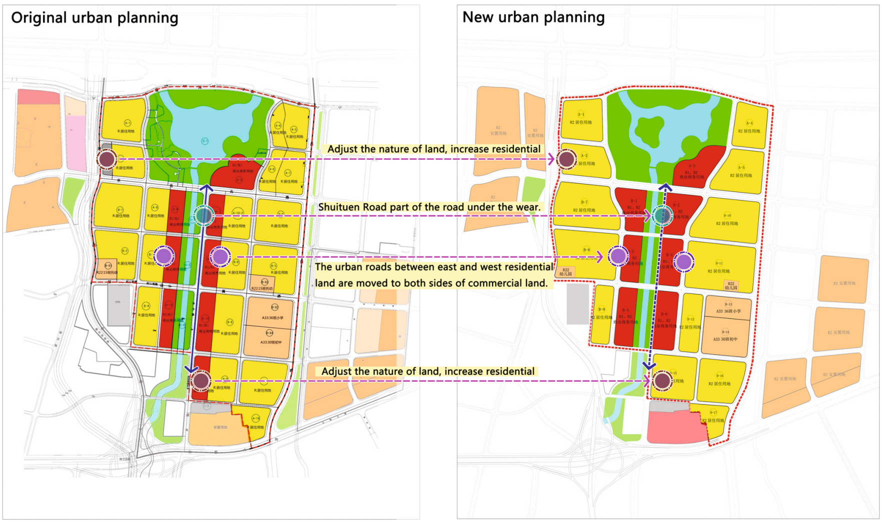

Fig. 2. Jinan Riverfront District North lake area conceptual design. Planning adjustment diagram.

C. The technical scheme of the project is:
- Data collection and collation
- The specific approach is to adjust the data format to BIM software can recognize the format, the 3Dmax model into a standard IFC format.
- Into the micro-environment simulation platform for calculation.
- The parameters of the collected meteorological data are parameterized and compared with the parameter settings in the simulation platform, and finally the parameter list is formed.
- Get the simulation results, and then two-dimensional or three-dimensional output (Figs. 3 and 4).

Fig. 3. Jinan Riverfront District North lake area conceptual design. 3D simulation model and building height control analysis and visibility analysis.

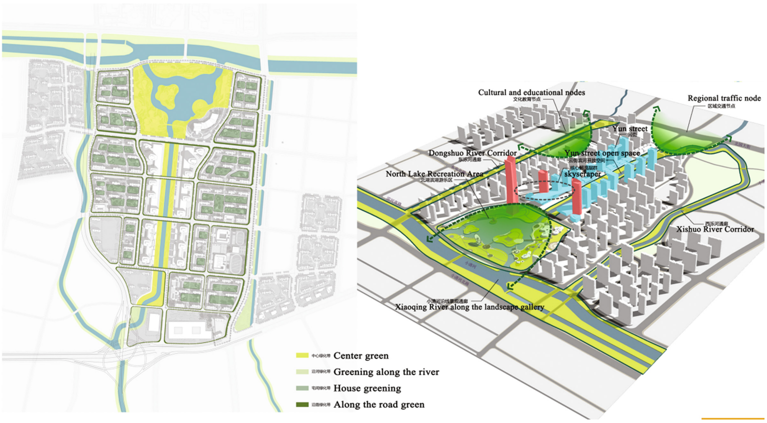

Fig. 4. Jinan Riverfront District North lake area conceptual design. Analysis of greening landscape and open space.

3D simulation model and building height control analysis and visibility analysis: The overall spatial form is the core area of the two public construction which constitute the main axis. The city's skyline is low in the middle and gradually rises to both sides of the north and south, to the north of the 300 m high end of the high-rise building. The layout of the residential building is arranged in a point and board, along the edge of the river. The overall height of the building is relatively high in the middle, the surrounding is relatively low, so that the building's visual surface is more open, making the residential area and the city's environment has a mutual communication, and low buildings arranged in the B block East, to avoid the building density is too large, but also a very good sunshine. Urban planning space is very flexible, making the visibility of landscape architecture is very wide (Fig. 5).

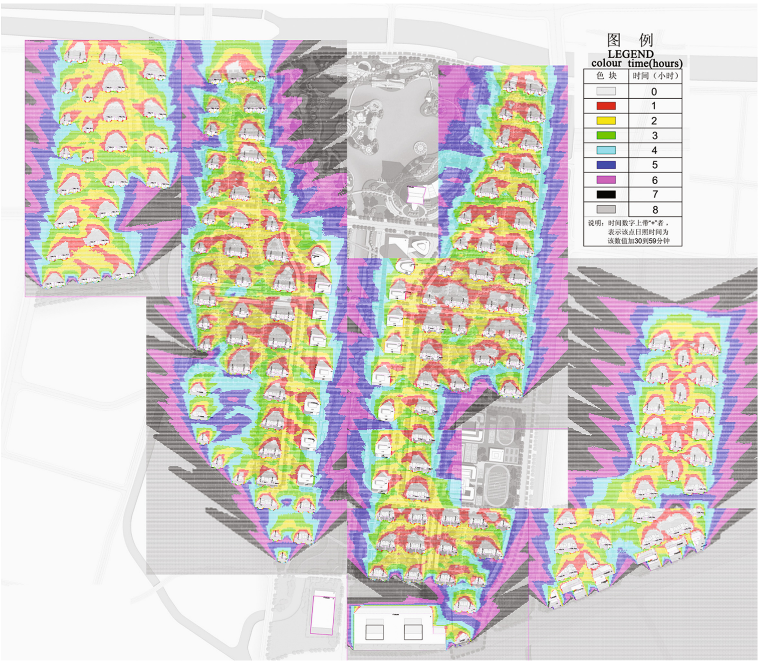

Fig. 5. Jinan Riverfront District North lake area conceptual design. Sunshine analysis.

Sunshine analysis

Sunshine spacing refers to the minimum distance between the two rows of south-facing houses, in order to ensure that the rear houses in the winter solstice (or large cold days) to get at least 2 h under full sunshine (sunshine) and to keep the minimum distance. In China, the use of different functions of the building has a corresponding sunshine time requirements. The designer can adjust the spacing between the corresponding buildings and the height of the building through the sun analysis to meet the design requirements (Fig. 6).

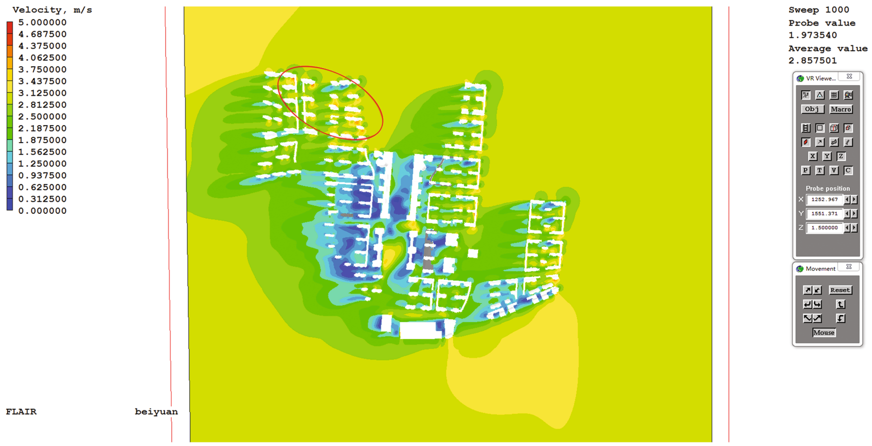

Fig. 6. Jinan Riverfront District North lake area conceptual design. Distribution of man - line height wind speed in winter wind direction.

Line height wind speed in winter wind direction

This program satisfies the requirement that the depth of the building is about 5 m/s in the area around the building, since the north side is relatively open and the red circle in the winter will have a high wind speed. These locations will have a strong sense of wind blowing, which reduces the outdoor comfort, yet this situation can be improved by planting trees and shrubs (Fig. 7).

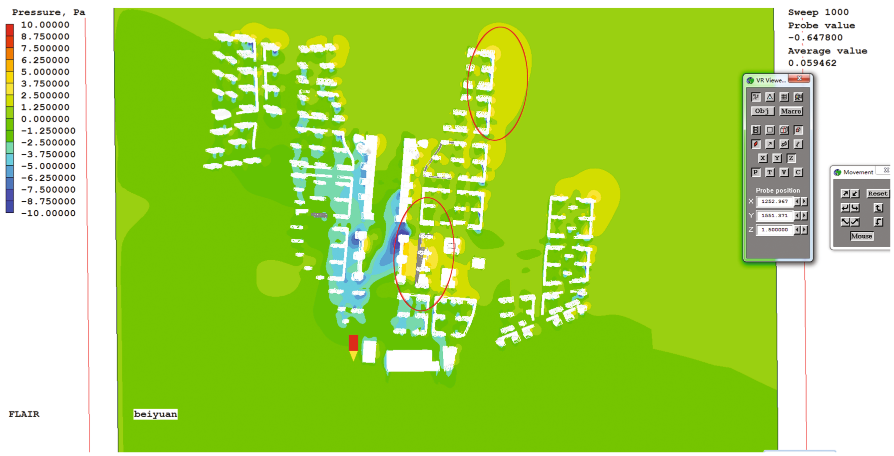

Fig. 7. Jinan Riverfront District North lake area conceptual design. Line height wind pressure distribution in winter

Line height wind pressure distribution in winter

The red circle marked the location of the front of the wind and the wind behind the face of the pressure difference is large, and will penetrate a lot coldness, leading to the consequence that the winter heating load will be larger. Hence the latter part can be ameliorated through improved building insulation practices, thus solving this problem (Fig. 8).

Fig. 8. Jinan Riverfront District North lake area conceptual design. Line height wind pressure distribution in summer

Line height wind pressure distribution in summer

Red circle marked the location, due to high-rise buildings, will result in inadequate building ventilation. The wind speed on the back is 1 m/s maximally insofar as it will produce hot feeling. The approach is to improve the situation by building sinks and increasing vegetation (Fig. 9).

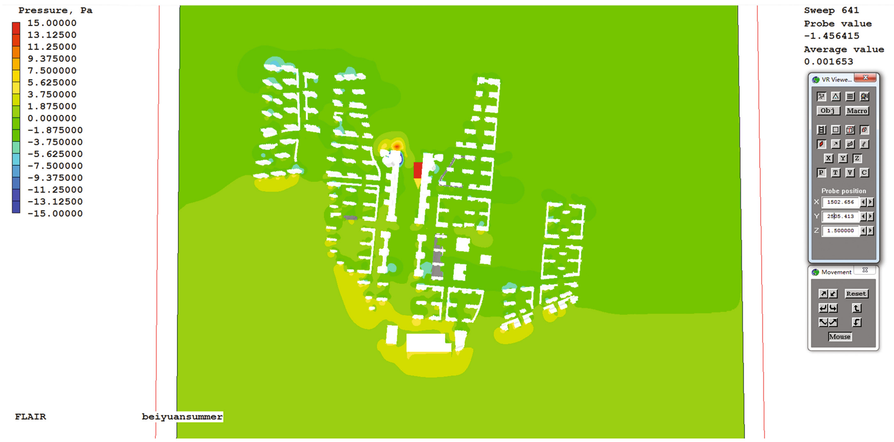

Fig. 9. Jinan Riverfront District North lake area conceptual design. Line height wind pressure distribution in summer.

Line height wind pressure distribution in summer
Most of the building's front and rear pressure differences are greater than 1.5 Pa, which can satisfy the room's natural ventilation requirements in the summer. In order to maintain a good ventilation rate, you can use natural ventilation to cool (Fig. 10).

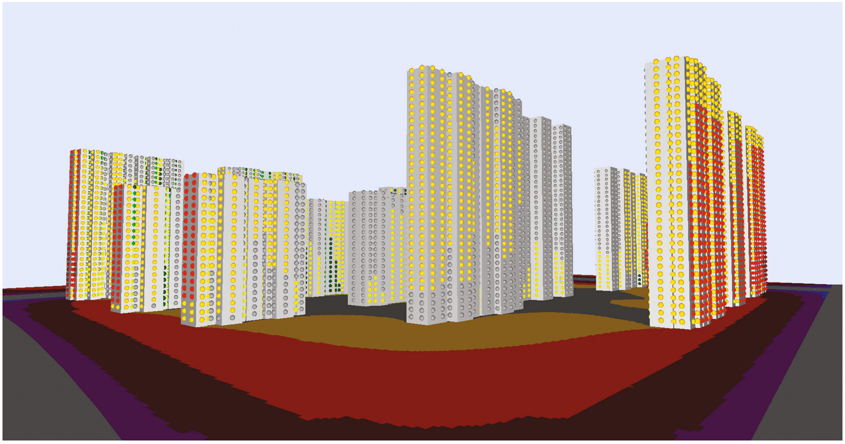

Fig. 10. Jinan Riverfront District North lake area conceptual design. Noise analysis.

Noise analysis
Before planning, it is necessary to predict whether the surroundings will be affected by the surrounding noise source and then avoid noise pollution as much as possible by adjusting the building plan. Through the analysis concluded that the building adjacent to the road facade noise is relatively large, in order to control the surrounding noise, in this building facade need to do noise treatment.

5 Conclusion

The presented example shows that the use of BIM (Building Information Modeling) is an effective tool for the urban planning and design.

By using BIM, the benefits are prolific:

- Better planning for smarter more sustainable environments.
- Better share digital design information, geospatial data, infrastructure models and other documentation among staff and project stakeholders.
- Better coordinate with architects, engineers, contractors and others.
- Use that information to model, analyze, visualize and accurately predict performance, appearance and cost.
- Reliably deliver projects faster, more economically and with reduced environmental impact [3] (Fig. 11).

Fig. 11. Jinan Riverfront District North lake area conceptual design. Project renderings.

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Requirements Engineering as a Tool for Sustainable Architectural Design

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Abstract. The paper presents options for using requirements engineering in architectural design and its significance for the introduction of sustainable development principles in architectural practice. The primary question in architectural design is whether an object actually does best satisfy the needs of users. Does it satisfy energy efficiency requirements? Is it in line with the social and landscape context? Are the requirements not contradictory, are they complete and how are they to be verified? It should be remembered that stakeholders usually have different requirements of design process, stemming from their diverse needs and expectations. That is why a systemic association of design requirements with user needs, taking into account sustainable development principles is important. A significant element of the presented approach is an identification of the technical, organisational, spatial and functional as well as use conditions, which have to be satisfied to comply with the aforementioned requirements.

Keywords: Requirements engineering · Design · Architecture · Sustainable development

1 Problem

The problem of rationally defining design requirements has assumed a particular significance in modern investment practice. It was already pointed out in the 1960s, that correctly formulated requirements (in the form of design guidelines) have a significant impact on the investment process and its functional outcome.

At that time, the "requirements engineering" phrase was not commonplace, and design requirements were most often committed to paper in the form of a "functional and use programme", which constituted the basis for commencing design works. On that basis architects further specified the requirements in consecutive design work stages. The requirements assumed a hierarchical structure, starting from the initial functional and use programme, through subsequent project execution stages (concept, plans and specifications, detailed design). Each subsequent stage of works entailed a more precise definition of the requirements as set forth in the previous stage. It should be emphasised that in accordance with this outline, requirements formulated at the earliest stage, or programme objectives and architectural concept, had the largest impact on the final

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outcome. Further design process stages constituted an elaboration and refinement of the requirements contained therein.

In investment practice, the manner for formulating functional and use requirements is set forth by the standards on the detailed scope and form of building design documentation, technical specification performance and handover of construction works and the functional and use programme.

In accordance with this provision, design requirements entail a description of the final use designation of the object in question (its dimensions and scope of construction works) as well as the basic technical, economic, financial and functional and use parameters expressed using area - volume indicators.

Such an approach corresponds with the worldwide practice established in the 1970s of creating specification requirements as the basis for design works. These requirements were formulated by the ordering party in a descriptive form, in tables, sometimes using attached diagrams and drawings. It was possible to divide them into two groups:

– Requirements (specifications) of a prescriptive character, describing in detail the size of the building, material solutions to be applied and the necessary system and technological elements.
– Requirements of a parametric character, aiming to achieve the assumed functional and use parameters, best efficiency and performance. Such an approach assumes that a building is to satisfy a priori operational requirements such as energy efficiency, without defining the design solutions, tools or methods through which those requirements are to be satisfied. That ensures the freedom to develop new design methods and innovative solutions, but also obliges to accurately assess and control throughout design process and performance of construction works [2, 5]. Thus a designer is free to choose structural and material solutions in such a manner that the use and functional parameters defined by the ordering party as well as the requirements stemming from building regulations are satisfied in the most efficient manner.

Both when it comes to the prescriptive type specification as well as the parametric (task oriented) specifications, the “ordering party” played a major role. The phrase “ordering party” is understood to mean a legal person (institution, business) financing the design.

When it comes to large investments (particularly those financed using public funds) it is significant to differentiate between the “ordering party” (the entity financing the design) and the “user” (or design beneficiary”).

In the 1980s it was noticed that requirements formulated by an ordering party do not always satisfy the expectations of future users. Then, expectations of actual future users of the project began to be taken into account in formulating requirements. For example, in residential projects the developer is most likely to be the “ordering party”, and actual users comprise persons who purchase properties from it and will subsequently reside therein.

The prevailing discrepancies between the ordering party’s and the users’ requirements have led to an improvement in the requirements formulation system, in a manner which takes into account market segmentation, consumer profiles of users and their resultant needs and expectations. The Post-Occupancy Evaluation (POE) [16, 18] quality assessment method in architecture, developed by Preiser, Rabinowitz and White played a significant role in this approach.

In the 1990s it was noticed that the expectations of end users (or the direct beneficiary) overly restrict the scope of design requirements, as they fail to take into account significant elements of the entire requirements system, which is made up of elements such as object management, object lifetime cycle, object's environmental impact, energy efficiency, urban planning and social contexts, transport connections, options for changing the spatial structure as a result of new market needs.

At that time, the sustainable development concept became an important criterion in formulating design requirements, which took into account the spatial, social, financial, natural and cultural contexts.

Standards determining a building's environmental impact are an example of such. These include:

– PN-EN 15643-1, PN-EN 15643-2, PN-EN 15978 (within the scope of environmental assessments),
– PN-EN 15643-3, PN-EN 16309 (within the scope of social assessments),
– PN-EN 15643-4, prEN 16627 (within the scope of financial assessments).

These standards cover the following groups of requirements:

– parameters which describe environmental impact (taking into account 6 quantifiable parameters),
– parameters, describing the consumption of resources (taking into account 10 quantifiable parameters),
– parameters pertaining to the quantity of waste generated through the product's or building's life cycle (taking into account 3 quantifiable parameters),
– parameters assessing the building's life cycle (Life Cycle Assessment), so called output streams (taking into account 3 quantifiable parameters).

Another document which follows this requirements system is the "CEN/TC 350 (Committee Europeen de Normalisation/Technical Committee 350) - Sustainable Construction" horizontal guidelines. The guidelines cover a requirements system necessary to design energy-efficient buildings, with low environmental impact, which satisfy the needs of users subject to lowest costs throughout the life cycle of the object.

This method for defining requirements is in accordance with the "Building Performance Evaluation" (BPE) method developed by Preiser - evaluation of buildings (functional) by comparing design requirements with the final outcome, from the investors' and users' point of view [19].

In general, BPE consist of three elements:

– checking the functional performance of buildings and in particular identification of problems associated with on-going building usage and maintenance,
– tests associated with energy consumption (lighting, heating, air conditioning) and a comparison of these results with the requirements which constitute the basis for design works,
– satisfaction assessments amongst people using the building in the form of questionnaires and user interviews.

Similar solutions are in place in the USA, where the American Institute of Architects (AIA) created a new standard for design works agreements, known as Integrated Project Delivery (IPD). This standard aims for such a cooperation between investment process participants, so as to ensure that the design outcome generate a permanent (not subject to depreciation) profit for the ordering party and satisfaction to the users, and at the same time to lead to a reduction in the quantity of waste, reduction in water and energy consumption and to provide maximum efficiency at all design process and investment execution stages.

BIM (Building Information Management) is the instrument which combines the requirements of integrated design, with standardized sustainable development requirements and the building's life cycle. Whereas is should be emphasised that initially the BIM abbreviation stood for building information modelling in digital format, automatically depicted in plans, cross sections and building visualisations. Whereas Building Information Management establishes a new quality in programming, implementing and monitoring design requirements, providing all process participants full access on an on-going basis to models as well as multi variant consequences simulations for the formulated requirements at subsequent design works stages (within the environmental, social and financial scope).

As a result of applying BIM (Building Information Management), conflicts which occur in the requirements formulation process were noticed which stem from:

- design objectives not clearly specified,
- conflicts between social and individual interests,
- lack of agreement and participatory cooperation,
- shortages within the scope of integration and harmonisation of financial opportunities with the planned functional outcomes,
- skills gaps and incorrect requirements formulation methodologies,
- requirements not adjusted to social, cultural and natural conditions of the given location,
- promotion of arbitrary decisions instead of taking into account sustainable development in formulating design requirements.

2 New Approach to Design Requirements

In the 2000s, when defining design requirements, the phrases "ordering party" and "user" began to be replaced by "stakeholder". In this meaning, a stakeholder is an entity representing the local communities, interest groups, consumer associations, NGOs, public authorities, businesses financing the design, design offices, etc. Their interests are most often contradictory, which may result in the formulation of conflicting requirements in relation to the planned investment. Sometimes in formulating requirements, there is overwhelming pressure to subordinate "the common good" to individual interests (most often financial) of investors or designers, without taking into account further and broader consequences.

In conjunction with the conflicts of interest which appear, negotiation methods and social participation in formulating the requirements system become important, particularly in designs, which significantly impact the economic and social environments and landscape transformation [17].

An inseparable element of social participation in the design requirements formulation process is the stakeholder communication process. Here, a more pronounced inclusion of local communities into the requirements definition process is important, through which it attains a "participative" character. Many authors point out that such a type of participation may be interpreted as an element of equilibrium which has a positive impact on the quality of articulated requirements.

In this context, requirements management methods based on the partnership equivalence principle, stakeholder analyses, stakeholder analyses matrices and analyses of communication amongst stakeholders started appearing in "project life cycles" [4, 13, 21].

The phrase "requirements management" was coined to describe the process of formulating, checking and implementing requirements within the scope of correctness, validity, credibility and completeness [8].

Requirements management started implementation design life cycle planning methods and design assessment and monitoring techniques. Tools such as the following are used here (Fig. 1):

– DuPont analysis - Critical Path Method, (CPM) [14],
– Work Breakdown Structure (WBS),
– Program Evaluation and Review Technique (PERT),
– Responsibility Assignment Matrix, (RAM) [23],
– Cost control methods - earned value (EV) analysis [11],

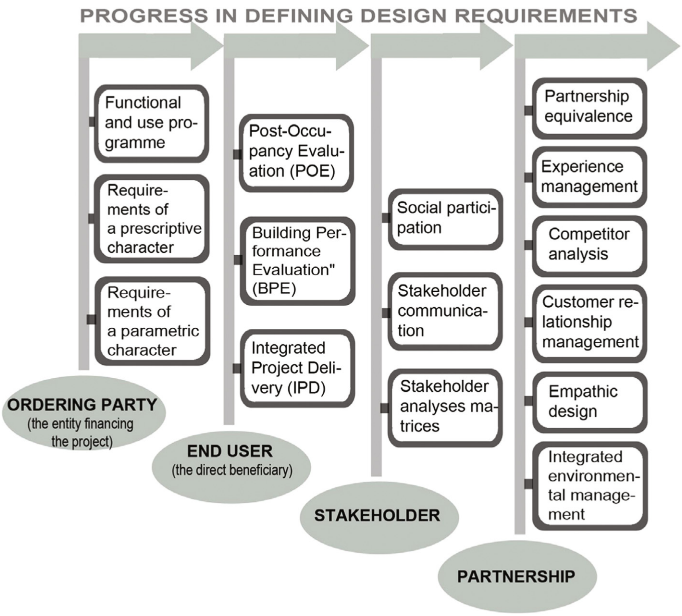

Fig. 1. Diagram of development of engineering requirements in architectural design (progress in defining design requirements).

– Precedence Diagram Method, (PDM) [15].

More up-to-date tools include:

– Experience Management, (XM) [23],
– Competitor Analysis, (CA) [3],
– Customer Relationship Management, (CRM) [6],
– Empathic Design, (ED) [1],
– IBM Rational DOORS [9],
– the Kaizen method [12],
– ISO 14000 Integrated Environmental Management Systems,
– Neuro-Design [7].

3 Systemic Faults

Many attempts to improve requirements failed to generate satisfactory results because stakeholder postulates were unnecessarily limited or incorrectly interpreted, which led to incorrect definitions of design specifications. In this context the following are significant:

– stimulating and encouraging the disclosure of requirements at early design process stages,
– specifying and refining requirements in subsequent design stages,
– requirements quality control,
– coordination of the requirements system combined with their implementation.

It is thought, that these four actions are a necessary condition for correct requirements management [8].

Based on my own investment practice I can state that correct formulation of requirements (particularly with reference to a design objective and completion time) may be problematic, particularly if the ordering party does not have extensive experiences stemming from similar undertakings in the past. Also, there are many problems associated with requirements system elements which are difficult or impossible to foresee. An example here is the requirement to obtain the necessary opinions and documents from officials, who, for various reasons, may delay making binding decisions.

Such causes lead to expiry of designs and the need to draw up design specification anew. Increasing costs and/or time as compared to that specified in the initial design objectives are an inevitable consequence of such circumstances. Sometimes, an approach which assumes maintaining the required costs and time at a certain level subject to a reduction in qualitative or quantitative requirements which a project should satisfy (for example limiting the floorspace or material standards) is an alternative. For example, that strategy may find application when there is a risk of losing the entitlement to public fund grants associated with annual local government budgets.

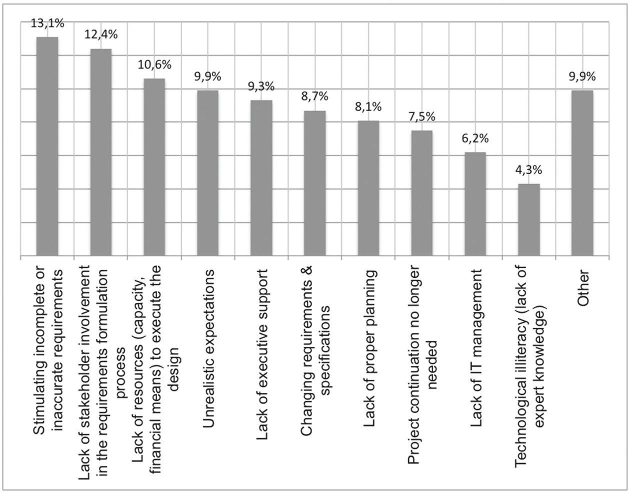

Fig. 2. Comparison of top causes of design failures. An inaccurate requirements has been found to be essential to design failure, based on [22].

From this perspective, technical problems are not the most common causes of design failures. According to The Standish Group [22], the causes of these failures are: stimulating incomplete or inaccurate requirements, lack of stakeholder involvement in the requirements formulation process, lack of resources to execute the design, unrealistic expectations, lack of executive support, changing requirements and specifications, lack

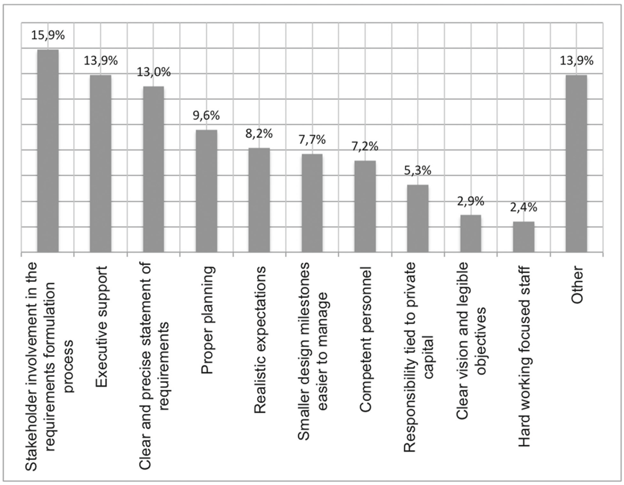

Fig. 3. The percentage share of the factors affecting the success of design. The stakeholder involvement in the requirements formulation process has been found to be essential to design success, based on [22].

of proper planning, project continuation no longer needed, lack of IT management, technological illiteracy (see Fig. 2).

Whereas success factors were as follows: stakeholder involvement in the requirements formulation process, executive support, clear and precise statement of requirements, proper planning, realistic expectations, smaller design milestones (easier to manage), competent personnel, responsibility tied to private capital, clear vision and legible objectives, focused staff (see Fig. 3).

The causes for challenging designs once they are complete are also interesting: lack of stakeholder input at particular design stages, incomplete requirements and specifications, changing requirements, lack of executive support, technology incompetence, unrealistic expectations, unclear objectives, unrealistic time frames, new technology (see Fig. 4).

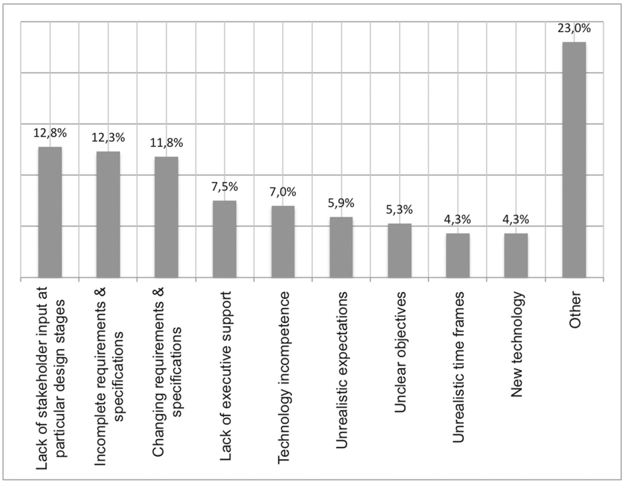

Fig. 4. The percentage share of the reasons for which the design is questioned after completion. The most important cause for challenging design is lack of stakeholder input at particular design stages, based on [22].

The above surveys show that involvement of stakeholders in the process of specifying requirements, executive support as well as clear and legible requirements are the main causes for success in the performance of designs.

Research by Hull, Jackson and Dick [10] confirms this, according to which correctly formulated requirements constitute a basis for:

– project planning,
– risk management,
– validation,
– necessary compromises,
– monitoring of possible changes.

4 Summary

As demonstrated by the presented deliberations, the requirements management process requires professional knowledge and extensive experience, which obligates designers operating within a competitive design services market to continually improve their skills. In this context, design firms are faced with a problem associated with the relationship between:

– design quality,
– time frame,
– costs.

In domestic design practice a view prevails that high design quality is inextricably associated with a high price and extensive time frames. Such an approach may partially be justified by the assumption that talent and the creative potential of a designer play a significant role in architectural creation, which should be unaffected by organisational and financial factors. A consequence of such an approach is the assumption, that a change to one of the factors (e.g. design costs) affects the others (time frame and quality).

However, in the opinion of many authors [10], contemporary competition on the global design services market, enforces a one directional change in the relationships between design quality, cost and time frame. In other words, designs of a better quality, within a shorter time frame and for less. Despite many difficulties - many architects who regularly beat the competition on the global design services market identify with this rule. Requirements management abilities present a realistic chance for faster-better-cheaper projects.

It's clear to see that the implementing requirements engineering principles to the design process requires even more advanced knowledge. This pertains both to teams preparing an investment programme as well as design firms. Unfortunately, domestic experiences point to insufficient knowledge and low awareness within this scope. A series of failures depicting this phenomenon could be presented.

A symptomatic manifestation of a low state of knowledge and abilities within the scope of implementing requirements engineering methods is the fact that as a rule Polish architectural firms are failing to win contracts from foreign firms on the global significant architectural investments market. Whereas a widespread phenomenon of hostile take-overs is apparent on the domestic design services market by foreign firms, which put the "faster - better - cheaper" principle into practice on the basis of advanced requirements management tools and methods.

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Changes in the Contemporary Public Space: Libraries

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Abstract. Contemporary library is no longer silent study hall filled with books and limited, small work-spaces, complemented by huge, closed storage rooms for almost inaccessible books. It is more of a welcoming public space, dedicated to culture and opened for all users. Designers create interesting forms, bringing people together and at the same time symbolizing knowledge and wisdom. The workspaces are ergonomic and provide people with sufficient space and friendly environment, allowing spending a whole day in the interior. This article was devoted to present findings on changes that have occurred in the contemporary public space of libraries, aiming at architecture humanization. The studies were carried out on examples, i.e.: "Harold Washington Library Center" in Chicago (USA), TU Delft Library (Nederland), Library of Faculty of Architecture of TU Delft (Nederland), Wroclaw Municipal Library "Grafit" (Poland), Library of Faculty of Architecture WrUST (Poland), "Muntpunt" library and information centre Brussels (Belgium), etc.

Keywords: Libraries design · Human design · Open access architecture space · Design of public use buildings · Architecture for all

1 Introduction

On the contrary to recently predicted paper decay, nowadays the libraries are being willingly built, becoming favorite places of pupils, students and cities residents all over USA and Europe. As Thompson [1] marks even during 1980s economic depression there where around sixteen new universities' libraries constructed per year in USA and around 100 existing buildings had been extended or restored. Current digitalization of many human resources did not stop the growth or development of reading culture, and books as well as archive materials stay still the most important source for researchers and experts of many scientific fields. Moreover, architecture of public (national, regional, municipal, local or even small) and universities' libraries, becomes a strong element of cultural identity of country, town or village and in many occasions turns into element of local pride [1–3].

Contemporary library (also university one) is open, public accessed building, which is a novelty, for in the past they rather were closed and silent, devoted manly to work and education [1, 3]. Today they are vibrant, fully community serving edifices, where

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people can gather, talk, exchange and communicate ideas, introduce workshops, find temporary welcoming shelter, use computer, WiFi or simply meet and spent quality time with others [2, 3]. Contemporary municipal or university library is a space, which introduces Gehl's rule – so far meat for external public spaces – of realization of needs for: **contact, knowledge and stimulation** [4].

This article was devoted to presenting findings on changes that occurred in a contemporary libraries design of public spaces. There was a special focus on the ergonomic and humane design, aiming at bringing people together.

1.1 Scope, Aim and Method

Scope. The research have been carried out on European and American examples of municipal and universities libraries, that have been recently erected and follow pattern of open access spaces, meant for all interested users. The case studies where subjectively selected among many studied interesting examples, to represent in a possibly best way changes that were noted. Moreover, objects were analyzed in situ, hence capturing real circulation and working scheme of space, as well as overall character and climate.

It can be stated, that libraries studied were of a medium scale. Of course, the volume will be different depending on collection: starting from books, audiobooks, going through maps, manuscripts, newspapers, genealogical trees, diaries, letter of graphics, photographs, videos, games, vinyl-records, CD-s, computer databases of each possible type, ending at toys [1–3, 5]. Therefore, the article was restricted to one-type collection, mostly books, supplemented by multimedia at particular cases.

Also encountered were different levels of storing, from national to single institutional level. However, most of the libraries in these case studies have been connected to only one, singular branch of culture or science, with one localization or institution.

The research have been strictly limited to public accessed and opened spaces and all storage or borrowing processes were omitted. Such procedures are complexes technologies and could not be presented in a single article.

Aim. Outcome of following research were focused on new humane qualities of spaces and devotion to strengthening community sense in society, at the same time enabling thoughts and ideas exchange among people. Moreover, it was important to show process of changes and transformation in architecture connected do both more commercial and cultural role of library in nowadays life of individuals.

Method. Researches were led with the use of two sources – literature, mainly for: theory, analysis, synthesis and in a discussion part and – case studies, for: presenting of examples, comparisons and discussion. Conclusions have been obtained with use of critical analysis and synthesis.

2 Discussion

This new approach to space treatment is connected to changing ways of library functioning, in which they follow similar rule as commercial institutions and not only government-financed cultural organizations. Their new role is to attract wide community, and serve common people, not targeting only towards book lovers, specialists, experts and students, who are bound by their profession [3].

Aforementioned changes manifest themselves as well in extreme transformation of external facade design. Traditional library received monumental elevations, with columns, symmetry, huge stairs, and all other representational features [3]. Nowadays, libraries still carry public use building quality, but with large glass shop-like windows (openness), high quality materials (attraction), designer solutions (attractiveness), all in user friendly, more casual and most welcoming scale and form. (Fig. 1) Such approach stays in accordance with Kowalczyk's statement that library must "look into the future", for it is "avant-garde" of culture [2].

Fig. 1. Two facade design methods, from left: "Harold Washington Library Center" in Chicago (USA) in traditional, monumental model (opened in 1991), on right: libraries in Delft following contemporary architectural patterns: DOK Centrum (in the middle) and TU Delft (on right). [Photo J. Jablonska]

2.1 Elements of Open Access

Reading Room and Shared Space. The one and always existent component of a library is large, free-space and usually high reading room, which was present historically and is an obligatory nowadays. It is important that structural span of this hall is wide and long, so pillars will not disturb clear view across. Common elements of space are: open shelf book access, seating between or among shelves, work tables (usually of a large multi-users measurements), open media access in a form of computers with Internet and free access to WiFi (Figs. 2, 3 and 4).

Seating arrangements can be of very interesting, unique forms, being element of interior design. They provide comfortable space for casual reading (not necessary working). If they are flexible, they can be used in varied settings, i.e. for reading by visiting author.

Fig. 2. Two types of public access spaces in contemporary libraries, from left: entrance hall of the "Muntpunt" library and information centre Brussels (Belgium) and reading room in Wroclaw Municipal Library "Grafit" (Poland). [Photo J. Jablonska]

Fig. 3. Arrangements for reading room, from left: different types of lounge seating, skylights and lamps in form of glowing squares, both at Wroclaw Municipal Library "Grafit" (Poland). [Photo J. Jablonska]

Fig. 4. Contemporary space treatment in a Faculties of Architecture (FA) libraries, from left: large common work spaces, open shelves system for periodicals and free access computers at FA WrUST (Poland), on right: open bookshelves and interesting check-out desk design at FA of TU Delft (Nederland). [fot. J. Jablonska]

The open book shelf, so called "open stack" concept – popularized during 1930s and 1940s – allows readers to use books freely inside the reading room space, and the idea have already been used for quite a time, especially for periodicals. It must be mentioned, that this type of arrangement requires sufficient distance between furniture – 1,80 m, which takes much more surface, than in a "closed stack" solutions. Never the less, it is most attractive and effective for users (i.e. allows random or interdisciplinary book findings). Also we observed lowering height of the bookstands, due to accessibility for people moving with the use of wheelchair. In this case, the possible reach range for book from shelf, is assumed between 1,20–1,50 m for an adult, depending on the anthropomorphic features of individual [1, 6].

While large common work tables (measurements ca. 2,5–3,5 m per 1,2 m) are new and have replaced traditional, narrow single-user work desks (0,9 m per 0,6 m), in the past arranged in long rows (economical surface use). At the same time, the shape may be diversified from circular work surfaces even to individually designed forms [1].

The public space must be attractive and magnetic for a potential user. Thus, there can be found: the unusual spatial geometry, like in the Library and Learning Centre of the Vienna University of Economics and Business by Zaha Hadid Architects, or "seating-architetural-shelves" of Vennesla Library and Culture House by Norway Helen & Hard or the "hammock" space, made from large net in Library of Muyinga, Burundi (Africa) by BC Architects. Common characteristic feature of all these spaces are unusual, original and encouraging design of: shelves and seating. The latter usually arranged as lounge furniture. The other factor is flexibility or as Thompson [1] would define adaptability of space, enabling interior architectural rearrangements and transformations, both due to changing users' needs and renewals. Therefore, an open-plan reading room with additional interiors, is so valued for library solutions [1, 6] (Figs. 2, 3, 4, 6 and 7).

One of the outcomes of such approach is usage of a full-walls glazing or – depending on building structure – evenly distributed skylights. Only these types of solutions allow for possibly the most uniform natural light distribution along all reading room. Hence, contemporary facades covered with glass double skin, are not only a manifest of new design but follow functional demands of interior plan (Figs. 1, 2 and 6).

Hall and Additional Rooms. The reading room can be occasionally connected to multistory hall of the building – depending on an architectural design – which will be fitted with information center, workshops, exhibitions zone or additional function rooms or spaces [5]. Analyzed space is also linked with educational and cultural role in a given society (meetings with authors, readings, conferences), thus common element is presence of conference and meeting rooms. They are usually of minor type, equipped with large central table, basic multimedia appliances, like: computer, loudspeakers and projector, as well as additional presentation utilities: white, black and cork boards, flip charts and occasionally touch screen interactive boards and monitors. For multimedia collections, there can be organized: projection, audiovisual and listening rooms. Public zones are often supplemented with cafeterias, connected to magazine reading rooms and social media links, that attract people, especially after official library opening hours. That helps to build cultural society based on intellectual discussion and vibrant knowledge exchange [5, 6].

Technology. Computer equipment and WiFi presence is a nowadays basic equipment of each library, though it is still quite new concept dated back to 1990s [6]. Thompson [1] turns also attention towards different types of users and their professions, suggesting that some of them might demand even more complex solutions, like: multimedia equipment, graphical station, graphical tablets, i.e.: artists or graphics. Despite this fact, all worktables must provide possibility of using personal laptops, notebooks and tablets, therefore must be equipped with electric and logic slots [1, 6]. Moreover, it must be stressed that computer technology is subdued to fast technological changes, world goes through dynamically, thus may require quick replacement or upgrade. At some cases this might influence furnishing of space.

Greenery. It is worth mentioning that all of these public spaces can be closely connected to a green recreation zones, designed if site options allow. Among others, libraries are connected to: inner (courtyard or side) gardens, green usable lawns and roofs, cafeteria or seating terraces, parks, different greenery arrangements (sometimes small plats in pots). The need for providing plants in libraries interiors is also observed in a form of interesting installations, similar to Zen, bamboo (i.e. at the University of Arizona, Helen S. Schaefler Poetry Center) or rock contemplation gardens. Solutions, which bring not only a quietness and almost spiritual value to the rooms, but also provide beneficial microclimate to books and users. The greenery is treated by designers as continuation of interior to exterior (or in reverse) as it was designed in town library in Opole (Poland) [5, 7] (Fig. 5).

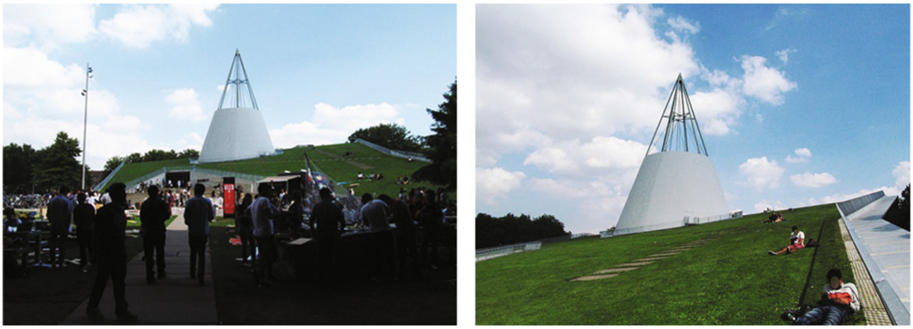

Fig. 5. Green roof-lawn in front of TU Delft (Nederland), on left: workshops, on right: recreation. [Photo J. Jablonska]

2.2 The Structural Solutions for Open-Space Large Reading Rooms

Libraries are objects of technologically complex function. Due to the structural and architectural solutions, one can distinguish three main zones: administrative zone (offices), collection storage zone and collection sharing zone (reading room). The first two of these zones are characterized by a long-established functional scheme, strictly subordinated to the demands of functionality.

In the case of the storage zone, structural arrangement is generally orthogonal, with modular grid adapted to the typical shelving's modules, allowing for maximum use of space. Due to the large live loads occurring in this zone, the construction is usually relatively massive. The reinforced concrete, or composite, steel-reinforced concrete structures are preferred due to fire protection requirements.

Administrative zone, clearly separated in older buildings is now minimized. This is facilitated by the use of electronic technology. This zone now occurs frequently as a dedicated portion of the collection sharing zone, but only in large libraries as a separate part. In the latter case, architectural and structural arrangements are similar to those of typical office buildings. Modular grid has a moderate span of approx. 6.0 ÷ 7.5 m. Due to the fire and acoustic requirements, structural system is usually based on reinforced concrete.

The most dominating in architectural and structural terms area is the collection sharing zone (reading room). It is very often the object's hallmark and its representative part. The tendency to such shaping that zone appears already in earlier objects. In the Mannerist building of the Laurentian Library in Florence (Biblioteca Medicea Laurenziana) designed by Michelangelo Buonarotti in the thirties of the sixteenth century, reading room is shaped in a form of an elongated rectangle covered with richly decorated, coffered wooden ceiling. The hidden treasure of this room is a terracotta floor mosaic of complex geometric pattern, also designed by Michelangelo. It remain inaccessible, covered by wooden bookrests (*plutoi*) and benches. It was exposed for a short time few years ago during conservatory works. Added in the mid-nineteenth century annex to the library, which also served as a reading room has been designed as a rotunda with interior reminiscent the Roman Pantheon.

The form of a large domed rotunda was particularly keen used in the reading rooms of libraries created in the nineteenth century. The wonderful examples are reading room of the Library of Congress in Washington and former reading room at the British Museum, which recently became the basis of iconic doubly-curved glazed lattice-shell of the Queen Elizabeth II Great Court, redeveloped to a design by Foster and Partners.

In the reading room of TU Delft library (Figs. 5 and 8), main hall, partially hidden under the grass roof, manifests itself by a slender cone piercing the roof. This steel structure, which imparts character to the whole interior, houses inside several levels of rooms with places to work for library users. At the same time it acts as the communication facility due to light steel catwalks linking it with galleries and enabling access to collections.

One of the most interesting contemporary reading rooms has been designed by the Norwegian office Snøhetta within the Bibliotheca Alexandrina, contemporary continuator of the Ancient Library of Alexandria. Huge, round room is tilted becoming an inherent part of the Mediterranean Sea coast. Inside there are eleven cascading terraces, with an area of 20 000 m^2. Under the terraces of the reading room magazines of library collection are located. The building is covered with a partly glazed roof, divided into triangular facets. The roof structure is designed as reinforced concrete grid, supported on slender concrete pillars with elongated and enlarged heads, which refer to the heads used in ancient Egypt.

Architectural and structural forms applied in libraries, especially in reading rooms confirms that public buildings, particularly prestigious, allows use of solutions that go far beyond mediocrity (Figs. 6 and 7).

Fig. 6. Library of the Technical University in Cottbus, proj. Herzog and De Meuron (2005), with an impressive structural solutions. [Photo R. Tarczewski]

Fig. 7. Library of the Technical University in Cottbus, proj. Herzog and De Meuron (2005), structural details, from left: spiral staircase, open reading room, open stack area. [Photo E. Trocka-Leszczynska]

3 Case Studies

3.1 TUDelft Library

TUDelft library (designed by Mecanoo, finished in 1998) is a great example of open building, meant for all people [6]. The usable space was structured and staked above each other around huge, opened hall and functioned-filled cone. The hall is a multi-story space for everyone to enter, due to which, it is treated as loud zone. It contains: information and check-out desk, administration, large tables for work in groups and meetings, work tables, study sets. The hall is surrounded by open-access bookshelves (in a steel-frame structure), which create levels, served with galleries, elevators and stairs [6]. The cone – quite zone – provides necessary intimacy and silence, and contains chairs, tabled, as well as other seating areas. It is meant for reading, studding, workshops and group work (Figs. 5 and 8).

Fig. 8. Library of TU Delft (Nederland), from left: common hall – loud zone, middle: open book shelves and vertical communication, on right: quiet work and workshop spaces in the cone. [Photo J. Jablonska]

Familiarity. The strongest statement of resigning from monumentality in the library is designing a green public accessed roof instead of front facade. It is replaced by gentle, slope with grass as a continuation of front lawn. The idea was to provide space for human interaction [6]. The main entrance seems to be a small "crack" in this green surface. The reminiscence of monumentality was kept only on back façade, and it still is more contemporary and up-to-date, then serious. It is worth mentioning that a green, garden roof space can also be found at: Warsaw University Library, Poland by Marek Budzyński and Zbigniew Badowski (opened in 1999).

Next aspect of creating familiarity in this building is usage of non-standard for library colors and materials. Thus, an orange floor and wood cladding is contrasted with raw architectural concreate exposure as well as natural steel structure. Also usage of iconic cone – piercing across whole interior – is not very typical solutions. Due to overall arrangement students and non-academic visitors feel welcomed in space. Hence, building is vibrant and lively all through the year.

3.2 The Grafit Library Municipal Library in Wroclaw

The interior of a library have been fitted into a community building, which transformed from initial shopping center into an office and cultural space (exhibition, workshops, offices) due to an economical issues. Project was implemented in 2014 and stayed an effect of an architectural competition, won by Buck.Studio. The open-space interior was wrapped-around seating arrangement of staggered configuration cubes. Colorful design is especially attractive to children, thus a low and "funny" bookstands with kids literature surround contemporary "playground". Each side of reading room is devoted to other activity: administration with small meeting rooms and book check-out, "open stack" with seating for young adults and adults, study area and computer-multimedia zone on the other (Figs. 2, 3 and 9).

Fig. 9. Wroclaw Municipal Library "Grafit" in Wroclaw (Poland), from left: seating in function of exhibition space, the island for children with bookstands, armchairs for relaxation. [Photo J. Jablonska]

The idea for space was: flexibility, friendliness and possibility of stimulation of users for self-arrangement of space, due to occurring activities and functions [8]. Due to flexible furniture arrangements, bright colors exposed at the background of white walls and ceilings, and friendly atmosphere this municipal small library is full of users, all through the day.

4 Summary

Contemporary libraries are treated as an important, valued element of cites or village urban environment and a highlight in structure. The buildings are open to the user and surroundings both in a symbolic and physical way. The open-access public space is a center of librarian architecture and states for usability of all facility. "Open stack" bookshelves distribution, unusual seating arrangements and new shapes of common worktables are much more appealing and magnetic for readers. They have also replaced economic (due to surface use) but unfriendly traditional solutions, i.e. "closed stack" and long-narrow tables. Thus, interiors became more humane, allowing creation of sense of community between users. At the same time new solutions prevent readers from disturbing each other and help to lower the stress, like it had place during moving between long tables (disturbing the work of seating people) or cuing to librarians for borrowing books (waiting, tension between standing guests). Similar role has, huge and very important novelty, in a form of greenery introduction into the library space. It provides sense of relaxation and a better quality of inner air.

As a positive phenomenon, the soft commercialization of the contemporary library, is perceived, as long as it is done without the harm to cultural and educational role. Due to this process, the public space is connected with technological changes – computers, WiFi, Free Internet access and social media presence (including smart PR), which enables this institutions to attract more users, also among youngsters. Thus, great library collections can reach wide society and be a classy meeting point for different individuals. It seems like a very important issue nowadays, taking into account aging of society and unwanted isolation.

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Ergonomic Solutions in Capsule Hotels?

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Abstract. World hotel branch have lately (across XXI century) experienced a phenomena of popping-up capsule hotels in an exact city centres, offering travellers accommodation with economical, yet highly restricted living conditions. Only a bed and an access to a shower are offered, and in many cases, capsule use time is limited to maximum 9-hours. Moreover, in studied buildings there is no natural light accessibility, with total lack of windows to the exterior, even on corridors or halls. Users have no privacy guaranteed and acoustical conditions are highly peculiar. This article will be focusing on a question, whether spending an overnight in a capsule is comfortable and why this phenomena nowadays occurred with such strength? During case studies on examples like: Youth Hostel in Munich (Germany), Luxury Capsule Hotel in Tokyo (Japan), The One Hostel in Wroclaw (Poland), the ergonomic of layouts and capsules was studied. Also psychological conditions of such solutions were an important issue for the Authors.

Keywords: Design of public use buildings · Hotels · Capsule hotels · Capsules accommodation · Contemporary hotels

1 Introduction

Traditionally Japan built environment is very dense, thus residential surface is highly valuable [1]. Therefore, this culture developed different from European or American living standards and solutions (look: Genesis chapter). Also nowadays Japanese designers come up with differed concepts of flats, in order to take as little room as possible, but at the same time provide high quality of life. The standards are raised by the use of futuristic technology, that solves problems and provides comfort and entertainment.

It is no surprise, that temporary residence shelters in forms of a hotel or a hostel, is subdued to even more severe usable surface restrictions. Hence, in 1979 first capsule hotel – a minimal sized “drawers” (packed with technology) for sleeping and relaxation – were created [1]. Initially, meant for busy Japanese workers, soon started to be used by tourists, to finally become economical and popular solution all over the world.

This article was devoted to study on ergonomic of capsule solution, in order to understand the attractiveness phenomena of sleeping drawers. Is price factor the main

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feature? If so why did the luxurious facilities occur? Maybe there is more to this concept, as: possibility of meeting other travellers, creation of sense of the community between users, a chance for a game of a newest console, or comfortability in quick accommodation and check-out form the hotel?

1.1 Scope, Aim and Method

Scope. Researched where contemporary capsule hotels in Japan, Europe and USA, that occurred in the last 20 years period. Main focus was on spatial-functional solutions for layouts and plans, leaving out issues on localization and context. Most important where architectural solutions for interiors, with taking into account: furnishing and equipment provided to the traveller. A special focus was also placed on standard dimensions, thus ergonomics of capsules was studied.

Aim. Before any particular spatial aspects could be discussed, there was a necessity for spatial and functional analysis of solution, and further on a formation of typology of capsule hotels, which was presented in the second part of this article – as a first aim. Then, focus was placed on ergonomics of a hotel and a capsule, taking into account anthropomorphic features of different individuals.

Method. During elaboration of this studies two resources were used, firstly it was publication of books, articles and internet sources and secondly, there were conducted case studies on site. In the discussion part of the paper, there were used: analysis, practical and critical, as well as synthesis. For ergonomic part there was used mostly graphical analysis, while in conclusion comparative analysis and synthesis.

2 Genesis

2.1 The Metabolistic Roots of the "Capsule Way of Thinking"

The rapid, extensive post-war industrialization and emerging – for the first time on such a scale – environmental pollution, as well as the conflict between the demand of land for agricultural and for residential purposes, oriented thinking and activity of some architects in search of methods to solve this conflict through radical changes in urban planning. This resulted in the emergence, in the 60s of the last century, of variety of visionary groups whose program manifestos declared a new approach to architectural design.

The Metabolist group was formed by young Japanese architects affiliated with Kenzo Tange's MIT studio: Kiyonori Kikutake, Kisho Kurokawa and Fumihiko Maki, to whom later joined also the others (e.g. Noboru Kawazoe, Masato Otaka), as well as Kenzo Tange himself. Their works were first shown in a broader form during the last meeting of CIAM (Congrès Internationaux d'Architecture Moderne) in 1956.

The main postulate of Metabolists was treating the society as a living process. They saw their task in boosting its active "metabolic" development, rather than continuing the natural historical process. The task of the architect is not to propose ideal models of society, but to come up with such an organization of the space that residents can change by themselves. The Metabolists, following the ancient concept of four elements, thought that their activity should cover all types of natural environments of the planet: earth, water and air.

2.2 Implementation

In their design work they created a number of projects based on multiplication of forms, obtained by duplicating small-sized units forming burgeoning megastructure. On land they created, among others, a number of projects related to mobile and variable capsule units. Kisho Kurokawa on the base of his extensive analysis of application of the prefabrication in the housing industry, designed in 1962 the Box-Type Apartments.

In 1964, Kenji Ekuan, in the Tortoise House project (1964), explored complex systems of mobile units, which in his meant could be expanded in both vertical and horizontal direction. In 1969, in the project Yodokari Hermit Crab Capsule Lodge, he designed a mobile capsule, which can be positioned – carried by an external means of transport – even at the top of the hill.

Capsules were important and recognizable part of Metabolists' work. Kisho Kurokawa explained the phenomenon of such structures: "capsules constitute the release of building relationships with the land and are harbingers of the era of portable architecture" [2]. Example of Kurokawa's way of thinking is Takara Beautillion constructed for Expo'70. The project is a spatial structure composed of two hundred capsule elements. The individual mobile units have dimensions adapted to the transport by truck and can be connected to the system i.e. structural frame.

The best known example and the flagship realization of the trend is Kisho Kurokawa design (1972) of Nakagin Capsule Tower in Tokyo. In this vertical building one hundred forty-four capsules were connected to the two communication shafts. Individual units were designed to be replaced by new and moved, however in practice it never happened.

From this designs it was only one step more to transplant capsules into temporary accommodation – a hotel. Not necessary portable, solution was popularized world widely.

3 Definition

3.1 The Layout

In the capsule hotel there is a huge step down form – presented both in literature and practice – traditional hotel features, like: division to public accessed and private space. Also there was observed a resignation from well-established spatial-functional program, containing: entrance hall, recreation and waiting zone, reception area, gastronomy, lounges, drink bars, shops, services, technical and storage area, representational stairs and elevator lobbies, room area (private), washrooms, storages, etc [3–6]. In the typical capsule facility the functional plan is downsized to: entrance area and hall, reception or just check-in/check-out automated desk (money machine or computer stand), general communication, rooms and necessary service/technical area (depending or building requirement, administration and cleaning system).

In more luxurious units (Fig. 1) there are additional gastronomy, relaxation areas, sport facilities (depending on assumed offer) and in Japanese facilities there is a need for cloakroom, umbrella storage and slippers/shoes area. There additional elements are connected to the cultural tradition, not allowing guest to enter living area (house manners) in clothing meant for exterior.

Fig. 1. Luxury capsule hotel, Tokyo, from left: narrow but high façade of the building, the main entrance. [Photo J. Jablonska]

Moreover, capsule building will not fallow other important functional requirements for a hotel, i.e. there are usually no parking spaces, no shops or hair-dresser, also space or room height requirement declared by law documents are not full field. Yet, interestingly enough, in literature the capsule facility is still called a hotel.

Living Area. The guests' floors consist of communal: toilets, showers, sinks, capsules, shelves and closed lockers. Elements arranged in a different way in an open-space, corridor or compartments plan (Fig. 4), depending on a site disposition. The equipment may vary, however each capsule is fitted with mattress. As additional elements, there are treated: bed sheets, radio, alarm clock, TV on the top or side of capsule (or both), at some cases game console – especially in Japan [1]. Crucial is a proper ventilation for "the drawers" in a form of mechanical or air conditioning solutions. Each bed has possibility of partial closing for privacy, however there is no possibility of locking oneself in a capsule. Among popular solutions there are: curtains, rollers, shutters, blinds – all elements transparent (at least in some ways).

Dimentions. Typical measurements of the capsule are 100 × 200 × 100 cm [1], but literature mentions also 200 × 125 × 100 cm [7]. Depending on a size, as sources state [7] the Japanese hotels can host from 50 up to 700 guests in one facility.

3.2 Typology

The capsule solution can be generally divided, into: independent – where all beds are only of this type, and depended – where capsules are a fracture of couches in a hotel. Furthermore, there can be different configurations distinguished: capsules and service elements are mixed in 'an open space' – that would be an open space solution, capsules and services are grouped along elongated corridors – it will be referred as 'a corridor arrangement', and capsules with services divided into a smaller sets, distributed along general communication – that will be called 'a compartment solution' (Figs. 2 and 4). The latter is featured by best privacy and quietness, while open space generates better sense of community.

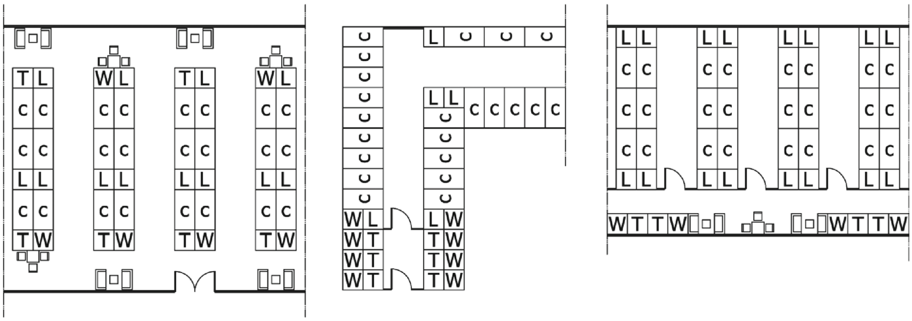

Fig. 2. Hotels' layout possible configurations, from left: an open space (capsules with side entrance), a corridor arrangement (capsules with head and side entrance), a compartment solution (capsules with side entrance). [Drawn by J. Jablonska]

Also arrangements of capsules towards shelves and lockers differ. In this aspect, there should be mentioned: long corridor with capsules on one side and shelves and closed lockers on the other, with capsules and lockers on one or both sides, and one sided arrangements, where both capsules and lockers are grouped on one side, where on the other side of a corridor windows can be located.

At the same time vertical plan of capsules distribution vary – there may be two or three rows in 'a stacked' or 'a staggered' configuration. In both cases, the access to upper level is with ladders and additional shelves is necessary. Finally, the capsules may be

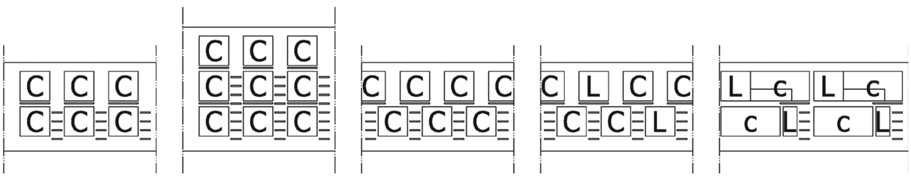

Fig. 3. Vertical arrangement of rows, from left: two stacked, tree stacked, two staggered, two staggered in mixed system – all capsules with head entrances, two staggered – capsules with side entrance. [Drawn by J. Jablonska]

accessed from wider side – it can be called 'a side entrance' or slimmer side – referred as 'a head entrance' (Figs. 3 and 4).

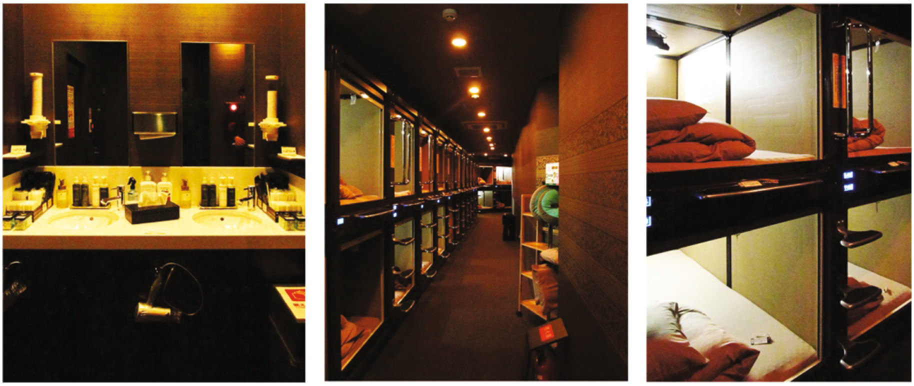

Fig. 4. Luxury capsule hotel, Tokyo – zoning of accommodation floor, from left: the all-accessed sinks (open bathroom), elongated corridor with capsules (with head entrances) and shelves, the capsules in two levels with ladder and handles. [Photo J. Jablonska]

3.3 The Design

The main idea for a capsule hotel is to save up space, therefore most of the design solutions are aiming on a space sufficiency. Thus, capsules are stacked over each other, corridors are as narrow as law allows and bathrooms are communal. Such layouts allow these type of facilities to be fitted into narrow sites, existing buildings, and as an effect to become windowless. Depravation of natural light, can be justified by limited time that guest are allowed to stay at the premises – restriction between 8 and 9 h. Moreover, some facilities define precise time for check-in and check-out.

Lack of sunlight in interiors provides deeper sleep and encourages guests to shortening their time of stay. In some cases this sleeping and night relaxation function is furtherly stressed by dark colours of interior finishing and only "information" light points. Therefore, the guest feels like one would enter a movie theatre, where illumination is temporary and will go off as soon as possible (Fig. 4).

Temporary use of space, and aforementioned theatrical climate of interiors, favours designers to futuristic design approach. What is more, in many cases the interior of drawer is made from fiberglass [7]. Thus, there were observed designs remanding solutions for: airplanes, hospitals, laboratories, gyms, industry, space ships, ships, prisons cells or glasshouses. These effects were stressed by: light colours (i.e. intensive blue or violet, bright yellow), futuristic light fixtures, technological equipment, and so on.

However at some cases the 'drawers' received more 'homey' treatment (a trend defined by Robson and Pullman [8]) with the use of: wood, curtains, vivid colours, additional comfortable and free-standing furniture (i.e. couches, armchairs), interesting carpeting design, windows, additional floor space within the capsule, small work places, etc. Despite the selected style all designer search for optimal solution for each element, of the projects, so ladders, handles, signs, receive a very careful treatment. They must be both useful and elegant.

4 Ergonomic Schemes

General Design. Y-shaped Bayreuth Youth Hostel in Germany is an example of compartment solution, where capsules are grouped with lockers, and distributed along general communication. Each set is preceded with small vestibule with shower and toilet on each side. The sink was located in the buffer zone. Overall wideness of compartment is relatively little and ranges from 3,75 m to 4,50 m and for sanitary equipment absolutely minimal surface was use (Fig. 5).

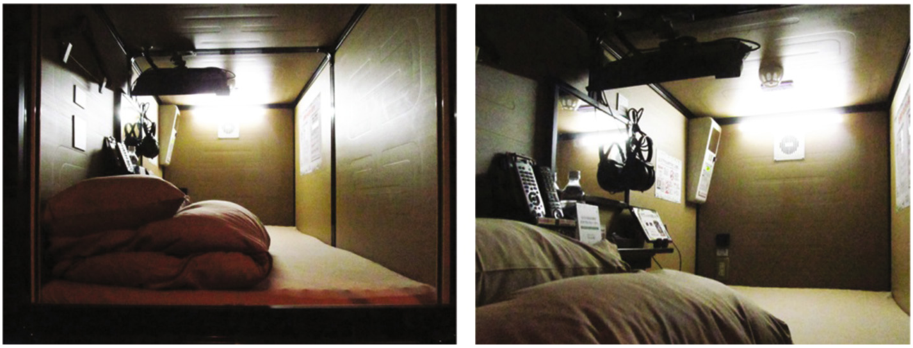

Fig. 5. Luxury capsule hotel, Tokyo – interior of the capsule and inner equipment. [Photo J. Jablonska]

To give an example the wideness of toilet is 1 m. In order to check the correctness of parameters selected by designer the Ramsey [9] scheme of hand movement ranges was used and placed in the crucial points of layout. It shows, that all equipment and furniture are well accessible and can be easily used by fully able people.

Such economical use of space and compact function solution is characteristic for mountain shelters and hostels for young people. Of course, the density of beds and lack of additional floor surface, provide only minimum comfort and there is no space for any extra utensils. It also must be stressed that there are designed for people with disabilities extra rooms and solutions.

Capsule Design. The standard capsule measures $100 \times 200 \times 100$ cm and as analysis shown the space is sufficient for person of 152 cm height – both for back or side lying position. However if we take into account human of a 185 cm tall, than free space of capsule in length is only 15 cm. In this case, also side position is uncomfortable, leaving only 17 cm of space left, if user extends arms and knees. For people of Asian origin standard parameters of capsule are comfortable. Hence, for European and USA solutions, it is recommended to implement larger, also occurring, measurement of sleeping surface of 125×200 cm (Fig. 6).

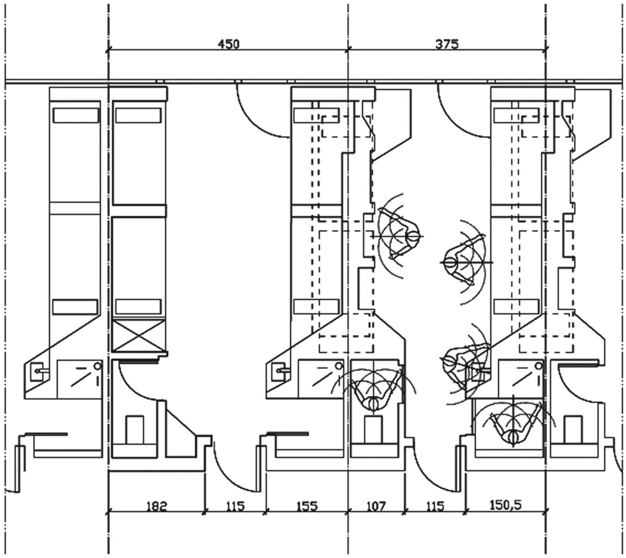

Fig. 6. The example of space sufficiency in the capsule hotel with analysis of man ergonomics and possibilities of hand reach. The scheme of a layout elaborated on the basis of real solution of Y-shaped Bayreuth Youth Hostel in Germany [10]. The man and reach scheme elaborated on the basis of the scheme by Ramsey presented in [9, p. 24]. [Drawn by J. Jablonska]

Seating in capsule was studied and it is uncomfortable for person 185 cm tall. In a fully straightened position only 10 cm of free space over head are left. Yet, sitting is only a temporary function in a capsule. It seems that, similarly watching television in lying position is uncomfortable and requires unnatural head flexion. At the same time

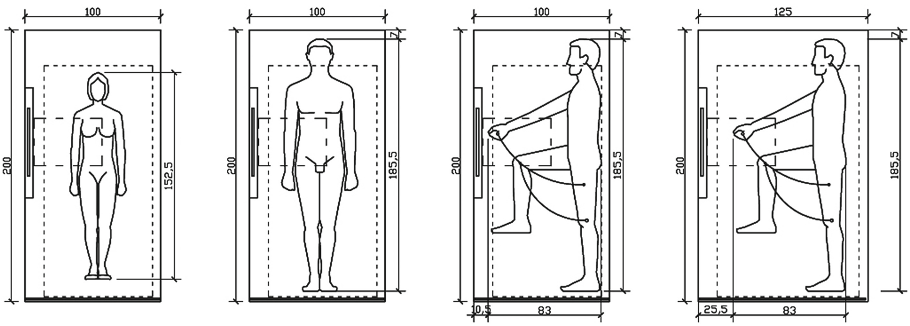

Fig. 7. Capsule ergonomics the analysis of sleeping position, from left: woman of 152 cm height on a back in a 100 × 200 cm bed, man of 185,5 cm height on a back in a 100 × 200 cm bed, man of 185,5 cm height on a side in a 100 × 200 cm bed – analysis of hand reach, man of 185,5 cm height on a side in a 125 × 200 cm bed – analysis of hand reach. The man scheme elaborated on the basis of the [11, pp. 5, 7, 8, 12]. [Drawn by J. Jablonska]

it is stressed that monitor position is adjusted. Never the less, it would not be recommended to observe screen for a longer period of time (Figs. 7 and 8).

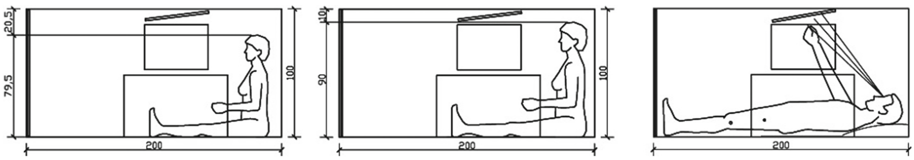

Fig. 8. Capsule ergonomics the analysis of sitting and watching TV position, from left: woman of 152 cm height, woman of 185,5 cm height in a 100 × 200 cm capsule, man of 185,5 cm height on a back in a 100 × 200 cm capsule. The man scheme elaborated on the basis of the [11, pp. 5, 7, 8, 12]. [Drawn by J. Jablonska]

5 Summary

The capsule hotel space and service is reduced to the absolute minimum from reception zone towards sleeping in a 'drawer' concept. Moreover, if facility is serviced by money machines or computers, the human personnel is completely omitted. As such capsule hotels are perceived as dehumanized and favouring progressive isolation of individuals from society. Discouraging are also small dimensions of sleeping space and communal sanitary areas. At the same time capsules – on a pattern of mountain shelters – provides young people, economical and smart accommodation in a city centres. At many cases the counties, would be for many far too expensive to visit on regular grounds. It also should be stressed that capsule offer is targeted towards backpackers, so travellers who rather move through the cities, not settling there for longer than 2–3 days. An occurrence of luxury facilities inform, that capsules are also used by reach, usually older people, who choose this way of accommodation, according to their needs. So, it may be stated that a capsule hotel fulfils its role.

Such solution can be also recommended as a complimentary function for hostels, large commuting nodes (i.e. airports) or even specific work places. So every place, where people would benefit from a short nap or even a few hours of sleep, during waiting or relaxing between activities. At the same time it is strongly stressed that this form of hotel is suggested only as a really temporary solution and only for people, who do not fear of small spaces or do not experience any sudden movements during sleep.

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Analysis of the Transformation of Industrial Parks in Chinese Urban Planning to Eco-Chinese Parks and How They Are Performing – A Case Study

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Abstract. In the past, a lot of industrial factories have been built around Chinese cities. This has led to serious pollution issues in many of these cities. Therefore, it is vital to solve this environmental problem as a matter of urgency. One of the solutions was to force the industrial factories to move out to more remote areas in China. Chinese Eco-Parks were developed and created in these former industrial areas to restore heavy and light industry. Although the evolution of Eco Industrial Parks in China has already been developed, in recent years the EIP model has been used in many other countries including Italy and the UK. But a lot of regions in China are still need to meet the demand of their sustainability and development. In this case study the researchers analysed the Bin river park along the Hutuo River and Fen River Parks. Eco-Industrial Parks can have a significant role in realising economic, environmental and social improvements both to individual plants and to a network of companies. The key to developing a successful Eco Industry Park is to determine the best connections amongst different industrial plants and their surrounding communities within an Eco Industry Park. In this research, authors analysed the function of these parks with an on-going planning for community process, including examining: sufficient assets within land; staffing and the equipment required to meet the system's goals; local resident's satisfaction as well as the benefits for the city beyond the boundaries of the EIPs.

Keywords: Eco-Chinese parks · Eco industrial parks · Urban planning · Case study from Chinese park · Environment benefits · Social friendly · Sustainability

1 Introduction

During the past 30 years, it is obvious that the Chinese economy has developed at a fast pace. Many environmental problems have been neglected during these developments. Many main rivers became dry or polluted by the waste water close to the factories as well!

The Central Government started to pay attention to these environmental issues through: Police and financial support projects: the Eco-Industrial Park Demonstration Program lead by the Ministry of Environmental Protection (MEP); the Circular

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Transformation of Industrial Parks lead by the National Development and Reform Committee (NDRC) and the Ministry of Finance (MoF); and the Low-Carbon Industrial Park Program lead by the Ministry of Industry and Information Technology (MIIT). While not identical, these programs share the overall ambition both to reduce the environmental impact of Chinese industry and to increase its competitiveness [1].

Firstly, let's look at the Fen river park located in Taiyuan city – the capital of Shanxi province! Only about 15 years ago, the city's mother river was nothing more than a dry riverbed. It was not until the late 1990s that the municipal government issued the construction of four rubber dams to achieve a step-by-step artificial replenishment of the city's major body of water accompanied by landscape greening along the urban riverbed. Further park and wetland constructions extended Taiyuan's waterfront landscape to its current length of 20 km. Though environmental beautification boosted both Taiyuan's national appearance and its real-estate business, since 2007, the Fen River Governance lead by the provincial government has pursued an integrated, inter-municipal, and multi-objective approach to restoring the river's ecosystem [2].

The second example is the Hutuo River park from the Hutuo river Basin pollution: it polluted the whole eastern part of Shanxi province and central Hebei province with a total of about 6.46 million people directly or indirectly affected. It was seriously impossible for people and animals living along the riverbank to drink directly from the river! The reason for the pollution came mainly from the industrial activity around the river bank. For instance, Wutai chemical plant sewage flowed underground at the same time assist went into the Hutuo River tributaries; on behalf of the county and Fanshi mining washing water to Hutuo River into the muddy river and also other waste water entered the river from the factories around the river bank!

The pollution was not only a serious threat to the health of the surrounding citizens and the farmers along the riverbank, but also it caused the people with a huge security risks.

But behind these pollution, enterprises and the government had many mistakes for destroying the environment. With the severe punishment and big penalties to the companies from the environment and water protection law in China, the eco-municipal park plays an important role in dealing with the pollution thus benefits the local population!

In this research, some of the aspects of the multi-functional park that were constructed in last few years will be analysed in order to clarify the multi-functional and compatible system balances people's daily outdoor activities, environmental protection and storm-water management. The site with a polluted and degraded fish pond is transformed into a socially and environmentally sustainable neighbourhood park, which provides a meaningful space for recreation, environmental education and social connections to the growing community.

2 Methodology

The methodology of comparative research is the act of comparing two or more things with a view to discover something about one or all of the things being compared. This technique often utilizes multiple disciplines in one study [3].

Research and analysis presented in this paper, is based on two Eco river parks transformations in Shanxi Province, China. The Fen River park, which is located in the capital of Shanxi province, Taiyuan, is functioning not only as the centre of the political, financial, technological centre in the whole province, but also works as the key transport hub linking the west part and the east part of China. The Development stages of the Fen River restoration in Taiyuan is as showed in Fig. 1.

Fig. 1. The Development stages of the Fen River restoration based on Matthias Falke in 2016; Right side is Bin River parks restoration plan created by Mo Zhou 2017.

Bin River park, not far from Hutuo river origin source, is located in Fanshi, Shanxi province. Some analysis through the comparative study were used by the effects by the river park projects along the city. The layout of the main Bin river park is showed in Fig. 1.

These studies address the link between structural connectivity and functional connectivity, e.g. asking under what kind of circumstances the construction of a movement corridor actually increases movements between protected areas [4].

3 Analysis and Results

3.1 To Improve the Ecological Environment Along the Riverbank Area as Well as in the Cities and Surrounding Villages

As observed and analysed from the river park transformations, we can see that since February early spring time, many big egrets, black storks, red wild ducks settled down in the Bin Riverside Park as Fig. 2 and are living with clear Hutuo River water. They are often in droves or leisurely wading and foraging, or dancing in the air, which attracted a crowd of people and villagers around to come to feed them and enjoy the beautiful river scene. In the previous few years, these birds often make their habitat in the spring, summer and autumn season along the Hutuo River bank.

Fig. 2. The wild birds are inhabiting in the Bin river Park in Shanxi, China.

But compared to the time before the eco-river park project, the inhabitants and animals didn't want to come to the river bank due to the polluted water from the Chemical factory around the year 2008. There is no doubt that there were not so many birds flying there, taking a rest as well as drinking the water.

Also Fen River Park as Fig. 3 had a lot of changes since the comprehensive control was imposed. It was obvious that many special plants were protected by the new eco-river park. In fact, many species of plant were found along the riverbank. 875 species of seed plants belonging to 398 genera and 94 families were found in the Fen river Source. The gymnosperms included 12 species in 7 genera and 3 families, and angiosperms included 863 species in 391 genera and 91 families. Among these species, four were National Key Protected Plants and 24 were Key Protected Plants of Shanxi Province [5].

Fig. 3. Fen River park bank with plants and green space

With various species of Aquatic plants along the Fen Riverpark, the Aquatic plants can restore the ecological balance within the river regions.

So the eco-river projects improve the ecological environment and living environment surrounds. It also continues to optimize and upgrade the Bin River and Fen river parks. At the same time it creates a beautiful living environment. Also it has created the necessary conditions for rare birds to settle, comfortable ecological environment has also attracted the precious human guests: Egret, black Stork, red wild ducks and other rare birds to live along the river bank.

3.2 Change the Hygiene Content Strongly Around the Cities and Villages

Hutuo River Basin pollution can spread to the eastern region of Shanxi and central Hebei province, with a total of about 6.46 million people directly or indirectly affected. Because of that large area of arable land already suffering from reduced farm production, it is so difficult for people to drink water in rural areas. Along the river many residents are affected by pollution and there is a high level of various diseases within this area.

Since the late 1990s, the Hutuo river became dry from time to time due to the climate derived from the river source and also high occurrences of pollution along the Hutuo river. It had already caused a lot of inconvenience to the citizens and villagers along the river. Hutuo river water was described as pure, clean, and from a hygienic source, as the spring for the people along the river is described in the past in the old poems. So it is urgent to control the pollution and purify the water.

Bin river park located in the Hutuo river is quite close to the river source. After the new control project, the Hutuo water was purified. At present, fish can swim in the water and most of the river bank session water can be drunk by animals. Even river water after purification in many parts along the Hutuo river can be drunk directly by people.

However, this could not have been imagined by around 300.000 citizens and villagers before the eco-industry park project completed in Fanshi County.

Since the late 1990s, the Hutuo river became dry from time to time due to the climate from river source and also big pollution along Hutuo river as Fig. 4 above. It already caused a lot of inconvenience to the citizens and villagers along the river. Hutuo river

Fig. 4. The water in the Hutuo River park was seriously polluted in the past

water was described as pure, clean, hygiene source, as the spring for the people along the river in the past in the old poems! So it is urgent to control pollution and purify the water!

Bin river park located in the Hutuo river and it is quite close to the river source. After the new project control, the Hutuo water get purified! At present, fish can swim in the water as Fig. 5 and most of the river bank session water can be drunk by animals. Even river water after purification in many parts along the Hutuo river can be drunk directly by people.

Fig. 5. The water in Hutuo River became clean in the Eco river park

3.3 Enhance the Biodegrading and Sewage Plant Function

Hutuo River has been cut off all year round thus the river self-purification capacity is very poor. Due to low temperatures in winter time biodegradation and other methods could not be applied, (which also means to pay off the Hutuo River, must be treated sewage???). Water control Experts mentioned that in the face of such difficulties, we have identified two comprehensive management ideas. Firstly we have to improve the level of river sewage treatment, a comprehensive clean-up of external pollution in the Hutuo River. Secondly we need to manage the river sediment and the accumulation of sewage and clean up the river's endogenous pollution. (Chinese environment Protection web).

Since the comprehensive park as Fig. 6 was completed along the river, the sewage plant was under control and put to work. With the efficient working ability it can degrade the sewage from the river and the city, which has largely improved the water quality and the environment along the Hutuo riverbank.

Fig. 6. The Chinese traditional Pavillion in the Eco industry Bin River Park

3.4 Create More Wetlands Parks Along the River to Get More Recreation Space for the Local Inhabitants

The wetland parks have been created along the Fen River bank as we can see from Fig. 7 and Bin River bank as well. It provides people with more space to walk and enjoy the view from the rivers. Recreations Integrated with Nature: Children in the Bin River Park and Fen river park could have the opportunity to feel, to touch, to learn and to enjoy nature as they are growing up. Natural elements such as sunlight, plants, flowers, rainfall, creeks, wetlands, ponds, waterfalls, birds, fish, frogs, fireflies, butterflies, insects etc. are part of their daily life and will have a positive lifetime impact on them. The inclusive design of the playground offers activities for a wide range of age groups. It balances people's recreational needs and environmental quality. The playground with slides,

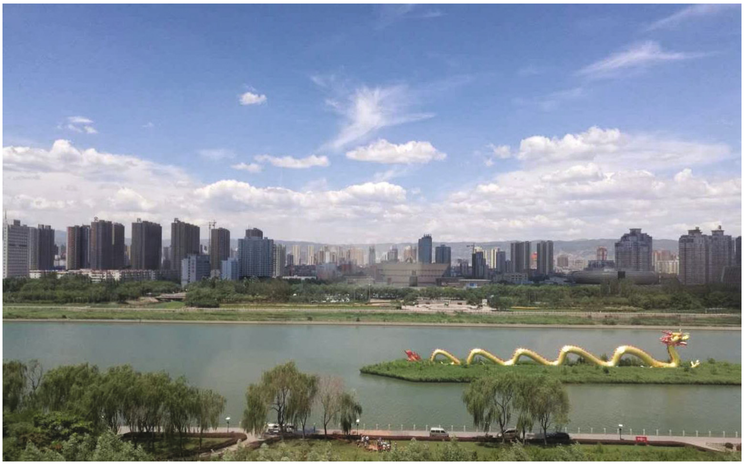

Fig. 7. Wetland park along the bridge around Fen river

climbing walls, sand pits and big insect toys is designed at the edge of the protected hill. With a mindful, yet playful design of "wood carpet", the edge of the forest becomes a landscape for gathering, sharing, and family time for the community.

Wetland park enhanced the enjoyment of the nature and ecosystem as people appreciate the beauty of the nature wetland science park, sponge demonstration garden, water purification park as the main basement, urban vegetable garden, forest development park, wetland plants as well as the urban green-roof system as a supporting function, the formation of urban leisure and Ecological restoration of waterfront in the open space [7].

3.5 The Water-Side Pavilions Had Protected the Local Culture and Architectural Style

Compared to the past, the eco-industry park at Bin River Park and Fen River Park have contributed to the protection of historical and cultural cities. Both of the parks are located in the Shanxi province with over 2500 years of history and old architectural style.

Fig. 8. The Traditional Water-side Pavallions in the Bin River Park

The water-side pavilions created in the Bin River Park and Fen River Parkas we could see from Fig. 8 have continued the Chinese style of traditional pavilion style, which has protected the local landscape.

It is the special feature of the shuixie (waterside pavilion) to be rectangular or near square in plan figure, half erected on land and half over water supported by stone pillars driven into the lake bottom. This structure is walled not with bricks but with wooden frames having fancy windows on all sides. The side on the water is bordered with railings and equipped with seats, fixed or movable, to provide visitors with a vantage point to feast their eyes on the scenes of the river.

3.6 Storm-Water Management

Innovative Storm water Treatment System. To deal with the complicated challenges the River Parkas is facing, the landscape architect introduced an innovative multi-functional storm water treatment system into the park. It integrates various open spaces where people can observe and interact with the water treatment process.

Generally, from Fig. 9 we could see the storm –water system through the bridges and small islands in the Bin River Park and Fen River Park can strongly control the storm water.

Fig. 9. Fen River park with good strom water management

4 Conclusion

In Conclusion, the Eco-industry river park combines the beauty of nature, the beauty of the environment with human local culture in one.

This research was based on the comparison of analysis and results of two river-restoration eco-parks in Shanxi Provinces.

From the analysis and results, it can be seen that in ecologically hygienic conditions, the recreational space, green areas in the river park, storm water management, sewage plant management as well as the historical heritage culture protection, both of the Bin River park and Fen river park, the ecological environment along the Hutuo river bank has greatly improved.

The Eco-river parks also help the Hutuo river to play an important role in climate regulation, prevention of dust storms and prevention of the river water pollution.

Furthermore, Eco-industrial parks can play a significant role in realizing economic, environmental and social benefits both to individual plants and to networks of companies. They can improve the ecology and landscape environment as well as enhance the city's image. Clean surroundings give a lot of benefits to the citizens and villagers in the form of natural water resource, recreation space, sewage management as well as waste-water management and recycling etc. In the long term, Eco-industrial parks have brought ecological environment sustainability.

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Infrastructure Planning and Learning for Sustainable Future

Better (not) Charge in Your Garage! Perceived Benefits and Optimal Positioning of Public Fast Charging Infrastructure for Electrical Vehicles from User's Perspective

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Abstract. In order to increase the number of electrical vehicles (EV) in Germany, a nationwide distribution of public charging stations is intended to improve the perception of EV usage potential. These can be equipped with novel fast charging technology. To examine the users' needs and deduce potential locations for charging stations, users of EV are interviewed with focus on acceptance of detours, the necessary back-up battery SOC (state of charge), and, as conclusion of both, the user's preference for home or public charging. Finalizing, factors of perceived effort and perceived benefit in public charging are evaluated. It can be shown that the positioning of public charging is not yet sufficient, but has to be improved. This can be deducted from the backed-up battery SOC which is left to manage long detours to public charging infrastructure.

Keywords: Electric vehicles · Fast charging · Charging infrastructure · User acceptance · Optimal charging location · Location criteria · Simulation

1 Introduction

Lately, the German Government announced the objective of releasing up to 1 million electric vehicles (EV) until 2020 [1]. Considering the 54.6 million passenger cars currently licensed in Germany, the amount of battery electric vehicles (BEV) is 25.502, the amount of hybrid electrical vehicles (HEV) 130.365 [2] (for the definition of BEV and HEV see [3]). In total, these add up to about 2% of all licensed vehicles in Germany [2]. A repellent reason EV and especially BEV is facing, is the insufficient distribution of charging infrastructure, in accordance to Bertram and Bongard, Frenzel et al. and Bailey et al. [3–5]. Also, the availability of charging infrastructure has a major impact on the users' decision for EV [6]. Further reasons to decide against an EV seem to be limited battery range and high charging time [7, 8]. With state-of-the-art AC technology, charging time is about 3 to 16 h, depending on the battery capacity [9]. With DC and a battery performance of at least 43 kW, charging time for a battery's state of charge (SOC) of 80% can be reduced to about 30 min [10], matching the average accepted maximum [11]. Considering the average

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battery range of EV produced in Germany, these 80% would correspond to a range of 120 to 160 km [12]. From a SOC of 80%, AC charging is applied to prevent battery overheating. Taking this into account, one countermeasure against the perceived barrier of time-consuming charging duration could be to increase both, the number and distribution of fast charging options (DC). The current paper focuses on public fast charging as an option to increase user acceptance for EV by minimizing the barrier of currently long perceived charging duration.

In 2016, about 150 public fast charging stations were available in Germany [13]. The mere public distribution of fast charging stations therefore seems to be still insufficient. It can be assumed that users of an EV do not intend to use public charging options. This would be especially the case if their presumed driving range appears to be within the battery range of their EV. Considering this case they would be able to charge their vehicle at home without additional waiting time or overnight. At a public charging station, users need shopping or eating opportunities to accept the waiting time [14]. Public charging gives an additional benefit when the station-to-station distance is below typical EV usage distances. This on the other hand means that public charging stations can exceed the driving range.

Now, an average BEV battery range of 150 to 200 km and a daily distance of 46 km can be seen as a typical usage profile [12, 15]. Such daily routines are easily manageable with any EV without additional recharging on public charging options [4, 12, 15]. Therefore, the first hypothesis is that daily EV users tend to rather charge at home than at public charging options because of a more time-consuming "refill process" compared to a conventional vehicle, whose refill is integrated into daily routine easily. This profile is a result of too few and unbalanced positioning of charging infrastructure and therefore too low perceived benefit of public charging.

The decision for putting effort into using a public charging station can be explained with an expectancy–value approach [16–18]. Expectancies, as well as the value of an option directly influence the choice of achievement [18]. It can be concluded that the option with the highest positive "value x expectancy" of occurrence result will be chosen. In this context, this result can be defined as "choosing a recharging location". For instance, considering home charging, the expectancy of no necessary detour will be high. The expected value or benefit will also be high, even with longer charging duration. This results in a high value x expectancy value. If the perceived value of using public charging however is too low, and the expectancy of no necessary detour is low as well, the value x expectancy result will be low. The user then rather uses home than public charging. From users' perspective, the attractiveness of a charging position increases when the detour decreases [11]. To increase the usage of public charging infrastructure, there has to be a nationwide, demand-oriented and balanced distribution of charging locations and, considering charging duration, especially fast charging infrastructure, with very small necessary detour. Concluding, the second hypothesis for this paper states that public charging infrastructure with necessity of long detours leads to a lack of perceived benefit compared to the effort costs perceived by the EV user.

To examine perceived effort and benefit of public charging infrastructure, an empirical study was conducted. The effort of using public charging infrastructure is calculated by the maximum accepted detour, the battery SOC needed for the detour getting to the fast charging location and the residual SOC at the charging location. The benefit is calculated by the mean battery SOC after recharge. The study was conducted within the project SLAM (rapid charging on axes and in metropolises) with focus on a nationwide and demand-oriented distribution of fast charging stations in Germany [19]. Effort and benefit will be calculated separately for urban and rural areas because of former studies that identified differences in the calculated detours with an EV, depending on the area (for example, see [20]).

The final section of this paper is a short discussion on the results and a response on the hypotheses.

2 Method

The reported study was conducted as an online survey on an online platform within the project SLAM (rapid charging on axes and in metropolises) which determined the focus of the survey on fast charging. However, comments on charging behavior in general are discussed in the final section of this paper.

The survey was implemented from July 2015 to March 2016.

2.1 Material

The link to the questionnaire was available on the SLAM homepage, on the Institute for Automotive Engineering's Facebook page, and was sent to potential participants via email. It took about 15 to 20 min to fill in the questionnaire, which was divided into a demographic part and two question sets on (A) charging behavior and (B) knowledge on fast charging technology. About one third of the 74 questions are taken into account to examine the hypotheses of this paper. The hypotheses are:

H1: Daily EV users tend to rather charge at home than at public charging options.
H2: Public charging infrastructure with necessity of long detours leads to a lack of perceived benefit compared to the effort costs.

The questionnaire consists of four topics with regard to effort and benefit:

- Effort: Battery SOC starting to look for a fast charging station (urban/rural),
- Effort: Battery SOC reaching a fast charging station,
- Effort: Maximum of accepted detour (km, min) to the charging location,
- Benefit: Absolute battery SOC leaving the fast charging station.

2.2 Participants

The total sample consists of N = 132 eV users. 15 subjects had to be excluded due to reasons of extraordinary battery range. These 15 data-sets do form a unique and incomparable sample characteristic which will be treated separately in future analyses, leaving a sample of 117 participants. Seven of the subjects were female. The mean age of the sample was 45 years ($SD = 11.67$). Considering the driving amount in km, two drivers had to be excluded due to unrealistic values, resulting in a total sample of 115 subjects. The total average of km driven per year was 17,461 km ($SD = 7,453.32$), and the mean daily km 60 km (SD = 34.57). The reported mean EV battery range was M = 139.67 km ($SD = 24.00$).

3 Results

3.1 Home/Public Charging

The first hypothesis stated that that users of a rapid-chargeable EV rather charge at home than at public charging stations. To examine this hypothesis, participants were asked to specify both, the percentage of home charging processes and the percentage of public charging processes.

The results show a mean percentage of charging at home of 60.0% ($SD = 3.17$) and a mean percentage of charging processes in public of 40.0% ($SD = 3.17$, Fig. 1). In detail, 51.6% of all participants do at least 80% of their entire charging at home and two out of three participants do at least half of their charging at home. The results tend to confirm the hypothesis stated above.

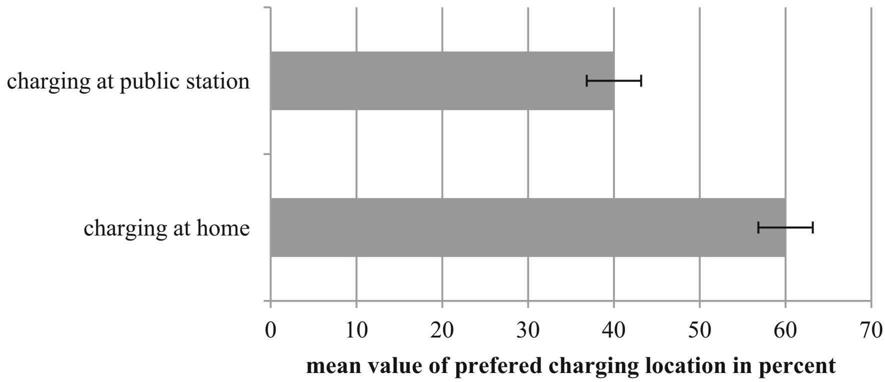

Fig. 1. Mean value of preferred charging location, with standard deviation. N = 115.

3.2 Effort and Benefit of Public Charging

In the following sections, relevant criteria for evaluating perceived effort and benefit of public fast charging infrastructure, considering the second hypothesis of this contribution, are examined. Effort and benefit are calculated separately for urban and rural areas.

To quantify the effort of using public fast charging infrastructure, the participants were asked (A) for accepted detour maximum, (B) at which battery SOC they start to look for a public rapid-charging station, and (C) what battery SOC they usually have left when reaching a station. The battery status when reaching a public fast charging station indicates the estimated back up the user factors in. In order to quantify the benefit of public fast charging infrastructure, the battery SOC when leaving a fast charging station was surveyed.

Effort Costs of Public Charging Regarding Battery Range

The mean battery range of EV examined in this study was 139.7 km (SD = 24.00). This mean value is marked as the average real battery range (see also Table 1). Regarding the residual state of charge when starting to look for a charging station, the mean value for trips in rural areas was 27.8% (SD = 13.44) and for trips in urban areas 19.8% (SD = 12.85). This means that EV users already start looking for a recharging option when they used about 72 to 80% of their actual battery range.

Table 1. Descriptive statistics of effort and benefit factors when using public charging options (M = Mean value, SD = Standard deviation, SOC = state of charge, D = Difference). The average EV battery range in km (see first row) is taken as 100% battery range and as benchmark for further calculations of ranges in % and km for all other factors in this table.

			Battery range in %		Battery range in km	
			M	SD	M	SD
Reported average EV battery range (used as benchmark for further calculations)			100.00	–	139.67	24.00
Effort factors	Neccesary detour: SOC at start of search for a public fast charging option	Urban	19.79	12.85	27.84	18.97
		Rural	27.78	13.44	38.69	19.12
	Maximum of accepted detour		9.15	6.67	12.59	10.54
	Residual SOC arriving at public fast charging station		17.02	10.56	24.42	16.58
Benefit factor	SOC leaving public fast charging station		88.17	10.65	124.00	24.67
	Calculation D1 - B*enefit at charging location:* (SOC leaving public fast charging station) – (Residual SOC arriving at public fast charging station)		70.35	13.44	115.35	49.80
	Calculation D2– *Actual benefit for EV*: (SOC leaving public fast charging station) – (SOC at start of search for a public fast charging option)	Urban	44.07	17.49	60.64	25.73
		Rural	36.03	19.01	49.95	28.90

For estimating a more realistic battery range when taking into account a battery recharge during the trip, the back-up residual SOC was subtracted from the battery range. Calculations show that the actual mean battery range for the EV with regarding the back-up SOC decreases to 100.9 km (SD = 26.84) in rural areas and to 111.1 km (SD = 24.76) in urban areas. It can be concluded that the actual available battery range is lower when the driver takes public charging into account. Based on this calculation, the mean wasted battery range to recharge at a public charging station was about 38.7 km (SD = 19.12) in rural areas and 27.8 km (SD = 18.97) in urban areas.

Effort Costs of Public Charging Regarding Necessary Detour

In this study, the detour that the user is willing to invest was taken as an indicator for the maximum accepted detour to a public charging station. This value was compared to the calculated SOC from which the user starts to look for a public fast charging option. The second value was used as an indicator for the detour calculated as necessary. The identified average maximum accepted detour was 12.6 km (*SD* = 10.54). This means that the user is willing to calculate an additional distance of about 13 km. For urban as well as rural areas, the residual back-up SOC at start of search for a public charging location was significantly higher than the maximum accepted detour ($t_{(89)rural} = -13.70$, $p < .001$, $t_{(89)urban} = -8.34$, $p < .001$), which leads to the conclusion that detours calculated as necessary are higher than the maximum accepted detours.

Benefits of Public Charging Regarding Battery Range

The mean residual battery SOC left when getting to a public charging station calculated by the user was 17.0% (*SD* = 10.56). Considering the limitation of fast charging at a battery SOC of 80% (see also Sect. 1), the maximum benefit of fast charging would be an average SOC of 63.0%, in theory.

Examining the user perspective, the average battery SOC when leaving a fast charging station was 88.2% (*SD* = 10.65). With that value, a benefit at charging location was calculated by the difference of residual SOC when arriving at a public charging station and the SOC when leaving the station. This average benefit at charging location was 70.4% (*SD* = 13.44). The analysis, however, also includes charging processes up to 100%; processes being cut at 80% SOC reveal a mean benefit per user of M = 63.0% (*SD* = 10.56).

Furthermore, taking into account the residual back-up SOC for searching a public rapid-charging station and the SOC when leaving the charging location, an actual benefit for EV can be quantified. This actual benefit results in a mean value of 44.0% (*SD* = 17.61) for urban and 37.5% (*SD* = 19.00) for rural areas.

Effort in Comparison to Benefit

The final step is a calculation with the benefit compared to the effort using the parameters:

- Benefit at charging location with processes cut at 80% (M = 63.0%, *SD* = 10.56) and
- Effort factor Necessary detour: SOC at start of search for a public fast charging option (rural areas: M = 27.8%, *SD* = 13.44; urban areas: M = 19.79%, *SD* = 12.85).

An overall average benefit of recharging the EV at public fast charging infrastructure is derived from the difference of this effort and benefit parameter. The difference results in an overall average benefit of about 35.2% for rural areas and 43.2% for urban areas. That means, at current situation, the average perceived benefit of using public fast charging infrastructure is less than 44%.

Considering the expectancy x value approach, current EV users obviously have to plan long detours to public charging options. Therefore, they have to calculate at least 20% of their battery SOC just for reaching public charging options, not taken into account the additional time of about 20 to 30 min that are lost during recharge. At the same time, the actual benefit of public fast charging is less than 44%. Concluding, the result of the expectancy x value calculation for public charging opportunities will be small. Therefore, the second hypothesis can be confirmed.

4 Discussion

The aim of this study was to examine the current perceived effort and benefit of using public fast charging infrastructure. It was hypothesized that current EV users rarely use public charging infrastructure but prefer home charging. The second hypothesis assumed that public charging infrastructure with necessity of long detours leads to a lack of perceived benefit compared to the effort.

The results show that, as expected, charging the EV is mostly done at home rather than at a public charging station. The enquired effort factors show that users have to calculate significantly more back-up battery SOC when starting to look for a charging option than they are actually willing to do. This could lead to the conclusion that detours, which have to be planned in order to reach a public charging station, are on average still too long. This in turn would probably reduce the user's willingness to use a public charging station. A further benefit factor when using a public fast charging option is taken into account by the maximum amount of recharge during fast charging (SOC: 80%). Considering the effort costs relatively to this maximum amount, the relative benefit of fast charging ranges between 36% (rural areas) and 44% (urban areas) of the battery's capacity, most likely due to lower charging grid density in rural areas. A low benefit however is assumed to be a reason for neglecting public fast charging stations.

A suggested course of action could be a higher and optimal distributed number of public charging locations both in urban and rural areas, to increase the perceived benefit of public charging. Charging infrastructure and especially fast charging stations should be positioned demand-oriented and area-wide to reduce the actual necessary detour and therefore, to decrease the effort perceived when using (fast) charging infrastructure. SLAM as one of the German projects with focus on optimizing the public charging infrastructure has the aim to plan a nationwide demand-oriented and comprehensive fast charging grid with the help of an open access web based platform for future charging station investors. With optimal positioning of public fast charging stations, the perceived effort regarding necessary detours may decrease.

A recharge of up to 100%, of course, provides a higher maximum SOC and therefore should increase the perceived actual benefit of public charging. However, a recharge to an SOC of 100% needs a substantially higher amount of time. In future research, the exact influence of the factor time on the usage of public charging infrastructure should be examined.

Furthermore, a technical improvement of the EV battery range and therefore higher SOC available for driving could increase the actual perceived benefit of public charging, but does not necessarily decrease the charging duration. Therefore, the actual charging time required for recharge, compared to an accepted duration of recharge, should be taken into account to specify the time effort and the influence on the benefit, especially when using public regular charging infrastructure.

Overall, the current results show that the use of public charging infrastructure is no important subject to daily routines as EV users primarily recharge at home. It is however probably considered if the traveled distance exceeds the vehicle's battery range and a recharge at public charging opportunities is necessary. When thinking about public recharging locations for EV in the future, a benefit and usage of public charging should also be noticed in daily driving situations.

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Analyzing Time-Dependent Infrastructure Optimization Based on Geographic Information System Technologies

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Abstract. There exist different reasons for infrastructure providers to think about upcoming changes and necessary adaptations. This paper covers the experiences made during a three-year research project (called SinOptiKom) during the development of a geographic information system supported tool for analyzing time-dependent infrastructure optimization results. Beside the data preparation and requirements for the successful implementation of such a tool, the resulting design decisions are presented. Examples for the use and combination of common techniques (such as semantic zooming or highlighting) as well as important usability aspects are explained and will greatly support future research in the domain of infrastructure optimization.

Keywords: Geographical information · Systems · Infrastructure · Optimization analysis · Transformation visualization · Time-Dependent visualization

1 Introduction

The ongoing trend for moving away from rural to urban areas forces basic infrastructure providers (such as waste/drinking water or electrical energy facilities) to think about upcoming changes and challenges. Besides raising requirements by law for resource efficiency and sustainability, possible effects of climate change and the corresponding natural phenomena (like heavy rainfalls, temperature changes) as well as demographic and social-economic changes have to be considered.

Funded by the German Ministry of Education and Research, a novel approach across multiple sectors had been developed in the research project “SinOptiKom” [1, 2, 4]. This approach aims at flexible adaptation or transformation processes for the (predominantly water) infrastructure including all already known upcoming issues such as material lifetime limitations, technical restrictions, or new buildings. In addition, “soft facts” such as acceptance factors for certain actions as well as uncertainty aspects like population changes, financial aspects (e.g. decreasing technological costs or inflation) or possible changes in laws have to be considered. Of course, such a (probably massive) impact for an infrastructure cannot be handled in one single step. Therefore, a detailed, time-dependent multi-step approach had to be developed to reach the optimization goal over a long time period.

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Especially in projects which concern a large amount of affected stakeholders (which is obvious for a project affecting all inhabitants of a certain geographical region), it is necessary to communicate the results and impacts properly. Therefore, the need for a platform- and location-independent software-based solution is obvious. Besides highly complex algorithms in the background, this solution needs a user interface applicable for different user types (from beginners to experts) to fulfill a wide range of expectations and needs to communicate the project's results properly.

Although the underlying application domain of the paper at hand is the optimization of waste water infrastructure, its results concerning design and concept can be applied to most other infrastructure domains. The application domain of water infrastructure provides a variety of user groups, resulting in different needs and complex requirements. User requirements differ widely, on the one hand "easy to use" for a local major or citizen without technical background, interested in population development in certain quarters of a city. On the other hand, "maximum detail level and analysis" for engineers of the local water supplier with the need for technical details like pipeline diameter, lifetime or legal restrictions, or waste water ingredients for the forecasted infrastructure.

To address all mentioned aspects, a software-based optimization and decision support system has been developed in the afore-mentioned research project "SinOptiKom", which can be described as a concatenation of the following three steps:

1. A new scenario is generated using a wizard-based scenario manager. A scenario contains all necessary information such as data from georeferenced pipelines and technical institutions, population data, environmental variables, and a catalog of allowed measures for the optimization (e.g. pipeline renew), defined by the person who created the scenario (see [2]). The static data is gathered from a relational database, holding general information (like pricing for investments) and area-specific information (like geospatial data from buildings, pipelines or technical institutions). The information of this database has been collected by domain experts from various data sources, e.g. governmental databases, local population data from the city administration office, etc. After all data is preloaded into the scenario wizard, the user adjusts the optimization variables like desired time range (e.g. 2015–2065), time step for the optimization interval (e.g. 5 years), or priority of the optimization criteria (e.g. high priority on costs, low priority on renewable energy). Afterwards, the optimization issues themselves, e.g. future population development, environmental predictions (like amount of rain), or allowed actions can be adjusted. After successful creation of the scenario, the gathered data is splitted into two files (based on a JSON format). One file contains all relevant information for the optimization and the other file contains all additional information needed by the analysis tool in step three, which is the focus of this paper. Both files are uploaded to a central server via web sockets. For more details on the scenario generation step, we refer again to Baron et al. [2].
2. Based on integer linear programming (ILP), the existing infrastructure is optimized in the second step. For each time step within the predefined time interval (e.g. every 5 years from 2015–2065), a complete snapshot of the optimized infrastructure including all available data is calculated and stored. After the successful optimization, its result is saved on the same, central server as before. Its format is also a JSON

file, readable by both, human and machine. The fact of readability was very crucial especially for experts, using the data in their own analysis environments outside this chain. For more details on the optimization step, please see Baron et al. [1].
3. The third and last step of the chain is the visual analysis and presentation of the results. The paper at hand focuses on this result presentation; i.e. the analysis step with the underlying concept as well as its design and features.

For visually analyzing geospatial data, a geographic information system (GIS) offers itself. GIS, in general, can be used in every application domain where data can be visualized on a map. The National Geographic Society summarizes the scope of GIS as follows: "A GIS is a computer system for [...] displaying data related to positions on earth's surface. [...] With GIS technology, people can compare the locations of different things in order to discover how they relate to each other" [11].

Prominent usage scenarios of GIS are the analysis of urban planning and infrastructure [12, 13] or applications in the transportation and logistics domain (e.g. vehicle tracking [15] or crash analysis [16, 17]). For disaster and crisis management, GIS are widely used [18–20], as well as for analyzing weather forecasts [22] or analytical tasks like expected solar electricity potentials [21]. Analyzing diseases in the medical domain [14] or even public services like Google Maps [24] or Google Earth [25] would not be possible without GIS.

One can distinguish between commercial GIS suites (like ArcGIS [26], Maptitude [27], or Hitachi GIS [28]) with a wide range of inbuilt analysis functionalities or GIS frameworks, which can be adopted or used inside an own application, providing certain GIS functionalities like layer management, measurement functionalities or working with common GIS standards (such as open map layers, coordinate transformations etc.). Examples for such GIS frameworks are the NASA World Wind Java SDK [10], QuantumGIS [29], GRASS GIS [30], or GeoServer [31]. For the analysis tool in our project, the NASA World Wind Java SDK fits best; its platform-independence, open source character and the large community promised a fast development and an easy adaption to our needs.

The structure of this paper is as follows: first, a brief outline of the data preparation step is presented in Sect. 2. In the Sect. 3, the concept of the analysis tool itself with its approaches and design guidelines is described. Section 4 gives a short overview on the evaluation of the tool. The paper finishes with a conclusion and an outlook on future work.

2 Data Preparation

As already explained in the chain above, the data exchange between the different modules is done via human-readable JSON based files. For analyzing the results from the optimization (step 2), all available information is combined into a new data model as a preprocessing step before using the analysis tool. This step is necessary because of three reasons:

1. Due to organizational issues, the optimization output file does not include the initial state of the infrastructure from the real world. Of course, for a complete analysis, the initial state is needed for making comparisons or analysis of the current (initial) infrastructure and its underlying issues. To solve this issue, the initial state of the infrastructure is transferred to the snapshot format of the optimization and then pushed to the list of infrastructure snapshots as first entry. This leads to a complete set of snapshots for the whole optimization time range and makes querying them easier.
2. By design, the optimization module only gets limited data as input, i.e. only data that are relevant for the optimization. Example: the name of the street or its coordinates are not relevant for the optimization model, but the diameter, age or material of the pipeline are important variables for calculation of the system restrictions. This step of abstraction is necessary for preventing a memory overload when conducting the optimization. For the later analysis, the user may need (depending on his background and task) all existing information about an arbitrary element, including the data excluded for optimization. Therefore, the results of the optimization have to be combined with the "meta" data gathered in step one of the three-step chain as mentioned above. Thus, the data from step one (scenario generation) is merged with the data available from the optimization.
3. The amount of available data is very large. To ensure a high performance and low response times inside the analysis tool, the data is stored according to the way it is used later on. Example: for the analysis of parameters of a single pipeline, an extra list is created holding all pipelines with all information concerning them. If the user wants to get some data for a single pipeline, it is much faster to access this list, get the selected pipeline and provide all the available data instead of traversing through the list of snapshots of the whole infrastructure and searching for the corresponding data.

In addition to the data merging process, statistics and key performance indicators are pre-calculated and stored to save computation time in the later analysis and visualization process.

3 Analysis Tool

This section covers the requirements, design and implementation of the analysis tool.

3.1 Requirements

To understand the user's needs, a stakeholder analysis has been conducted by user experience experts. Therefore, different questionnaires as well as half-day workshops have been developed and conducted with potential domain users of the system [23]. For a wide acceptance of the optimization results and the derived transformation strategies, the analysis tool is targeted on a broad range of users. Based on the nature of research projects, unexpected changes of the requirements can easily occur. The following list of requirements is an excerpt only based on the final version of the analysis tool after three years of development:

Platform-independence: to support a wide range of user-groups and devices (including mobile devices), the tool should be developed with a platform-independent technology.

Scalability: the tool has to scale to a variety of display devices. This is necessary due to the multidisciplinary background of the users. Many of the traditional infrastructure providers still use small screens with a resolution of 1024×768 (often still using DOS applications), while for presentation purposes or in modern engineering companies, higher resolutions are commonly used and needed to display all relevant information.

Usability and Understandability: due to the fact that many potential users of the system do not use IT on a daily basis, all elements and features have to be easy to use and to understand. It termed out that at least the following approaches and features should be followed and implemented:

- *Shneiderman's Information Seeking Mantra [3]* - Overview first, Zoom and Filter, then Details on Demand: the need for an always-present overview of the scenario conditions und the optimization parameter leads to Sheiderman's mantra. To build a mental model and recall the generated scenario, each analysis shall start with an overview of the optimization parameter and of the scenario area. Due to the fact that the scenario generation is a separate step which may be done a few days or weeks ago (or even from someone else), the overview capability is crucial for a successful analysis. With different interaction possibilities it should be possible for the user to focus on the interesting areas for further analysis. Popups and additional reports should then be used for details on demand, resulting in workflows and use cases which will be easy to understand even for non-experts.
- *Coordinated Multiple Views (CMV):* it termed out that all views visible by the user shall be connected in a way that if one property of the data has been changed (or selected) in one view, all other views update accordingly. This is especially crucial for users not familiar with the use of complex software applications. For more details on CMV, we kindly refer to [5].
- *Interactive georeferenced analysis capabilities:* to create a mental map of the infrastructure and the scenario area when analyzing the data, a georeferenced visualization, i.e. the use of a geographical information system, is highly recommended. To serve different user groups, multiple background layers for the map as well as additional layer functionalities are needed. Prominent examples for requested layers are satellite or street maps for analyzing infrastructures or black plans for analyzing population development. Different properties of the infrastructure shall be directly visible using color-coding or other representations (such as icons).
- *Time slider:* the most important aspect for analyzing time-dependent data has not been mentioned yet: the interaction technique for the analysis of infrastructure changes over time. This is the key feature of the analysis tool; therefore, a timeline-based slider should be used [6]. Each change of the slider on the timeline shall load the snapshot of the infrastructure from the selected year. All coordinated views have to update accordingly.

Powerful export functionalities: to satisfy not only expert users, extensive export functionalities are needed. For different reasons, many domain experts work with their own tools for analyzing special parts of the infrastructure data to generate customized reports. Therefore, the underlying data is needed. To complement the already human-readable JSON files, an Excel (or at least CSV) exporter is needed for the most important results.

Summarized one can say that different functionalities, views, and reports are needed. The following section covers the concept, design and implementation of the analysis tool and will explain how the requirements have been taken into account.

3.2 Design and Implementation

Based on the requirements from above, a concept for an extensive analysis tool has been developed. To ensure a high platform-independence, the tool has been developed using Java8 and JavaFX. Thereby, more user-groups and devices could be supported (e.g. desktop PC, tablets, or tabletops) without any installation effort.

The graphical user interface (GUI) visible to the user is structured into two sections following the focus and context principle. The first section is a narrow area on the left,

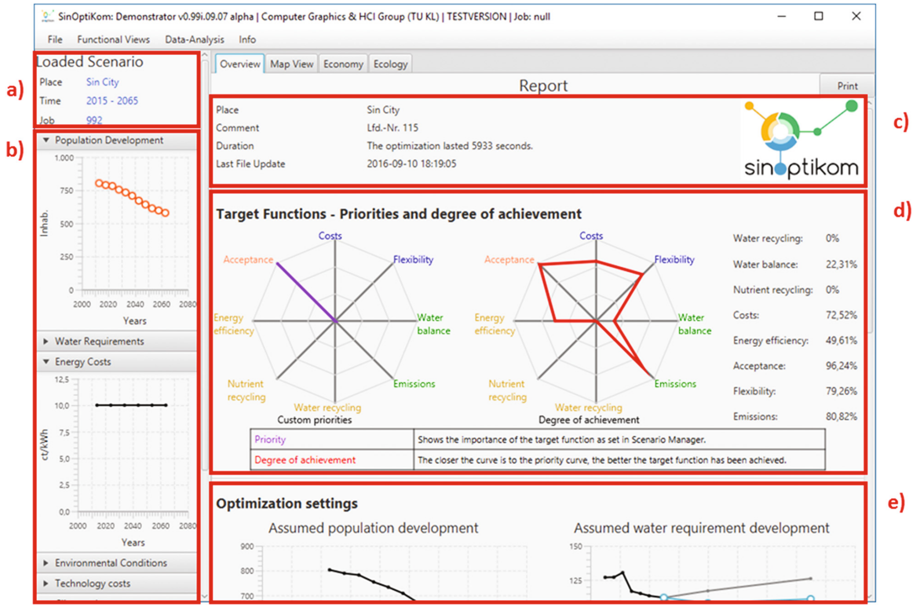

Fig. 1. Overview page. (a)+(b) The key parameters of the scenario are always visible during the analysis using the tool. This enables the user to review the settings of the scenario concerning important settings for the optimization (such as population development or water requirements). (c) shows the title of the report with detailed optimization results like comments, last update or optimization duration. In section (d), the target functions of the optimization and their degree of achievement are presented using the spider chart technique. (e) is a detailed view of the scenario settings, visible in (b).

showing all relevant information of the scenario (like time range, optimization criteria etc., see Fig. 1a+b). This section is always visible during the whole usage of the analysis tool to provide an always-present overview of the scenario. The second, larger and display-filling section is used for presenting the results of the optimization in certain ways. It contains different views and reports, which will be explained in the following.

Overview Page

After loading the optimization results from the server, the user sees an overview of all relevant parameters of the optimization (see Fig. 1). This includes information about the scenario such as region, time, population development etc. as well as information about the optimization process and parameters. One of the most important elements on this overview are the two star plots (see Fig. 1d), showing the target functions of the optimization and their degree of achievement. For more information on star plots we refer to [7, 8]. With this information, the analyst already can get a feeling on how well the results match his expectations. With a print option the user can print a report containing all available data of the scenario and optimization settings for further offline analysis.

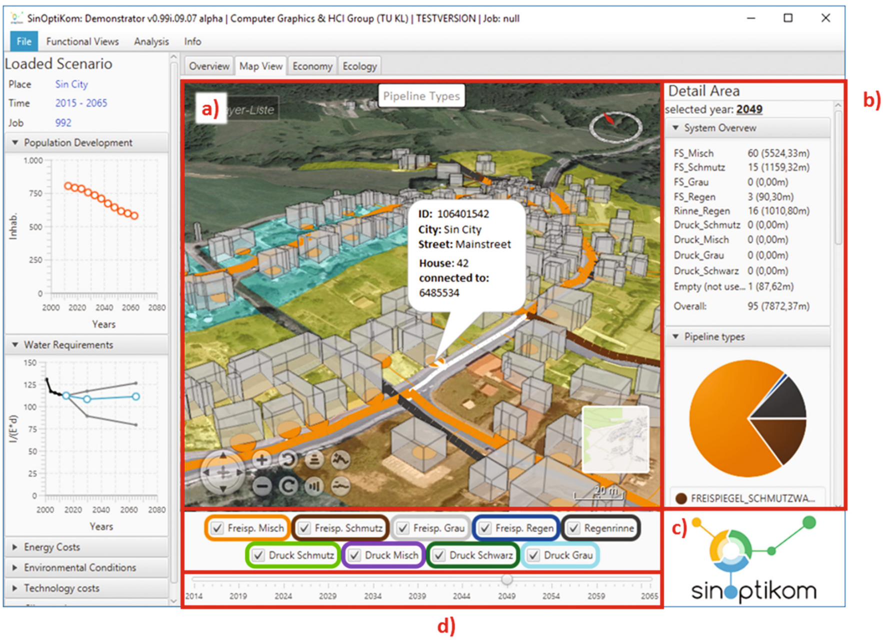

Fig. 2. Map view. In section (a) the map is shown, using a satellite image as background layer and the pipeline network as the selected resource to show using color coding. Right of the map (b), different statistical data, distributions, element histories and detailed information for the selected element are shown. The different line colors in the map (a) represent different pipeline types, explained and (de-)selectable in the legend (c). Using the slider on the bottom of the application (d), the user can browse through the snapshots of the optimization.

Map View

The main and most interesting view of the analysis tool is a map view (see Fig. 2a). This view provides a 2D and 3D map visualization of the area from the selected scenario. Using the time slider below the map (see Fig. 2d), the user can browse through the infrastructure snapshots of the optimization to analyze the transformations.

The *NASA WorldWind SDK* has been used for implementing the underlying geographical information system (GIS) functionalities [10]. This SDK provides a highly customizable framework for every kind of geo-referenced data representation and can be easily adapted to the users' needs. With the *NASA World Wind SDK* and the chosen techniques below, the analysis tool is highly adaptable to the use in further domains like energy analysis, drinking water demands etc.

The analysis of the optimization results for deriving transformation strategies for the infrastructure is supported by many different functionalities. Due to space limitations, the following list is only an excerpt of all features implemented on the map view:

- *overview and detail:* the map view is divided into two sections: on the left, the map itself is visible (see Fig. 2a) and can be manipulated by zooming, panning, rotating and tilting by the user to focus on his area of interest. On the right, an additional pane is visible showing statistical data such as distributions and detail information about the highlighted object (see Fig. 2b).
- *semantic zooming:* based on the zoom level of the map, the amount of visible information changes to prevent occlusions or visual overloading (see [9]). Example: when zooming into a certain region, icons appear on the ground showing different measures. When zooming out to get an overview, the individual icons disappear.
- *semantic highlighting:* visualizing the connections between elements connected in reality is very important for helping the user to understand the influences of certain changes. For example, selecting a single pipeline highlights all connected objects like drains, house connections and pipelines (Fig. 3a–c).
- *details-on-demand:* elements visible on the map are interactive and detailed information can be obtained by clicking on the desired element (see Fig. 3(d)). The detail information is provided in a popup, pointing to the selected element. In addition, it is also printed in the right column to prevent occlusions on the map.
- *predefined views:* based on use cases of different user groups, predefined views are available. They are extremely helpful for a fast comparison of different optimization results. They fasten the process for creating an often needed view by visualizing a certain amount of data with predefined settings (including layer settings etc.). Prominent examples are views for the pipeline type or age, technical restrictions (e.g. flow speeds), connected inhabitants, or data quality (see Fig. 4).

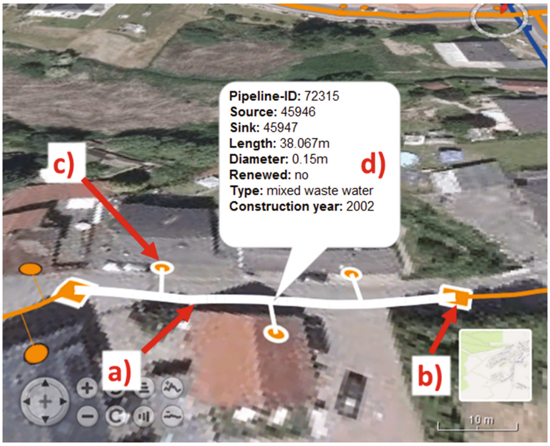

Fig. 3. Semantic highlighting and details on demand: When selecting an item all semantic connected items are also highlighted. In this figure the user clicked on the pipeline (a) and all connected nodes (b) and house connections (c) are getting highlighted. In addition, a pop up is shown with all details of the selected item.

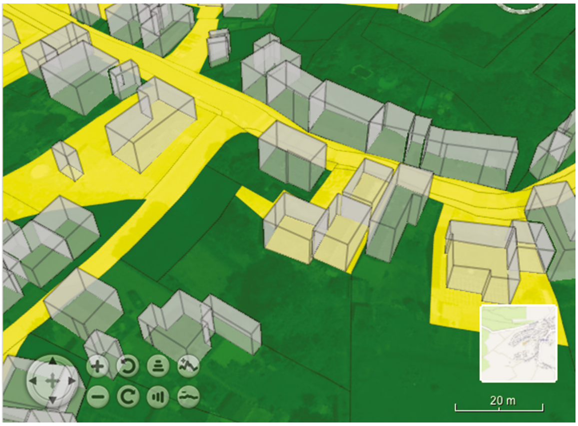

Fig. 4. Visualization of data quality: due to the fact that the quality of the underlying data is often not good enough, visualization techniques are used for analyzing wrong or missing data in advance. This example shows a predefined view concerning properties with missing statistical data colored in yellow, properties with entire data in green. For a better perception, the buildings are visible as 3D sketches.

- *search functionality and cross-connections:* to enhance the user comfort, a search functionality is provided. When searching for an element, the map is zoomed in and centered to the target automatically. In addition, the element gets highlighted for a better visual perception. The search functionality saves a lot of time when comparing different optimization results, because the user can directly jump to the element of interest. Furthermore, all reporting views use the same, unique element IDs, so it is possible to jump from an entry in a report directly to its geospatial representation in the map view to see the elements' context and position. This feature has been proven to be crucial for understanding the spatial relationship of all elements in the reports.

Reporting Views
For analyzing optimization results with no geospatial references (e.g. analyzing the costs or measures grouped by year), reporting views are needed. The analysis has been simplified according to many use cases by providing different predefined reporting views, e.g. financial cost reports, detailed population development, and technical data about the infrastructure. To explain all reports in detail would go over the scope of this paper. As already mentioned, the items from the reports (e.g. a single pipeline appearing in a table) and the map view are connected, i.e. if a user is interested in the geospatial information of an item from the report, he can directly jump to it on the map. This helps to enhance the usability a lot; resulting in a better understanding and perception of the optimization results

3.3 Application and Results

The analysis tool has been developed over a period of three years with ongoing feedback from users in the engineering domain. The tool has been used on a daily basis, on the one hand for analyzing the results of the optimization, on the other hand to comprehend, debug and enhance the optimization algorithm. The time to find and correct an error in the optimization has been greatly reduced after the first version of the analysis tool was available, which encourages its great importance for communicating and analyzing results with appropriate visualization. Choosing an iterative development approach (a new version was released every week), the users were able to directly influence the development, features and evolution of the analysis tool. Many different views and detail levels were developed, allowing all stakeholders to evaluate relevant aspects from the optimization results and use them in their daily work such as adaption of water fees in the administration department, political changes or reactions on population development for majors, and functional limits of single pipelines for engineers. Experts were able to successfully analyze different transformation strategies for infrastructures in rural areas.

The tool has been tested on a variety of traditional desktop devices as well as on large tabletops (using a Microsoft Surface tabletop device) and different tablet devices running Microsoft Windows. It termed out that the used *NASA World Wind Java SDK* was not optimized for multitouch input, but until the end of the project no extra touch-optimized features were implemented.

During the runtime of the project, more than 1000 scenarios have been analyzed. Instead of scrolling through tables with hundreds of rows and mentally combine the data, users got visual support via map-based georeferenced presentation of the results using our analysis tool.

4 Conclusion and Future Work

In this paper, we presented a concept and techniques for analyzing time-dependent optimization results of waste water infrastructures in rural areas. The developed platform-independent analysis tool features a GIS based map view for analyzing geospatial relations between the optimization items. For traversing through the optimization snapshots for each timestamp, an easy to use slider metaphor has been implemented. Common visualization techniques (like sematic zooming and highlighting, details on demand or layer techniques) are used to enhance the usability and support a wide range of users and use cases. For connecting textual reports with the (geospatial) mental model of the user from the scenario area, a search functionality has been deployed enabling a direct connection from an item out of the report to its geospatial representation on the map.

For the future, we want to port the analysis tool to the web using the new HTML5 based *NASA World Wind Web SDK*. This will simplify updates and enable additional devices like *Android* or *iOS*-based smartphones and tablets to be used without creating native applications. We expect that providing the tool optimized for touch interaction on mobile devices would additionally enhance its use and acceptance for even more stakeholders.

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Urban Informality and Infrastructure Planning in Hong Kong and Lagos Metropolis: Professionals Perspectives

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Abstract. This study assesses the professional perspective of urban informality and infrastructure planning in Hong Kong and Lagos metropolis so as to develop a strategy for sustainable urban development and ameliorate the challenges of urban informal settlement and infrastructure planning globally. The study adopts case study methodology with the qualitative method of data collection and mixed method of data analysis through reconnaissance survey, participant observation and the interview of environmental professionals. The data were analyzed through the theme description and descriptive statistics such as tables, pictures, images and the reported statements of the interviewee. The findings of this study reflect that urban informal settlement and infrastructure challenges exist and it's associated with several other factors. Also, inadequate infrastructure is described to affects the condition of living in Lagos metropolis, but such cannot be stated in Hong Kong, as the proliferation of poor condition of living is more of a system and governance than infrastructure development.

Keywords: Urban informality · Urban informal settlement · Infrastructure · Planning · Urbanization · Sustainable development

1 Introduction

Globally, the urban environment is greatly challenged and it was estimated that by 2020, the global urban areas will be the most challenged areas of every nation [1]. Although the issue of urban informality and infrastructure challenge as a global challenge is controversial, however, the studies of [2–4] and several other related literature argued that urban informality challenge is a global urban challenge that is contemporary in every country despite its contribution to urban development.

There is a growing concern for Lagos metropolis as a megacity with the world's most rapidly urbanizing area that is severely challenged with urban informality and infrastructure planning challenges as a developing nation [5]. The growth of Lagos metropolis has been phenomenal in both the demographic growth and spatial growth, but the metropolis is still greatly challenged with different urban informality and infrastructure challenges. The population of Lagos metropolis from about twenty-five thousand (25,000) in 1866, reached six hundred and sixty-five thousand (665,000) in

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1963; it became over ten million (10,000,000.00) in 1995 thus attaining mega-city by UN definition and over seventeen million (17,000,000.00) by the current 2006 Lagos population census. This population growth lacks basic facilities and services, thus the living condition of the metropolis is characterized with several urban informal settlement and infrastructure challenges [6]. Considering, this severe global urban challenges in developing countries of the world and in Lagos metropolis, this study assesses the professional perspective of this challenges from the study of Hong Kong and Lagos metropolis to develop a strategy to ameliorate this challenges globally.

2 Literature Review

Urban informality also refers to as urban informal settlement is an urban planning and urban design philosophy that describe physical development activities in relation to its required standard; that is the ‘formal’ versus ‘informal’ [2, 4]. Although its definition and uses are controversial, however, several other literature and research in urban planning, urban design, social sciences and environmental sciences described it as critical urban challenges that militate against achieving sustainable urban development from different perspectives [7]. Urban informality is described from the perspective of formal versus informal with several criteria measurement adopted for its conceptualization, definition, and application in urban planning and design [2]. But generally, it is a frequently used concept by different professionals to describe irregularity. It is a concept that cut across different professions and different sector of every nation with several professional schools of thoughts about its causes and evolution. Some school of thoughts believes it’s a system of urban development (organic settlement evolution) and some described it as a phenomenon that occurs as result of urban growth, urbanization (urban metamorphosis) and some other school of thoughts refer to it as consequence of urban deficiencies globally.

Despite the conclusions of several studies on urban informality as a critical urban challenge globally, urban informality (informal sector) still contributes greatly to the economic development of several developed countries and developing countries such as Nigeria. [8] also agree it’s a global challenge yet described urban informality (informal economy) as the highest employer of labor. The study describes the significance of urban informal economy in Lagos metropolis with (UNDP 2000) and (Lagos state government 2004) statistics, stating that informal economy accounts for over 70% of urban employment in Nigeria and an estimate of 50%–70% of Lagos residents are employed by informal economy respectively. [9] also argue that informal settlement accommodates substantial population but without significant planning framework to upgrade them. [9] described the significance of informal settlement globally using Sri Lanka, Cape Town and South Africa among others and concludes that informal settlement is an untapped asset that is been marginalized and it requires planning framework. This study identifies urban informality from several literature perspectives (informal economy, informal settlement, formal versus informal) as a covert potential activity with economic capital, human capital, social capital that is greatly disregarded, challenged and often referred to as urban challenges globally.

This research, however, describes the challenges of urban informality and infrastructure planning in the study areas so as to create a theoretical stance for this study and to assess the professional perspective of ameliorating this challenges from the study of Hong Kong and Lagos metropolis. [3] attributes urban informality and infrastructure challenges in Lagos metropolis to urban growths and states that the security of tenure as part of the settlement evolution in Lagos metropolis, coupled with the urbanization growth rate creates urban informality and infrastructure challenges that incapacitate the achievement of the Millennium Development Goals 7 in Lagos metropolis. Also, [6] states that the challenges of urbanization and urban informality also contributes to the proliferation of infrastructure challenges and vice-versa in Lagos metropolis. These challenges create an awkward expansion of urban centers with agglomerations of different pockets of planning problems such as the challenges of provision and management of infrastructures like roads, electricity, health and sewage systems just to mention few in the metropolis. Urban informality and inadequate infrastructure planning are evidently identified as a major factor of urban poverty, environmental pollution, increased spread of diseases and epidemics, and urban crime among other challenges in Lagos metropolis [8].

The condition of urban informality and infrastructure planning challenges in Lagos metropolis continues to deteriorate the quality of living of its citizen, partly because of the land acquisition challenges, the complex procedures and the bureaucratic challenges that makes the land acquisition goes beyond the reach of the poor and which makes it more challenging for both the urban manager and the citizens [10]. The public utilities are insufficient and overstretched from the reach of the general public [6] and more than half of Lagosians are tenants and homeless in both slum and non-slum areas of the metropolis [10]. There is no difference between the slum and non-slum areas in terms of ownership of houses within the urban centers [10]. [1] and several other related literature have established the fact that the formal house ownership in developing countries of the world is below the national average of 30.0%, and informal settlement occupies above 55.0% with significant numbers in Sub-Sahara Africa and Lagos metropolis in particular [1].

The issue of urban informality, housing inequality, and homelessness in Hong Kong SAR with literature evidence shows that these challenges exist in Hong Kong and other developed countries of the world. [11] investigate the significance of policy changes and government response to the challenges of housing provisions and distribution in Hong Kong. The study finds out that there has been a drastic change in housing policy with different positive and negative effect since 1997 and most of this positive and adverse effect is attributed to Asian financial crisis, economic boom and policy changes along these areas. Thus, the government effort according to the research targeted 70% (85,000) housing units every year by 2006 to improve home ownership rate; enhance social equity and social sustainability. These challenges were discussed from the perspective of social housing sustainability principle and the concept of sustainable urban development. That is, the indices of equity and housing capacity to meet the future needs. The study emphasizes that to achieve social equity in housing, there must be social sustainability and sustainable development structures in Hong Kong.

[12], describe urban informality, housing insecurity, homelessness, and infrastructure challenge in Asia particularly Hong Kong as social exclusion challenge. The study of the three fastest growing economy in Asia (China, Hong Kong, and Japan) among others, by [12] reveals that despite the dynamics of economic formation and transition into market socialism; not all areas of these countries have benefited from these countries dynamic economic growth. [12] further states that, although economic growth and development is been achieved in Hong Kong, yet it does not benefit all its citizens and the growth is also not sustained across all the society and thus the experience of this excluded areas are characterized by urban informality and infrastructure challenges despite the significant development of the country's infrastructure, housing, and economic development. [13, 14] also, share the opinion that infrastructure development is a challenge in Hong Kong in relation to project development execution and thus develop the process framework of public-private-people partnership to improve infrastructure development in Hong Kong.

2.1 Research Framework

Urban informality and infrastructure planning challenges are described as the functioning geographical area below its planned or organized planning standard [1] and it's also described it in terms of 'formal' versus 'informal'. Also, urban informality is described with areas of illegal occupant, degraded environmental condition, haphazard buildings with inadequate or lack of infrastructure, juvenile delinquencies, unemployment, and general slum characteristics. The urban informality and infrastructure challenges are also identified to significantly associate with urban poverty, social justice, the nature of settlement development, urbanization, infrastructure planning and management related issues in urban areas [4].

Considering, the challenges of urban informality and infrastructure in Lagos metropolis and Hong Kong from the literature perspective above and the need to achieve the aim of sustainable urban strategies in this study. Figures 1 and 2 below describes the concept of urban informality and infrastructure integration as the research framework of this study. The figures illustrate the concept and factors of urban informality and infrastructure integration in the study area and describe the strategy for integrating the professional perspectives of ameliorating the challenges of urban informality and infrastructure planning. The concept emphasizes the integration of urban informal and formal with infrastructure for sustainable settlement (the people and the area) development.

The research framework for this study as described in Figure below bridge the gap in knowledge of sustainable urban informal settlement and infrastructure planning integration in Lagos metropolis and other developing countries through the study of Hong Kong and Lagos metropolis. The research framework answer the research question of what are the system and operation of urban informality in Hong Kong and Lagos metropolis towards achieving a sustainable infrastructural settlement? To achieve the aim of this research and to answer the research question of this study

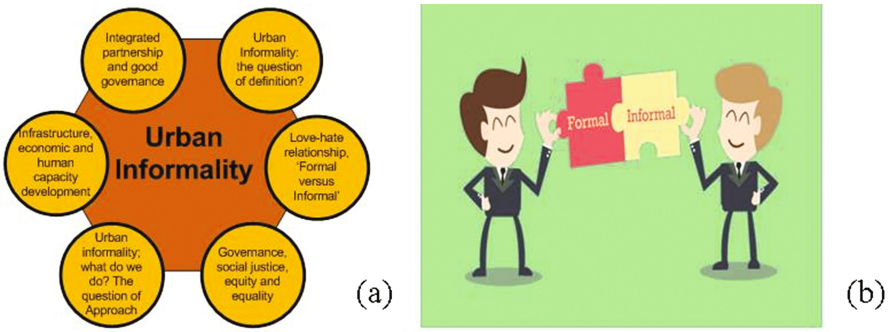

Fig. 1. The concept of urban informality (a) Source: Authors 2017, Urban informality and infrastructure integration (b) Source: Google image extracted 2017

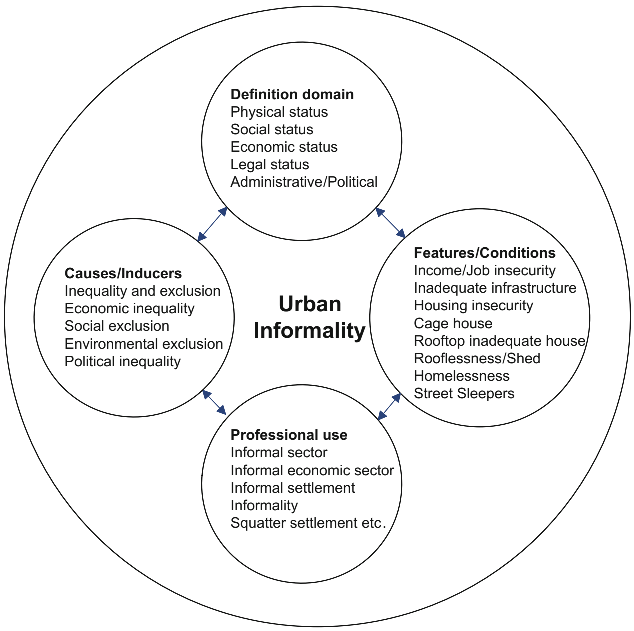

Fig. 2. Context of urban informality against formality. Source: Author's 2017

through the research framework, this study investigates the formal and the informal settlement and infrastructure planning in Hong Kong and Lagos metropolis using a case study methodology through the qualitative method of data collection and mixed methods of data analysis as discussed in Sect. 3 below.

3 Methodology

3.1 Study Context

The coastal city of Lagos is one of the largest city in the world, with latitudes 6°23″N and 6°41″N and longitudes 2°42″E and 3°42″E with a geographical area of 3,577 km^2 and a population of over 17 million that is critically challenged by urban informality and infrastructure challenges [8]. There is a growing concern for Lagos metropolis as a mega-city with one of the most rapidly urbanizing areas in the world and the Nigeria's most populous conurbation. Its growth has been phenomenal in terms of demographic and spatial development over the years. The population of Lagos metropolis grows from about twenty-five thousand (25,000) in 1866 to six hundred and sixty-five thousand (665,000) in 1963 and it became over ten million (10,000,000.00) in 1995 thus attaining mega-city by UN definition and now over seventeen million (17,000,000.00) by the current 2006 Lagos population census. This population growth is void of adequate infrastructure and facility development; thus the metropolis is characterized by several urban challenges [10].

Hong Kong as one of the study area of this research is located within 22o19′42″ N and 114o11′30″ E southern coast of China with an estimated population of 7, 152, 000, 1,110 km^2 land area. The environmentalist perspectives of this study include the three (3) main geographical region or territories of Hong Kong, namely the New Territories, Kowloon Peninsula and the Hong Kong Island [15]. The professionals within the three (3) geographical region of Hong Kong is adopted to allow adequate representation of Hong Kong professional perspective and to allow convenient practicable research area for this study. Hong Kong is adopted for this study considering its past experience of this challenges and its transformation from critical urban informality and infrastructure-challenged area to one of the best urban areas in the world, although not without this challenges at the moment [12]. This challenge is evidence in Hong Kong with several urban constraints that creates a high cost of housing, high housing demand and the wide gap between the rich and the poor that exists in the country to the development of homeless, street sleepers and others.

The evidence of this challenges from the literature review and field analysis of this research in Lagos metropolis and Hong Kong justify these areas for this study to adequately create a strategy to ameliorate this challenge. The research methods adopted in this study for the recommendations and the conclusion made in this study is discussed in Sect. 3.2 as follows.

3.2 Methods

This study adopts case study methodology with the qualitative method of data collection through reconnaissance survey, participant observation and interviews with the professionals from the built-up environment. The data were analyzed using mixed method data analysis with the theme description, descriptive statistics such as tables, pictures, images and the reported statements of the interviewee. The case study methodology in Lagos metropolis and Hong Kong as described in Sect. 3.1 above was adopted to allow a site-specific data collection and analysis in relation to specific locations and to subsequently generate site-specific conclusion and recommendations required for this study generalization. The qualitative method of data collection adopted for this study is through the interview, while the reconnaissance survey and the participant observation was to validate the reliability of the response received from the interview. The reconnaissance survey and the participant observation is a method of data collection that was carried out through the researchers constant and structured visit and participation as residents of the study areas for a period of three (3) month to study the urban informality and infrastructure situation of the study areas and thus use it to validate the findings of the interviews conducted. The study sample frame includes all the built-up environmental professionals in the study areas and the sample size adopts the concept of saturation [16]. The sampling techniques adopted in the study areas include a snowball sampling techniques, (a chain-referral sampling techniques) of professionals that meet the minimum required criteria of Master's degree in any environmental sciences or design related studies and must have been practicing in the public or private practices between five to ten (5–10) years. The illustration of Tables 1 and 2 below presents the distribution of the professionals sampled and the samples taking in the study areas.

Table 1. The sample size of the study areas

S/N	Professionals Interview (PI)	Lagos metropolis	Hong Kong	Total
1	Lectures/Academicians	5	5	10
2	Public Professionals/Civil servants	10	1	11
3	Private Practitioners/Consultants	3	6	9
Total		**18**	**12**	**30**

Source: Author's Field Work 2016.

According to the study of [16, 17] and other literature, there is no real standard or benchmarks to measure or determine how much of interview study or sample that is enough in interview and ethnography studies. However, a minimum of twelve with evidence of repeated responses (the concept of saturation) from the interviewee has been established over time useful to set limits for further interviews and this has been adopted in this study. The characteristics and the distribution of the interviewee are presented

The professionals interviewed according to Table 2 below in Hong Kong and Lagos metropolis, share their professional perspective of urban informality and infrastructure challenges and the perceived relationship between urban informality and infrastructure in Hong and Lagos metropolis and this is discussed in Sect. 4 below.

Table 2. The distribution of the interviewee

S/N	Lagos metropolis, Nigeria		Hong Kong	
	Professionals Interviewed (PI) Profession	No. Sampled	Professionals Interviewed (PI) Profession	No. Sampled
1	Quantity Surveyor	2	Landscape Architect	2
2	Architects	4	Interior Designers/Architects	2
3	Estate Surveyors	4	Estate Manager	3
4	Urban Planners	8	Urban Planners/Designer	5
Total		**18**		**12**

Sources: Author's Field Work 2016

4 Discussion

The issue of urban informality and infrastructure planning is a multifaceted discussion with different perspective, however considering this research aim, this research framework and the need to provide sustainable approach to solve the challenges of urban informality and infrastructure planning from the study of Hong Kong and Lagos metropolis, this study discussion includes the formal versus informal; question of definition, urban informality and infrastructure; the system operation and the urban informality and infrastructure perspective and approach.

4.1 Formality Versus Informality; the Question of Definition

The issues of urban informality and formality has been discussed severally with different conclusions, however the perspective of the professionals interviewed in Hong Kong and Lagos metropolis reflects that there exists unequal growth, inadequate distribution of urban resources, poor condition of living, unruly development and urban areas that are greatly described as urban challenged by this professional. Although some professionals question the use of the word and the criteria for describing an area as formal or informal, for example, and interviewee states that

"…yes urban challenged area exists in Hong Kong and similarly in other countries, I want to believe but how do you judge an area formal or informal? I would rather refer to those areas as urban challenged areas…" (PI4 K).

but Fig. 3 describe the summary of what most professionals refer to as urban informality and the reverse as the formality. The summary of findings of the professionals interviewed reflects that there exists urban challenged area, urban informality as regarded in this study in Hong Kong and Lagos metropolis and the findings also shows that it is associated with several other sectors of the urban areas such as the infrastructure, the economy, the governance and the quality of the environment where they are identified. Figure 3 below describe the various context of the definition of urban informality against the formality from the study of Hong Kong and Lagos metropolis as follows:

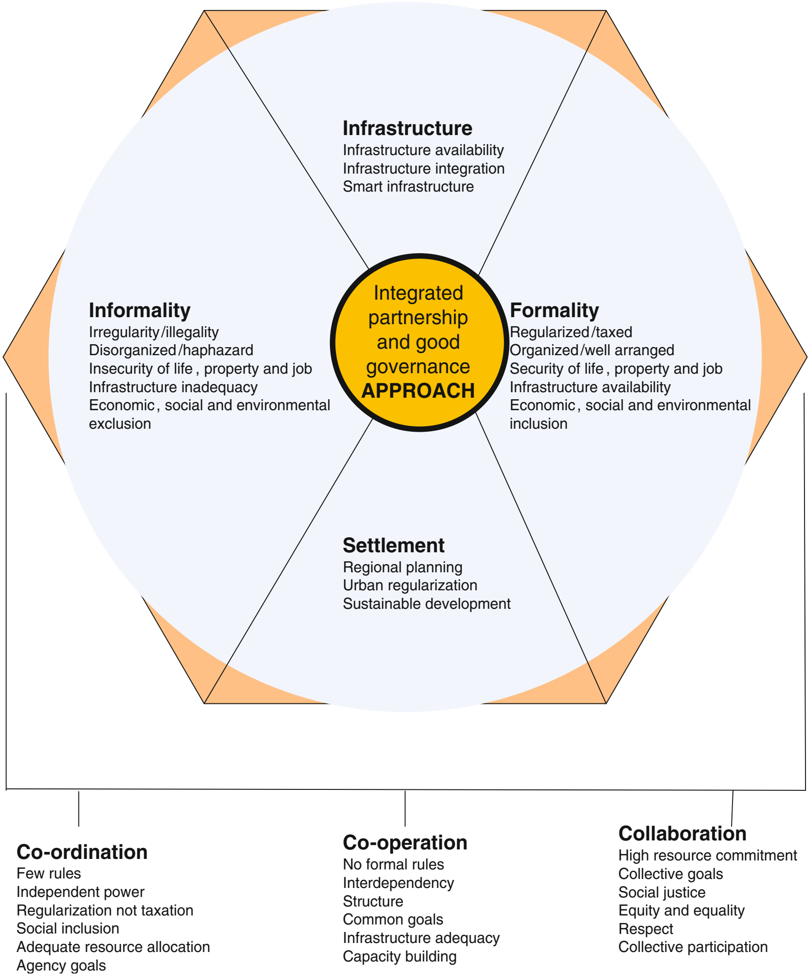

Fig. 3. Urban informality and infrastructure planning integration, from the professional perspective. Source: Author's 2017

4.2 Urban Informality and Infrastructure Planning; the System Operation

This aspect of this study described the professional perspective of the urban informality and infrastructure planning in the study areas and how they exist or operate. The relationship that exists between the urban informality and the infrastructure development of the study area towards the sustainable development of the urban challenged areas in the study areas was also discussed and the findings of this study are described in Table 3 below.

Table 3. Urban informality and infrastructure; system operation

	Lagos metropolis		Hong Kong		Theme description (Significant response from interviewee)
Q1	**Do you think urban informality occur in your area and what do you think is the causes?**				
PI	**No**	**Yes**	**No**	**Yes**	"…yes it occurs and I think it's because Hong Kong is an open economy that most of our people have no power to compete and which create a wide gap between the rich and the poor…."
PI1	0	2	–	–	
PI2	0	4	1	3	
PI3	0	4	1	2	"…yes and so many factors such as tenure-ship, political, socio-economic are the causes…"
PI4	0	8	0	5	
Total	**0**	**18**	**2**	**10**	
Q2	**Do you think infrastructure availability affects urban informality in your area and vice-versa?**				
PI	**No**	**Yes**	**No**	**Yes**	"Maybe in another country, but in Hong Kong, we have good infrastructure it's just policy, economic and social issues I think still keep larger people in poor housing…"
PI1	0	2	–	–	
PI2	1	3	3	1	
PI3	2	2	3	0	"Yes, of course, in fact, I can say most of our challenge is infrastructure based, maybe if we get the infrastructure right other things will fall in place and which will reflect on housing and condition of living…"
PI4	2	6	4	1	
Total	**5**	**13**	**10**	**2**	
Q3	**Are you satisfied with housing and infrastructure in your area, and why your opinion?**				
PI	**No**	**Yes**	**No**	**Yes**	"…hmm, infrastructure yes I am satisfied because we have good infrastructure but for housing Hong Kong government still need to do a lot more…"
PI1	2	0	–	–	
PI2	4	0	2	2	
PI3	4	0	1	2	"…satisfied? how can I be satisfied with housing or infrastructure in this country, when there is no electricity, good road and affordable house…"
PI4	8	0	1	4	
Total	**18**	**0**	**4**	**8**	

PI = Professionals Interviewed, 1 = Quantity surveyor, 2 = All architects, 3 = Estate surveyors, 4 = Urban planner/Designers, for more details see Tables 1 and 2 above.
Source: Author's Field Work 2016

5 Recommendation

The study of urban informality and infrastructure planning in Hong Kong and Lagos metropolis reveals the professional's perspectives of this issue and this corroborates several kinds of literature in most areas except the case of Hong Kong where the infrastructure development cannot be stated to have a significant influence on proliferation of urban informality and vice versa. Thus, this study recommends the following strategies as described in Fig. 3 above to adequately ameliorate these challenges and achieve sustainable urban development based on the findings of this study.

The study recommends the following strategies based on the findings of this study, the research framework and the integration approach of Fig. 3 above as follows:

1. The application of co-ordination, co-operation and collaboration strategies to the integration of infrastructure in the urban settlement.
2. Good governance through the application of co-ordination, co-operation and collaboration strategies towards urban informalities and infrastructure planning policy formulation and implementation.
3. The adoption of social justice, equity, and equality in wealth creation and distribution.
4. The citizen's capacity development through the poverty alleviation and job creation strategies to bridge the gap between the rich and the poor and which will consequently reflect in urban development should be adopted.
5. The challenges of urban informality and infrastructure planning are identified to associate with several other factors, which described it as system issues and it should be addressed as a system and in cyclical tactics as illustrated in Fig. 3 above.

6 Conclusion

This study concludes that the definition and use of urban informality can be referred to as urban challenged areas that are described with basic criteria such as the inadequate housing condition, non-regularized, non-tax, obsolete with run-down physical structures and the condition of living is generally below the required standard. The concept of urban informalities and formalities varies and the application of this term in social sciences and urban design discourse still lacks significant attention and developmental approach towards achieving sustainable urban development. This study also concludes that infrastructure is relatively broad and its associated with urban informality, but it cannot be stated as significant in the proliferation of urban informality. The study of Lagos metropolis reflects that inadequate infrastructure development contributes significantly to the development of urban informality and in some cases, the urban informal settlement drifts to paralyze the infrastructure in some areas and creates pockets of several urban informal settlements with challenged infrastructure areas in the metropolis. This cannot be stated in Hong Kong as the study of Hong Kong reflect one of the best infrastructures in the world but the challenges of urban informality do exist in few areas and which was attributed to the system of governance, the increasing gap between the rich and the poor and the increasing population against the fixed small proportion of the buildable area in the country among other factors. Thus, this study further concludes that urban informality and infrastructure challenges are products of several factors but significantly urban inadequacies, the wide gap between the rich and the poor, urban social injustice, inadequate infrastructure, social exclusion, political issue and policy challenges which are more significant among other factors globally.

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Global City: Index for Industry Sustainable Development

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Abstract. Nowadays, discussion on global cities concept is been addressed at a European level. The concept is a consequence of the array of globalization processes, adding different analysis layers according to social, economic and environmental requirements, such as, cultural, user-friendly and amenity, assessable, sharing, energy, smart, green or city factory age-friendly cities and communities. Cities should also be analyzed as working systems, with the same needs and requirements in terms of safety and well-being that are considered for other systems. Taking this into consideration, the goal of being a Global City should also comprise the so-called occupational layer. Therefore, it is important, within a city context, to define indicators for Sustainability regarding the occupational Layer. This paper aims to develop a methodology helping cities, at a local level, to define an Index for Industry Sustainable development contributing for the global city model.

Keywords: Global cities · Sustainability · Occupational layer

1 Introduction

Nowadays, at a European addressed discussion on global cities concept. The concept is a consequence of the array of globalization processes, adding different layers according to social, economic and environmental requirements, such as, cultural, user-friendly and amenity, assessable, sharing, energy, smart, green or city factory age-friendly cities and communities.

According to [1], cities represents a certain geographic context where people leave, socialize, study, work and more recently are connected. Permanence on cities is depending on historical, cultural, environmental or religious attributes [2]. Several "smart" initiatives for improving cities' energy efficiency, human living and environment, economy and governance are identified by [3]. A study conducted on smart cities point out smart city neglected people and communities on the expense of a deeper understanding of the technological aspect of smart, meaning technological and structural aspects [4]. Despite all the technological progress, some authors [5] believe that people are the most important value in cities. Therefore, cities should have certain features to improve people's life quality and satisfaction so they identified themselves to the place and permanence there. Some authors [6] argue that for a city be livable it should have identified Physical features (including Culture, green areas, public transport efficiency

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and availability, Sports grounds and facilities, among others), Features of a Social nature (Neighborhood networks), Environmental features (calm, clean, good air quality, among others), Economical and Institutional features. Labor market opportunities are included on the last one – Economical and Institutional- considering private investments and public policies aiming to create more sustainable employment. Therefore, to a city be livable, it also should be attractive in terms of jobs opportunities and working conditions. More recently, [7] state that cities should also been understood as working systems, with the same needs and requirements in terms of safety and well-being that are considered for other systems. According to the holistic approach developed by Rasmussen [8], any work place should been understood in terms of social-technical system comprising the individual, technological and organization sub-systems. This approach also includes a view on an internal and external environment. In the external one, worker it is studied as an integrated part of society and in a narrow sense of a given community. The overall system performance (Working system) is analyzed by the way that worker conducts this interaction. At a business level, environmental-efficiency and socio-responsibility and ecological equity are often associated to sustainability [9]. Meaning that, natural, human, and social capitals are important to maintain the system performance. To ensure safe, healthy and functional workplaces, an organization must consider a system performance that ensures longevity and overall comfort and well-being of their workforces. Taking this into consideration, the goal of being a Global City should also comprise the so-called occupational layer. Therefore, Global means several layers that a city can add in order to achieve sustainable development in its different dimensions. A report supported by the European Union [10], identified several indicators for cities aiming to access their level/progress in terms of Sustainability development. These indicators included policies, infrastructure analysis, socio-economic factors, Water resource use, emissions and any other processes that contribute to city's metabolism, prosperity and above all to citizens' quality of life. This study presents several methodologies used to assess the sustainable status of a city. It is important to remark that the indicator to assess Industrial contribution for the city sustainable goal it is related to quantitative data from Energy consumption for industrial use, industrial waste, wastewater treatment, air quality and acoustic impacts.

Industrial Spatial planning and design of industrial parks have a long history, however just recently, their planning began to incorporate in a more integrated way new components, such as sustainable transportation and spatial articulation [11]. This new vision is part of an eco-industrial development and integrated development systems approach. On the other hand, current literature includes new trends in the development of industrial parks – the Eco-industrial parks, which includes green jobs, green marketing, environmental concerns, academic support for industrial ecology, renewable energy, restoration of contaminated land and public policies [12]. Less explored topics related to planning of an industrial park are the characteristics of the infrastructures, the use of green materials, the accessibility and the spatial articulation with the neighboring areas [13]. Moreover, transport and land are a major source of resources needs in an industrial area [14]. The integration of these new drivers is embedded within a holistic vision of development and sustainability, in which the industrial park acts as an interactive space with the surrounding territory.

Note that Public policies and governance aiming to define strategies for the economic development of a city are already indicators for the territory sustainable development. There is a lack of indicators regarding the Industrial sector/ Industrial parks to assess the impact of the implemented measures into the global goal of the city. In addition, the relation between livable cities concept versus occupational city, should been analyzed accessing if working condition improvements contributes to increase permanence. Meaning that, Private contributions to the so-called city goal should also be assessed in terms of policies to promote workers' green skills, to improve working conditions or to develop sustainable initiatives more environmental friendly such us sustainable mobility considering the trips work-home (carpooling, bike-sharing systems). Private policies such as investment on electrical fleet, innovation programs, new technologies implementation or plans for green areas preservation should be consider as indicators that contribute to city sustainable goal.

This paper aims to present the necessity of cities having an Index for Industry Sustainable development contributing for the global city model. General guidelines are presented in this paper. For that, a methodology was establish using a city considered a reference in sustainable development at National level, as sample.

2 Methodology

The methodology under this study, used as a context a city located in the North of Portugal named Guimarães. The first step of the methodology was to gather information of the city regarding (1) geographic reference, population and administrative organization, (2) a description of the territory in terms water resources, industrial activity, and technological centers helping the Industry development. The second step consisted in the identification of the main achievements of the city, considering the past years. Each achievement was a layer added in order to achieve the mail goal identified as the Sustainable Goal for the territory development. The third part comprises an analysis on the indicators that city is using to assess the progress in terms of sustainable goal. Finally, a first approach to a questionnaire development, was made. The objective of the questionnaire is to gather information on good practices that companies are implementing as well to understand the level of commitment to improving working conditions.

3 Comments

Guimarães is located in the North of Portugal; being this region the fifth most industrialized region in the European Union representing tradings' of 17 billion Euros. According to the 2011 Census, Guimarães has 158 124 inhabitants distributed by 240.955 km^2. In terms of administrative organization, the territory has 48 parishes, with a group of 17 medium size agglomerations, and 31 small sized (Fig. 1).

Fig. 1. Administrative organization of Guimarães, 2013 (From Guimarães City Hall website).

3.1 Context Characterization

Guimarães integrates the Sub-basin of Ave River, which has a total area of 1391 km^2 covering 19 municipalities. Ave River has more than 100 km length, a third of which is located within Guimarães. Note that this river is the main source of the water supplied to the city and is where most of the Industries are located. The River is the blue line presented on Fig. 2 and industries' distribution presented in purple. Footwear production, textile and cutlery are the main activities.

It is important to notice that the Region were Guimarães is included, one of the North Regions named Minho Region, was very affected by the 2008 National economic crisis being increasing unemployment the huge consequence. With this, several social problems affected our society. It was than necessary to adopted strategies and policies at local level turning over the page to recover its position in terms of industrial and exporting vocation.

To face global challenges, Guimarães industries invested in innovative industrial process less pollutant. Quality was preferred to mass production requiring Educational policies from local authorities to train people, creating new skills. Also, local authorities were challenged to create specialized departments in finances and economy helping Small Medium Size companies to face crisis, developing facilitating regulation, creating new business opportunities and promoting entrepreneurship helping Region' and consequently local development. Nowadays, the secondary sector is the dominant economic activity, in which 70% of the companies represent the textile industry. The metallurgical

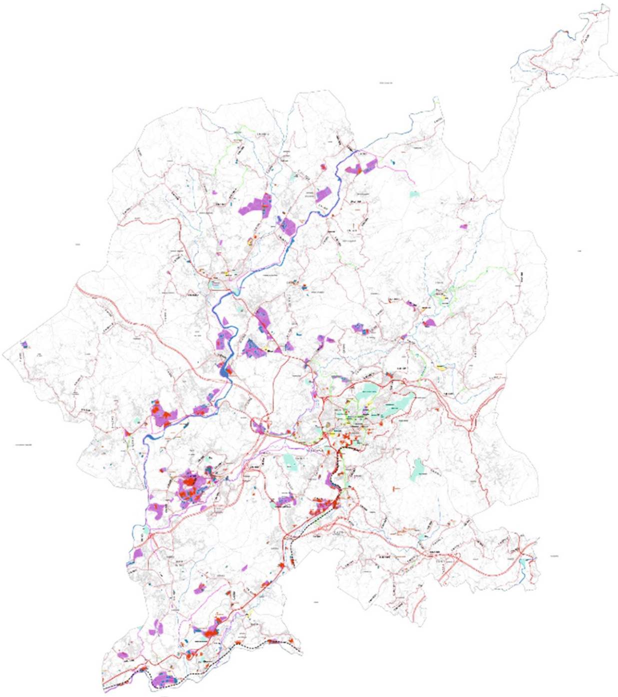

Fig. 2. Guimarães: Industries distribution (purple) (From Guimarães city Hall Website).

industry is also represented mainly the cutlery industries. Footwear and leather industries also have some representation. It is important to notice that a vast majority of Guimarães citizens work in the Industrial sector.

Over the years, several technological centers were created supporting companies in innovation and strategies to face global changes. Most of these technological centers are a part of the University of Minho having City Hall as a partner in the Institution Board. An example of that is the CVR – Center for Waste Valorization, the TecMinho – platform for knowledge and innovation transfer, PIEP – Innovation in Polymer engineering. The city Hall is also responsible for the management of the most important technological park in the Region, named Avepark where important spin-off and star-ups and research centers are located.

3.2 City Achievements

The main city achievements and Goals are presented in Fig. 3.

The historical center of Guimarães suffered for over 20 years a requalification focused on buildings refurbishment and public squares regeneration. This strategy improved the quality of life of citizens also a usufruct of the public space. The existent factories in this area were requalified being now important facilities for the Municipality. That is why in 2001, UNESCO recognize the work done. In 2012, Guimarães positioned in the map of Europe, being European Capital of Culture. Culture and History were

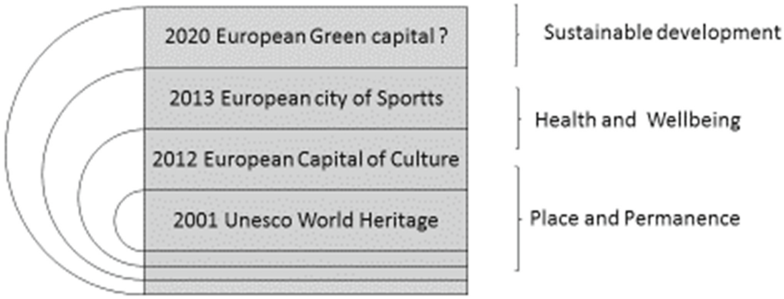

Fig. 3. Guimarães main achieves and goals.

brought to discussion and in that year the city host more than 5.000 events. A year after Guimarães was the European City of Sports. Once more, an investment in green areas, sport's facilities and events, was made to promote Health and Wellbeing among the citizens. In the meanwhile, the industry sector became one of the most important in Portugal. Guimarães is the 5th Municipality in terms of exportation ratio.

3.3 City Indicators

City uses to important methodologies in order to assess the sustainable development process: the 21 Indicators of ECOXXI-ABAE National contest and the 12 Indicators from the European Green Capital application form (Table 1).

Table 1. Indicators - ECO XXI vs. European Green Capital application form.

Methodologies to assess sustainable indicators	
European Green Capital	ECO XXI
Climate change	Environmental education|programs
Local transport	Communication
Green areas and sustainable use of the soil	Citizens' participation
Nature and biodiversity	Cooperation
Waste	Protected areas
Water quality	Forest protection
Waste water	Sustainable mobility
Eco innovation	Certification
Acoustic	Urban planning
Air quality	Nature and biodiversity
Integrated management	Water quality
	Air quality and public information
	Water quality services
	Waste management
	Municipality energy performance
	Sustainable tourism
	City acoustic quality
	Rural sustainable development
	Employment

Note that the each of the EGC indicators has details on past performance, current situation and proposals for future actions. Most of the indicators have quantitative data, including Strategies for Citizens engagement and stakeholders' involvement. The ECO XXI indicators are assessed by quantitative data. The year of reference is the previous year of the assessment. Meaning that this methodology allows the monitoring of each indicator' progress.

In 2015, Guimarães was 8th in ECO XXI National Contest. Last year, Guimarães was the third most sustainable Municipality in Portugal. Results of the European Green Capital candidacy will be known by 2018 as the submission process will take place in September during current year.

Both methodologies assess the indicators for economic development. ECO XXI assess City Hall performance in terms of increasing green jobs. In addition, a question on Municipality Employment Strategy for the territory. The indicator Eco-innovation (EGC) assesses not only the City Hall performance but also its capability on promoting initiatives to raise awareness among Privates to sustainable issues: Framework, Practices and Measurement of the initiatives.

3.4 Questionnaire Development - Validation

A questionnaire was developed to analyze Good practices that privates are implementing and that can contribute to the general goal of the city – become more sustainable and a global city; adding a new layer of sustainable development. The questions toke in consideration the indicators from both methodologies – ECO XXI and ECG. The questionnaire was divided in three main parts. The first part was related to a characterization of the Industry namely, localization, size, sector of activity and number of employees. The second part was related to the general practices in terms of industrial waste, certifications, green areas maintenance, Environmental Acoustic, company fleet. The implementation of good practices among workers such as carpooling, use of bike were included. The third part includes questions focused on working conditions. Several questions, were included focusing on investment constructive measures to promote health and wellbeing among workers; mainly when a risk factor was identifies. Investment on Personal Protection Equipment was also asked as well as training sessions.

To test the sensibility of the questionnaire a sample considering five industries, was used. All the industries were from Textile sector being Medium Size Companies (less than 50 employees and less than 10 million euros of Market Turnover). Two of them have certification for quality and Environment (ISO 9001; ISO 14001), one also have certification for Safety Systems (OHSAS 18001). All the Industries answered affirmably regarding waste treatment, industrial waste, green areas maintenance having also concerns on Acoustic and air quality. Nome of the companies promotes good practices among workers regarding sustainable mobility but one is investing in electrical cars (Industrial fleet). Regarding constructive measures or investment on Personal Equipment, they refer that only the necessary to fulfill the law requirements.

4 Final Remarks

It became important to analyze Guimarães Industries and Industrial parks in terms of sustainable performance due to city representability in terms of industrial tissue. This analysis should consider three premises: (1) the Occupational context is a part of a System (organization) [8], (2) the sustainable development of a company considers the working conditions [15], (3) Workers are also citizens of a given place (external environmental) that contributes to his permanence. Therefore, in terms of city global goal, an assessment on companies' investment on sustainable practices that can beneficiate-working conditions should be done.

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Effect of Skills Shortage on Sustainable Construction

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Abstract. The desire for sustainable construction has been on the increase and one of the identified challenges is the adequacy of skilled workforce to understand and execute projects in line with sustainable goals. This study examines the general effects of skill shortages in the construction industry with a view to improving the delivery of construction projects. Variables from reviewed literature materials were examined using closed-ended questionnaires administered on professionals and artisans in the industry. Shortage of project managers has the most effect on sustainable construction while the general effects of skill shortages are cost increase, time overrun, decrease quality, high accidents rate and more rework, which are related to the three elements of sustainable development, that is, economic, social and environment. Agencies shouldered with the responsibilities of managing and regulating skilled workforce in the construction industry will find this study useful in their quest for delivery of sustainable construction projects.

Keywords: Development · Education · Incentive · Skill development · Training

1 Introduction

The continuous development of the construction firms and their products is an important factor for provision of employment and reduction of poverty. However, for such to occur, necessary skills in term of professional, business and managerial skills are required not only to improve productivity of workforce but also for overall performance of construction projects. In South Africa, the Construction Industry Development Board (CIDB) controls, manages and regulates the growth and development of construction firms; the essence is to monitor the growth and failure rate of such construction and associated firms in order to be able to improve the construction industry [1]. The associated firms include construction related professionals, sponsors and financiers and regulatory bodies among others.

The database of Workplace Skills Plan submissions and Construction Education Training Agency [2] revealed that there are low percentages of major construction occupations in the South African construction industry. There are only 10% of managers and 8% of professionals, and in a developing country like South Africa, there should be a larger number of these category of professionals for better performance of the construction industry. Observation from the yearly and quarterly statistics of CIDB

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indicated that the shortage of skills in the construction industry has become one of the major constraints to growth and development of business (CIDB 2015). Further observation from the weighted index for general building and civil engineering revealed that there has hardly been any improvement when it comes to access to skills in the construction sector between the years 2012 to 2015.

The skills shortage however is not only high in the business sector, there are also shortages in the technical sector such as engineering, architecture and construction skills, which are necessary at both preconstruction, construction and post-construction phases of infrastructural projects. However, previous studies revealed that some of the technical skills that appear to be inadequate in the construction industry are related to skilled workforce. In a study by Tshele and Agumba [3], it was noted that lack of skilled workforce is a huge business constraint for about 40% of South African private construction firms. More so, the Engineering Council of South Africa [4] reported that they have trouble in recruitment of engineers and technical workforce for construction firms on a yearly basis.

Studies have revealed that there is a high shortage of skills in the construction industry [3, 5, 6]. It was further observed from existing literature materials that the key skills clusters that appear to be mostly critical and need urgent attention include high level world class managerial, planning and engineering skills; town, city and regional planning skills; as well as artisan and technician skills. The current study therefore examines the effect of skills shortage in the construction industry with a view to recommending necessary solutions to mitigate the menace.

2 Concept of Skills Shortage and Their Effects

Rasool and Botha [7] opined that South Africa is currently experiencing a drastic problem of shortage in skilled workers; this in turn has been a threat to the country's economy and her international participation. Shortage of skills has a significant effect on the socioeconomic growth and development of a country [3]. In a study by Windapo [8], employers of labor were asked about the possible effect of skills shortages on their organizations, 82% concluded that it would reduce their competitiveness and productivity, while 75% agreed that it would drastically reduce their ability to provide necessary services for their clients.

The inadequate and lack of basic skills in the construction industry is threatening the future of the industry and will continue to do so especially when there is increase demand for construction products [9]. As the demand for construction products and services are increasing, the problem of skills shortages are getting due to high number of senior employees with adequate skills, and low number of younger ones to take over from them. There is a need for technical, business, managerial and other forms of skills for artisans and professionals for the construction industry to be successful. For construction firms and contractors to attract skilled artisans and professionals, there is a need to improve on their welfare, increase their salaries and wages as well as improve on their total compensation [3].

The construction industry is facing many risks ranging from tight delivery schedule imposed by clients, capacity constraints, financing related issues, among others. These and other projects' performance indices are affected by shortage of necessary skills [10], which affects the image of the industry and hinders the development of infrastructure in the country. The lack of adequate skills in the construction industry negatively affects the growth and development of Small Medium and Micro Enterprises (SMMEs). For emerging construction firms to be sustainable and develop in accordance to Construction Industry Development Board (CIDB)'s grading, adequate skills are required from their employees. However, the issue of skills shortages has resulted in high failure of emerging construction firms. Thwala and Phaladi [11] stated that lack of skills lead to ineffective management strategies at the beginning or early stages of a project, which eventually lead to failure of construction projects. It was further mentioned that owners face the challenge of good record keeping, poor contract documenting skills, and they lack the ability to employ workers with adequate skills.

Some effects of selecting and using unskilled workforce in the construction industry have been identified by previous studies [3, 12, 13]. Contractors often experience cost overruns and delays in of construction projects and where such projects are completed to time and cost, the issue of poor quality is a major concern. Makhene and Thwala [14] noted that construction industry often experience workforce shortages, which in turn cost both contractors and other stakeholders resources relating to time and money. It was further noted that after the completion of such projects, the final product is not of good quality. Furthermore, the productivity of work is deteriorated when working with unskilled workforce [13].

Increases in infrastructure spending since 2003 have seen a steady increase in the number of jobs as well as skills shortages that accompany such increases [4]. Mores so, it usually takes a longer time to complete a project than the estimated time when the workforce has inadequate skills necessary to perform the work. This implies that the more unskilled workers are involved in the project, the more time it takes to complete such project. It has been opined that contractors experiencing a shortage of skills in artisans suffer dramatically from time overruns and project delay [3].

The problem of skills shortage in the construction industry has affected the quality and productivity of construction projects over the years [8]. More so, Utting [10] explained that the shortage of skills has put pressure on the construction industry and as a result, the industry is struggling to meet the service demands that are drastically increasing. The boom in project demand by clients is putting pressure on the construction industry and the industry is struggling to meet increasing demand for its services [9]. Rework is another effect of adopting unskilled workforce in the construction industry, and it is because of poor quality of workmanship and low productivity. Skills shortage can lead to rework as a result of inadequate supervisors, foremen and tradesmen ratios, low skilled level of labors, unclear instructions from supervisors, non-compliance with given specifications and poor co-ordination of resources [6, 16].

Enterprise failure, which is common in emerging construction firms, is another result of skills shortage. Small Medium and Micro Enterprises (SMMEs) experience high failure when there are inadequate managerial, business and technical skills by managers and employees. Herrington et al. [16] opined that lack of training and education has led to the reduction of management capacity in emerging firms in the country. However, lack of managerial skills and adequate training are major causes of enterprise failure

[17]. This is one of the reasons for low level of entrepreneurial conception and the high failure rate of new emerging construction firms in South Africa.

Skills shortage reduce the profits and organizational competitiveness of construction companies [3], this is because the current workforce with the adequate skills in the industry begins to have higher expectations and demand higher salaries, wages, recognition, compensation and organizational costs [10].

3 Research Methodology

Quantitative research approach was adopted through in-depth understanding of the existing literature in the area of skills and skills shortage as well as their effects on construction projects. This allows for formulation of a clear research question for acquiring necessary information for the study. Using survey method, questionnaires were administered on respondents with adequate knowledge of the skills shortage issue in the construction industry, these include engineers, architects, quantity surveyors, construction project managers and artisans in Gauteng region of South Africa. The main reason for the choice of these stakeholders is due to their experience of construction activities, it is believed that they would have a better insight and provide necessary information how skills shortages can be mitigated in the construction industry. A purposive sampling approach was adopted in the selection of respondents; this was achieved by ensuring that they possess a minimum of 5 years of experience in the construction industry for proper understanding of the industry and issue of skill shortage. Overall, 50 questionnaires were distributed while 45 were retrieved.

The questionnaire designed for the study comprised of two sections: the first section contained demographic questions where respondents had to choose and answer from the alternatives provided while the second section was designed to assess effects of skills shortage in the construction industry. Majority of the questionnaires were distributed and collected directly from the respondents' workplaces, which were construction sites, consulting firms as well as construction firms within the study area. A 5-point Likert scale was adopted which ranged as follows; 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree (Neutral), 4 = Agree, 5 = Strongly Agree.

The 5-point scale was transformed to a Mean Item Score (MIS) and standard deviation (SD) for each of the factors and the indices were used to rank and determine the importance of each item. The internal level of consistency of the collected data was evaluated using Cronbach's alpha and the obtained value of 0.7731 indicate that there is correlation among the scores from the various respondents.

4 Finding and Discussion

Results of the analysis in this section are based on 41 of the 45 questionnaires that were completely completed by the respondents. Figure 1 indicates the effects of shortages of various skills on construction project performance. It could be observed that shortage of project managers has the major effects with about 43.9%; this is followed by quantity surveying profession (22%), artisans (15%) as well as engineering (9.8%) and construction management (9.8%).

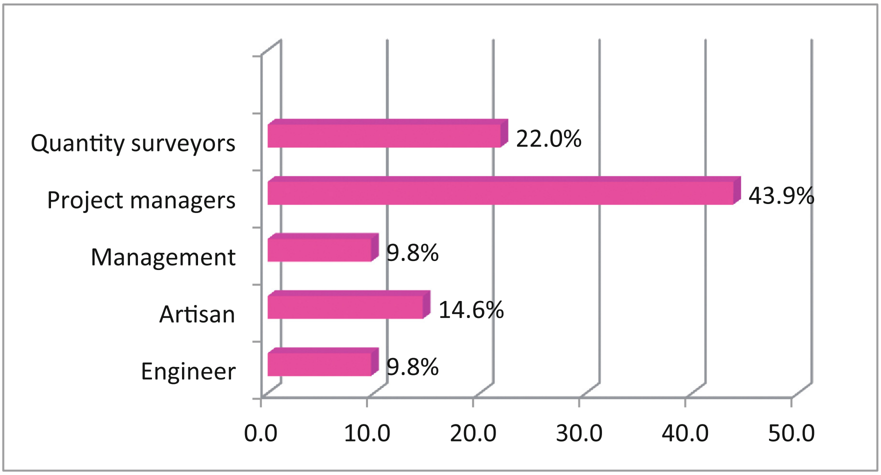

Fig. 1. Effects of professional skills shortages on sustainable construction

Table 1 indicate various effects of skill shortages on the construction industry, the standard deviation (SD) values revealed that there is considerable agreement among respondents in assessing the identified variables.

Table 1. Effects of skills shortages in the construction industry.

Effects	MIS	SD	Rank
Increase in costs	4.68	0.471	1
Delays	4.61	0.494	2
Reduce quality	4.61	0.494	2
Higher accidents rates	4.54	0.778	3
More rework	4.51	0.597	4
Low productivity	4.44	0.502	5
Increase in cost of production	4.44	0.743	5
Reduction in organization's competitiveness	4.32	0.567	6
Enterprise failure	4.10	0.664	7
Decrease in the size of the construction labor sector	4.05	0.835	8
Rise in construction workers' pay	3.61	1.159	9

Key: MIS - Mean Item Score; SD - Standard Deviation

The most significant effect of the menace in the construction includes such variables as project cost increment with MIS of 4.68 and SD of 0.471; delay in completion of projects with MIS of 4.61 and SD of 0.494; reduction in quality of final work with MIS of 4.61 and SD of 0.494; higher accidents rate with MIS of 4.54 and SD of 0.778; as well as more rework during project construction. Other effects of skills shortages include low productivity (MIS of 4.44 and SD of 0.502), driving up cost of construction project (MIS of 4.44 and SD of 0.743), reduction in organizations' competitiveness (MIS of 4.32 and SD of 0.567), enterprise failure (MIS 4.10 and SD 0.664) and reduction in the size of the building construction labor sector (MIS 4.05 and SD of 0.835). The least important of the eleven effects of skills shortage is concerned with the rise of payment and compensation for construction workers with MIS of 3.61 and SD of 1.159. It could be observed that this factor is also important judging by the MIS value, which is within average, based on the adopted 5-point Likert scale.

In support of the findings by Tshele and Agumba [3] as well as Bilau et al. [13] where skills shortage was described as a determinant of project performance, the result of this study indicates that shortage of skills has a high impact on quality of the workmanship as well as quality of overall project. With this result, there is bound to be more rework that will lead to increase in construction costs and delay in completion of construction projects. Shortage of skills has put pressure on the construction industry [10], as the industry struggle to meet the service demands. The shortage of skills has been on the increase due to low productivity of workforce in the industry [6, 8]. With such poor outcomes from workforce, there will be enterprise failure, which may prompt construction firms to dismiss employees leading to reduction in the size of construction workforce. Therefore, the shortage of necessary business and technical skills, among others, are major determinants to achieving economically, environmentally and financially sustainable construction projects.

5 Conclusion and Recommendation

Construction industry is a people oriented one with the presence of various forms of skilled to unskilled labor. These people are multidisciplinary but their focus is to deliver their services to enhance sustainable project performance for the satisfaction of clients and other stakeholders. The shortage of necessary skills in the industry has been on the increase as observed from reviewed literature materials, which prompt this study to examine the effect of the phenomenon on sustainability of construction project and the industry at large.

Skills shortage in the construction industry leads to such issues as project cost increase, project delay, reduction in quality, increase in number of accidents on site, rework and low productivity of workforce. Other effects include reduction in organization's competitiveness, complete failure of the enterprise failure, rise in construction workers' pay and decrease in the number and size of building and construction labor sector.

The availability of necessary construction skills affects the success of project in terms of sustainability, quality, cost, time, health and safety as well as satisfaction of stakeholders. To manage the situation, there is a need for absorbing and training of more skilled workforce in the construction industry, that is, artisans and professionals, to enhance performance of construction projects. In view of this, construction firms and other associated ones from both public and private sectors should invest in training, research and developing their employees cutting across various departments of the organization. There is also a need for government agencies such as Construction Education Training Agencies (CETA), to invest in technical schools with a view to introducing youths to construction related disciplines at early stages of their education.

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Renewable Energies: Sustainability by Installation of Photovoltaic Panels and Urban Mobility by Electric Bicycle Electronics

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Abstract. To experience the prospect of sustainable development that meets all the needs of the present without compromising the ability of future generations through the rational use of natural resources. The technologies that allow the capture of the energy coming from the Sun are in constant development, allowing its use, successfully, in several situations. Is the need to think, design and operate a mobility plan that will affect the profile of cities with an impact on economic development, stimulating the use of means of transport, especially bicycles. The research project is fundamentally related to the practical feasibility of the use of solar energy by means of photovoltaic panels as a source of clean energy production, effective and capable of being used as fuel for bicycle racks, at low cost, as a correct policy Planning, development and quality of urban life. Sustainability and economics attract consumers to solar energy.

Keywords: Sustainability · Photovoltaic solar energy · Electric bicycle · Urban mobility

1 Introduction

The environmental issue gains space in society day after day and the discussion on environmental protection is not recent. We are experiencing the prospect of sustainable development that meets all the needs of the present without. Compromise the ability of future generations through the rational use of natural resources in particular the use of energy sources "Clean and inexhaustible."

Article 225, "caput" of the Brazilian Federal Constitution, completed the environmental thematic valorization initiated with Law 6.938/81, as it recognized the right to an ecologically balanced environment as a fundamental right of the human person. It gives it the nature of "good of common use of the people" and essential to the healthy quality of life, imposing the co-responsibility to the Power Public and the citizen for their defense and preservation.

The twentieth century portrayed significant changes determined by human activities, saw the cities of previously occurring in number, size of population and areas occupied, and complexity of the places where they came to settle. Throughout the Planet, humanity

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migrated to cities and less than 5% of urban eighteenth century today half of humanity is in the cities, forming true urban purgatories - which are the outskirts of large cities, where citizens do not have the minimum access to living conditions. The domain of scientific knowledge in the 21st century is at a level that allows the search for solutions the generation of sustainable energy, while at the same time meeting the demand economically viable.

Brazil, with a territorial extension and privileged geographical location, has at its disposal a diversity of sources and others that emerge as promising in the medium and long-term scenarios. Solar power, source inexhaustible and abundant, deserves our attention.

Besides Brazil, other countries are aware of this tendency. Germany and the Netherlands, Spain, China, Japan, India, The United States and others, for example, are pioneers in the development of initiatives in the field of energy in order to society alternatives that represent quality, reliability, combined with technical feasibility and sustainability of projects, especially in relation to cities.

The technologies that propitiate the capture of the energy coming from the Sun are in constant development, allowing its use, successfully, in various situations and endeavors, as we will see next. However, for this project to succeed, it is necessary to implement public policies that stimulate its use, providing reliability, safety, interest, social welfare and protection to the environment.

2 Use of Solar Energy from the Capture by Means of Photovoltaic Plates

In this article we will focus some considerations based on bibliographic studies to ascertain the viability of the use of solar energy such as: previous survey of potential, the importance of the attractiveness of this technology, the execution of projects in Brazilian municipalities and success in other countries, the comparative study of national and foreign legislation, providing practical applications, promoting research opportunities aimed at the well-being of the population.

Solar energy is that which comes directly from the Sun through its radiation directly from the atmosphere and is not distributed equally on Earth.

This is mainly because of the rotational and translational movements of the planet in relation to the Sun, as also by the atmospheric variation in the terrestrial surface.

It is renewable energy day after day, abundant, and the use of it as a source of both heat and is one of the most promising alternatives to meet the new challenges of the new millennium, in Brazil, where the rates of solar radiation are significant.

Photovoltaic solar energy is obtained through the direct conversion of light into electricity (photovoltaic effect). Between the most suitable materials for the conversion of this radiation are silicon.

Different technologies are employed in the manufacture of photovoltaic panels. The most recurrent are the use of monocrystalline silicon, polycrystalline silicon and fine silicon film. The silicon present in the photovoltaic cell is withdrawn from the mineral uartz passing through of the cells.

Brazil is one of the world leaders in the production of parachute in metallurgical grade, although there is no purification of silicon in commercial grade solar in the Brazilian territory (ABINEE 2012). The capture of solar energy and the reception in a certain property are part of the quality of life and is an integral part of the individual and social function of the property.

Solar light or solar radiation possess economic value and fall into the category of movable property, second definition of the Civil Code in its article 83, I. They belong to nobody And can be freely appropriated. In order to capture solar energy, there is no need for environmental licensing, but the Federal, State and Municipal Public Authority does not withdraw the possibility of establishing norms regulating activities that make use of this energy. This contributes to planning Environmental and land use planning.

Photovoltaic systems require frequent maintenance, their operation is automatic, operates directly in the presence of solar radiation, without the need for fuel. It is a practical system, it can be moved and it can not be complicated. Its components can be easily replaced or added with ease.

They have low environmental impacts, with regards to the battery because they contain acid and the photovoltaic technology practically do not offer a risk to the environment. Financial and environmental advantage: the question of sustainability and urban mobility. One of the main constraints to the diffusion of solar energy projects is the low efficiency of energy conversion systems, which makes it necessary to use large areas to capture enough energy so that the enterprise becomes feasible.

However, compared to other sources, such as hydropower, for example, which often requires flooding of large areas, it is noted that space constraint is not so restrictive for the use of solar energy.

There are many small national generation projects Photovoltaic electric power in rural communities ouisoladas of the North and Northeast of Brazil and these projects basically operate in four areas: 1 - water pumping for residential supply, irrigation and fish farming; 2- public lighting; 3 systems of collective use, such as electrification of schools, health posts and community centers; 4- home care. Among others, there are telephone stations for remote monitoring, electrification of fences, ice production and desalination of water.

The São Paulo State Government, for example, recently conducted a study of the potential survey of solar energy where systems Photovoltaics directly transform solar energy into electrical energy as a way of contributing to economic and regional growth and can benefit greatly from this situation, as it presents favorable conditions for its development due to climatic conditions, besides the atmospheric conditions (cloudiness, aretc relative humidity.) Most of the Brazilian territory is located relatively close to the equator, so that there are no large variations in the characteristics of sunshine and radiation.

This survey intends to definitively direct São Paulo in the “Rota do Sol”, since it was able to measure the solar radiation index in the main municipalities of the State.

An example of water pumping with photovoltaic electricity generation is the Paranapanema State, In the State of Rio de Janeiro we can cite as good examples of the use of photovoltaic solar energy, the Library of the State of Rio de Janeiro, the Metropolitan Arch and the electric showers installed in the beach of Copacabana. In the city of Belo

Horizonte, Minas Gerais after the refurbishment of the World Cup in 2014, photovoltaic panels were installed to supply all the electrical needs of the building with greater cost savings.

With regard to urban mobility, the major challenge for the 21st century is in the need to think, conceive and operate a mobility plan that impacts the profile of cities with repercussions on economic development, stimulating the use of means of transportation, especially bicycles, as the most accessible means of transportation for the population in general. Municipality of Lorena, State of São Paulo, commissioned a group of environmental engineering students from the University of Taubaté - SP (UNITAU) to produce a prototype eco-efficient bike rack made of reusable concrete, old tires and aluminum.

The urban furniture was designed to increase the offer of places for those who use the bicycle as a means of transportation in the city. The parking for bicycles counts with 56 places and was recently presented to the Municipal Council of Lorena. In order to reduce the problem of lack of infrastructure for cyclists in the city, bike stands in addition to the materials used in the construction of the bike rack, the model also has photovoltaic panels installed in the upper part.

The eco-efficient bicycle rack already has the approval of the traffic secretary of the city and outside Presented to the prefecture of Lorena, so that it can be adapted, simplified and placed in the reality of the Lorena is known as the capital of bicycles in the Paraiba Valley - data indicate that about 80 thousand inhabitants of the municipality use bicycles as the main means of transportation. On the other hand, there are no vacancies for cyclists, mainly in the central region.

The research project is fundamentally related to the practical feasibility of the use of solar energy by means of photovoltaic panels as a source of clean, efficient and capable energy production as low cost fuel, as a correct policy for planning, development and quality of urban living.

In India, almost the entire rail passenger transport system is powered by photovoltaic solar energy, in addition to contributing to sustainability without the use of fossil fuels, also favors urban mobility.

3 The Brazilian Legislation on Photovoltaic Solar Energy

The generation of photovoltaic solar energy so that it can be implemented depends on specific regulation so that, in fact, it can compete with other sources of energy. Brazilian laws that encourage the use of renewable energies do not deal directly of the generation of the photovoltaic system, but create an environment conducive to this type of application, Law 9.991/00 provides for the resources of the universalization programs of the public electric energy service; Law 10,848/04 provides that Eletrobrás will institute specific development programs for the use of individual and collective equipment for the transformation of solar energy into electric energy using resources from the Global Reversion Reserve and contracting permissionaires and concessionaires.

According to article 14 Of Decree No. 4,541/02, which regulates Law 10.438/02 on the use of charges for the universality of care, especially when the demand reaches municipalities predominantly located in rural areas with investments instituted by Law

5,655/71. Created on April 26, 2002 to Energy Development Account, currently used to facilitate access to electricity within the scope of the Light for All Program to subsidize low-income consumers who do not yet have a network established in their region.

The Ministry of Mines and Energy Ordinance No. 36 of November 28, 2008 created a working group of generation from photovoltaic systems with the purpose of "to elaborate studies, to propose conditions and to suggest criteria to subsidize competent definitions about a political proposal of use of photovoltaic generation connected to the network and in urban constructions, like factor of optimization The management of energy demand and the country's environmental promotion in the short, medium and long term." Regarding technical standards, Brazil does not yet have sound regulations for components and installations of photovoltaic systems, with only sketches that include technologies that already developed.

There is no normative text for the installation and commissioning practices of photovoltaic systems of any kind. ABNT NBR 11.877 - Photovoltaic systems) ABNT NBR 10.899 - Photovoltaic systems - terminological) ABNT NBR 11.877 - Photovoltaic systems) ABNT NBR 10.899 - Photovoltaic systems - terminology) NBR 11.876 - Photovoltaic modules - Specification) ABNT NBR 11,704 - Photovoltaic systems - classification) ABNT NBR 11.878 - Photovoltaic devices - cells and reference modules) ABNT NBR 11.879 - Photovoltaic devices - solar simulator - performance requirements) ABNT NBR 14.298 - Photovoltaic systems - bank of batteries The National Electric Energy Agency - ANEEL, approved on April 17, 2012, rules aimed at reducing barriers to the small distributed generation facility, which include micro generation, with up to 100 kW of power, and From 100 kW to 1 Mk.

The standard creates the Energy Compensation System, which allows the consumer to install small generators in their consumer unit and exchange energy with the local distributor. The rule is valid for generators that use energy sources (water, solar, biomass, wind and qualified cogeneration). For the system, the generating unit installed in a household, for example, will produce energy and what is not consumed will be injected into the system. Distributor, who will use credit to cut consumption in subsequent months, the credits may be used within 36 months and the information will be on the consumer invoice, so that he knows the energy bills and has control over the invoice. Public agencies and companies with subsidiaries that choose to participate in the compensation system can also use the surplus produced in one of its facilities to reduce the invoice of another unit since it is in the same concession holders and CNPJ.

Understanding the advantages and disadvantages of solar energy helps to understand the possibilities offered by this energy source as well as its limitations. The first and foremost advantage of solar energy is that it is renewable, because the heat of the sun will remain active for some billions of years.

Therefore, any energy production that uses the solar radiation will not be worried about its finitude, contrary to what happens with other sources. Another positive factor is that this availability does not require any type of adaptation, since in the areas of greatest insulation, solar energy is always present without the need for human intervention, unlike what occurs, for example, with hydroelectric dams, where relevant changes are needed in the riverbeds.

It is a fact that the free availability of the heat of the sun, without the need of any type of control of their sources in cases of use. In hydroelectric dams, the construction of dams may eventually cause losses in the use of water resources in some of its points. Therefore, the human being does not need to develop any form of intervention, but only the best way to capture the light emitted by the Sun. In addition, solar energy is considered a clean way to produce energy.

This does not necessarily mean that it does not generate impacts, but at least it does not emit pollutants into the atmosphere. Therefore, its use means less greenhouse gas emission into the atmosphere by other sources of energy. For the production of solar energy, neither large areas nor any type of deforestation is necessary, not even in the great solar power plants.

The latter, however, need to be located in remote areas because of the grand scale generated in the environment around them. In addition, it is possible to produce power to remote places. For various technical reasons, solar energy is even highly recommended for the generation of energy to distant places.

The installation of solar panels can also help in the electrical supply of small villages or houses located in isolated spots and with low demographic densities. Finally, it is also worth noting the low maintenance need that solar energy technology has, more and more advanced. In general, the durability of the equipment used is high, although the replacement costs of the parts are high in cases of operating problems.

Criticism of the use of photovoltaic energy. The high cost of its technology, especially in photovoltaic panels, which have an advanced level of complexity, is one of the disadvantages of using solar energy. However, over time, the tendency is for such costs to decrease.

Concerning the generation of electricity per se, the problem of high dependence on climate is observed. In cases of anomalies in the behavior of the atmosphere, solar plants and homes that adopt solar energy can suffer from a lack of electricity.

On the other hand, improvements in storage techniques can prevent this problem. It is also emphasized the impossibility of using solar energy in any region, which can be observed as follows. In it, the areas with the highest insolation of the Earth and the points where it is most intensive are represented. It is worth remembering, however, that practically all energy sources present this problem of not being able to be used with the same advantage and efficiency throughout the terrestrial extension.

Some critics of solar energy also question the relations around the production of the equipment's, since Solar panels require a large extraction of ores, such as quartz. With the expansion of the use of these plates, the demand for raw materials can become even more intense, which can contribute to unsustainable minerals extraction policies, causing losses Environmental issues, not to mention the economic issues at the production sites. Therefore, the greater use of solar energy also requires control measures in the generation of raw materials; otherwise, the environmental impacts will be enormous.

There is variation in the quantities produced according to the climacteric situation (rains, snow), besides that during the night There is no production whatsoever, which means that there is a means of storing the energy produced during the day in places where the solar panels are not connected to the energy transmission network. Locals in medium and high latitudes such as: Finland, New Zealand, and southern Argentina and

Chile, are experiencing seasonal declines in production during the winter months due to the lower daily availability of solar energy.

Sites with frequent cloud cover, such as London, tend to have daily variations in production depending on the degree of cloudiness. Solar energy storage forms are poorly used when compared, for example, to fossil fuels (coal, oil and gas), and hydroelectric power (water). The storage of solar panels is still inefficient another factor that can be attenuated over time and with different technological developments. For the time being, this low utilization further damages the cost-benefit ratio of solar energy equipment. The solar panels have a yield of only 25%, although this value has been increasing over the years.

4 Conclusion

The increase in energy consumption and concern for the environment have made studies of renewable energy sources make it necessary for the larger scale application and consequently diversification of the energy matrix in Brazil and in other countries. However, Brazil does not have specific legislation on of the use of photovoltaic plates for the production of electric energy, which keeps it away from other countries that already use this technology.

The present article has proposed to demonstrate several alternatives available for the use of photovoltaic plates in the solar energy contributing to a medium environmentally balanced environment and urban mobility, especially in Brazilian cities where there is a higher incidence of solar radiation.

There is no doubt that the environmental impacts caused by the use of solar energy are minimal compared to other forms of energy generation, as demonstrated, however, Because it is expensive technology, there is no accessibility for the majority of the population, and this is one of the most criticized aspects.

The system of electricity production by means of photovoltaic panels is not yet self-sufficient because its storage capacity is small to supply large demands; however, it is necessary to develop technological and investment mainly by the Public Power for this modality of energy to be used on a large scale. That way, we conclude that the development of this scientific article was of great importance for academic formation, providing the practical application of knowledge bibliographical data obtained, and necessary for the execution of a future project aiming at the welfare of the population of the cities.

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A New Methodology for Partnering Transportation Projects

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Abstract. The U.S. Federal Highway Administration has recently emphasized 'e-Construction and Partnering' through its 'Every Day Counts' initiative which encompasses the use of state-of-the-art construction technologies in tandem with a management element for project delivery best practice. Traditional Partnering became firmly established in the U.S. in the 1990s when technology was simpler and design-build was just emerging in the transportation sector. With the current state of technology available for project delivery, as well as the diverse functional roles and stakeholders involved in life-cycle planning and implementation of transportation facilities today, there has emerged a need for collaborative teamwork of individuals across organizations involved in the delivery of the project. This paper introduces a substitution to the traditional partnering process based upon a proven technology employed first by M. Scott Peck in the early 1980s. The results of the paper should be of interest to public infrastructure contract stakeholders which desire a less combative and litigious work environment.

Keywords: Partnering · Authentic Community · Transportation project management · Team building

1 Introduction

Transportation projects in the United States are following the trends of Building Information Modeling (BIM) in the vertical sector of the industry. Intelligent Construction Systems and Technologies (such as automated machine guidance, digital terrain models, Intelligent Compaction and e-Construction (cloud-based applications which automate construction transactions) are now institutionalized by many transportation agencies. The U.S. Federal Highway Administration (FHWA) has recently developed a new advocacy campaign 'e-Construction and Partnering'. These two best practices each have demonstrable value on their own; in tandem, e-Construction builds project stakeholder collaboration via efficient work-flow process, while partnering integrates the use of e-Construction technologies with the human elements of trust and efficient teaming.

Traditional 'Partnering' in the U.S., to which the FHWA refers, is a non-contractual collaboration agreement produced by project stakeholders (owners, designers, builders, subcontractors, suppliers) after at least one day of facilitated workshops. Historically these agreements, and the processes used to develop them, have proven adequately

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effective in reduction of litigation on projects, and improvements with time savings and final project costs. Traditional Partnering became firmly established in the U.S. in the 1990s when technology was simpler and design-build was just emerging in the transportation sector. With the current state of technology available for project delivery, as well as the diverse functional roles of the stakeholders involved in life-cycle planning and implementation of transportation facilities today, there has emerged a need for not just collaborative, but synergystic teamwork of individuals across organizations involved in the delivery of a project. The existing model of partnering concerns non-contractual agreements among project stakeholders (individuals from different organizations) for resolving differences at the project level and the attainment of project values and goals. However, the existing method does not address the personal (individual) origins of conflict between decision makers collaborating on a project. The methodology proposed by this paper provides the ability to address and transcend biases and resentments between project team members which invariably negate the advantages which software applications and information technology (e-Construction) have enabled.

2 Existing Partnering Process

A military trilateral commission has defined what this paper calls 'traditional partnering' as follows: 'Partnering is a process by which two or more organizations with shared interests act as a team to achieve mutually beneficial goals. Typically, the "partners" are organizations that in the past have worked at arm's length, or have even had competitive or adversarial relationships'. The commission emphasizes the fact that the process does not result in a legally binding relationship, but involves commitment to: structured/facilitated team-building sessions and joint training to acquire the skills needed to work together as a team, removal of organizational impediments to open communication within the team, providing open and complete access to information, empowerment the working-level staff to resolve as many issues as possible, reaching decisions by consensus as much as possible (and when consensus is not possible, achieve resolution in a timely manner using an agreed-upon process for resolving disagreements. This early document is significant in that it also defined several over-arching principles of the process:

- Teamwork can overcome organizational impediments.
- Teams should be empowered with authority to make decisions.
- The best approach to resolving disputes is to prevent them.
- Shared responsibility involves shared risks and benefits.
- Partnering requires open communication and flexible boundaries.
- Partners (organizations) maximize each other's resources [1].

An alternate definition was determined in 1989 by the Construction Industry Institute Task Force on Partnering: 'Partnering is a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources. The relationship is based on trust, dedication to common goals, and an understanding of each other's individual expectations and values'.

The traditional partnering process was refined in the 1990s and today most of the state transportation agencies (Departments of Transportation or DOTs) require implementation on construction projects in excess of $10 million and optional for projects over $1 million in value. Typically, the agencies' standard specifications require that project leaders from both the agency (owner) and the prime contractor select a prequalified third-party facilitator to implement the partnering process for the duration of the project. The chain of events, in general, are as follows:

1. A one-day training event of project team members is conducted by the facilitator in one or more of the following areas: Building Teams, Change Management, Communication, Conflict Resolution, Cultural Diversity, Dealing with Difficult People, Decision Making, Ethics, Leadership, Problem Solving, Running Effective Meetings, Win-Win Negotiation, Problem Solving, etc.
2. A date and location is set for the 'formal' partnering session and key stakeholders are invited. The typical duration is a one day event, but the specifications are flexible on longer durations depending upon the number of persons involved and the size/complexity of the project. A project 'Charter' is the result/deliverable of the first partnering session.
3. A schedule of 'follow-up' periodic partnering meetings is created. These are typically 3–4 months apart and have a duration of one-half day. These are used to assess the metrics of project goals originally stated in the Charter.
4. A 'Close-Out' partnering session is scheduled and conducted for the purpose of reflection and documenting 'lessons learned'.

The partnering session Charter is a document signed by all the partnering session participants and can include the values and goals of the project as determined by the attendees in the session. It is a non-legally binding document, although it may contain intentions on dispute resolution in case issues are not solved at the project level [2].

3 Authentic Community Process

Wilfred Bion was a renowned British psychoanalyst whom conducted research on group behavior initially after the second World War. In 1961, he released his research papers on group behavior as a book, *Experiences in Groups and Other Papers*. Among Bion's discoveries on group consciousness was his concept of task-avoidance assumptions, that unless overcome, restrict groups from accomplishing their designated task(s) [3]. He observed that all groups have an implicit or explicit aversion to task accomplishment.

M. Scott Peck (1936–2005), was a psychiatrist and popular author in the late 1970s through the 1990s. His initial research concentrated on the psychology of individuals, the last several years of his career he devoted to the study of groups. His experiences lead to the discovery of a 'technology' which he deemed 'Authentic Community'. Authentic Community is a state of collective consciousness reached by a group of individuals in which task accomplishment and decision-making are completed with extraordinary speed.

Consensus is easily achieved at the conclusion of the process. Peck spearheaded an organization, The Foundation for Community Encouragement (FCE), to promote the technology, and claimed a 100% success rate in two of his books[1]. The caveat for the ability of such team efficiency is the need for the group to spend two facilitated sessions of approximately 8 h each. In the process of bringing a group into Authentic Community, the facilitator will guide the group through the following four stages:

3.1 Pseudocommunity

In the first stage of the process towards Authentic Community, group members communicate superficially in the attempt to avoid any conflicts in ideology, politics, past personal histories, etc. Hence the name, pseudocommunity, as communication is not on a deep enough level to build 'authentic' community.

3.2 Chaos

Once the group realizes that lingering in the pseudocommunity stage is non-productive (usually as a result of the facilitator's prodding), the successive stage of Chaos begins. This stage is characterized by emotion and conflict as group members attempt to 'convert' their peers into alignment with their ideology and politics as a result of a deeper level of communication/conversation.

3.3 Emptiness

Peck states 'There are only two ways out of chaos. One is into organization— but organization is never community. The only other way is into and through emptiness' [4]. According to Peck, this is the most difficult stage of the process. It entails 'emptying' themselves individually of the barriers to communication. Individual barriers include such things as expectations, biases, preconceptions, prejudices, ideology, theology, solutions, and the needs to heal, convert, fix, solve, control. As the group moves into emptiness, some members may share thoughts and realizations that make them vulnerable emotionally. When all members of the group can listen with empathy, the work of the emptiness stage is complete.

3.4 Authentic Community

The final stage and the ultimate goal of a two-day facilitated session is the state of 'Authentic Community'. When the group has reached this state, it has its own consciousness and identity. It is characterized by the following:

- Individual differences are not avoided (as in pseudocommunity).
- Diversity is experienced as a benefit.

[1] The Different Drum: Community Making and Peace 1987, and A World Waiting to be Born: Civility Rediscovered 1993.

- Team members sense how to function together.
- Joy, identity, and emotional security are experienced by the individuals.
- A sense of identity, purpose, and meaning is reported by group members.
- Respect and trust between group members is established.

In the 1960s, a researcher of group dynamics at Ohio State University discovered almost identical stages of work group formation as that of Peck. Dr. Bruce Tuckman defined four stages (and later a fifth) as Forming, Storming, Norming, Performing. The stages documented from his research are explained within the context of Wilfred Bion's task avoidance assumptions [5]. The differentiation between Tuckman's theory and Peck's is that in his stage three Development of Group Cohesion ('Norming') he explains the reduction of the conflict stage as 'resolution of polarized issues'. Peck's theory is that the group members *transcend*, rather than resolve polarizing issues (by emptying themselves of prejudice in the Emptying stage).

The popular author and documentary producer Sebastian Junger, experienced behavior that seems to support Peck's interpretation in his observations while embedded with the U.S. military in Afghanistan. He quotes one of the solders making the statement, 'There's men in the platoon that straight-up hate each other, but we would all die for each other' [6]. Junger observed the phenomenon of Authentic Community (without labeling it as such) in the bonds between members of the platoon (and later in his book, 'Tribe'). He has described the paradox of platoon members wanting to return to war not as an addiction to the excitement of combat, but rather 'the drug of brotherhood'. In these cases, platoon members have not resolved differences as much as transcended them to achieve the group task(s) and survive.

Junger's body of work also aligns with Peck's statement that Authentic Community occurs as a result of three origins: (a) in response to crisis such as natural disasters or war, (b) by accident, such as situations when groups of people meet periodically over time and become close enough to be vulnerable, and (c) by design as we are describing with this facilitated technology.

A characteristic of having reached the final stage as described by Peck is the precondition for groups to be learderless in order to achieve Authentic Community. For the group to possess its own consciousness and synergy, each person has equal power (a group of all leaders). While it seems paradoxical, Authentic Community can and has existed within hierarchical organizations which is obviously critical in business and project delivery. It is required however, that group members with superior job titles set aside power over subordinates in order to reach the final stage. The protocol is: form the group into Authentic Community first, then attempt the task. Or in other words, set aside hierarchical power to achieve group consciousness, then return to business structure to achieve tasks. Peck explains that groups can effectively alternate between community and hierarchical modes.

Finally, Peck's experiences revealed that over an unknown period of time, groups will fall out of Authentic Community and require additional time together to regain it (to going through several of the stages again in formal structured communication).

4 Contrast in Processes and Proposed Adaptation

As described, Peck's technology/methodology can now be adapted to enhance the traditional partnering process. The facilitated sessions create a more efficient working group once the team emerges in the Authentic Community stage. While traditional partnering focuses upon process (contractual issue resolution, change management, etc.) and development of a non-binding agreement, a partnering team which has reached the stage of Authentic Community focuses upon building interpersonal consensus first. Then, the group works towards its assigned tasks more efficiently and effectively. The 'hidden minefield' of interpersonal conflict can be transcended. We propose a modified methodology to partnering which utilizes the advantages of both the traditional and a new proposed method. In combining the two methodologies, there is the increased potential to both address the 'resolution of polarizing issues' (Tuckman) and eliminate task avoidance assumption (Bion).

At least two issues warrant consideration:

1. Duration of Formal Partnering Session:
   Peck's extensive experience suggests that two days of facilitated session are required, while the traditional method is typically one day. Besides the perception of 'a lost work day' if the partnering session extends to two days, since the facilitated sessions are typically conducted at a neutral site such as a hotel ballroom, it would require additional costs of overnight room/board for stakeholders which commute a considerable distance to the session.
   Peck states that groups can achieve the Authentic Community stage quicker than two eight hour sessions. Each group is unique and its progression through the stages will vary, but he prefers a 'safety factor' be built into the time set aside for the formal facilitated session:

> 'In my experience two days provide just the right amount of time for a group of thirty to sixty to become a true community. It is possible to do it more rapidly. Genuine community of sorts can usually be established in a few hours when the group is instructed from the outset to refrain from generalizations, to speak personally, to be vulnerable, to avoid attempting to heal or convert, to empty itself, to listen wholeheartedly, and to embrace the painful as well as the pleasant' [4].

2. Training Prior to the Formal Partnering Session:
   Our literature review produced two documented partnering methodologies from two large transportation agencies (CalTrans, NV DOT) which have these embedded into their state's Standard Specifications for (Highway) Construction. Each of these requires a one-day training on (selected) various topics related to either communication skills or contract administration. These sessions are prior-to and separate from the formal partnering session. If the formal partnering is extended to two days for achievement of Authentic Community, then the entire process prior to follow-up sessions would be three days (and a hard sell for change).

5 Recommended Changes to the Existing Partnering Project

5.1 Remove the Training Requirements Prior to the Formal Partnering Session

By suspending or removing the training requirements prior to the formal partnering session, the total elapsed time required to produce the Partnering Charter is kept at two days. By making such a change, the total elapsed time required for partnering stakeholders to participate is held constant, but may require additional room/board costs of one night (worth the return on investment in our opinion).

Training prior to the formal session is obviously deemed valuable by the transportation agencies. We agree that these topical trainings are valuable. However, we propose that a two-day facilitated session on Authentic Community is an exercise in experiential communication skills that exceeds the competencies of a topical session. For a work group to achieve Authentic Community, serious communication skills are learned incidental to the process. The word ‘community’ is based upon the essence of communication. As for the project administration-based training topics, we propose that these could become a part of the half-day follow-up sessions already mandated in the standard specifications when the group is not involved directly in Authentic Community maintenance. The comparison of elapsed time and sequence can be seen in Table 1.

Table 1. Proposed partnering event sequence contrasted with traditional sequence

Sequence	Proposed event	Traditional event
0	Omit or defer	One-day training
1	Two-day formal partnering session	One-day formal partnering session
2	Half-day maintenance session(s)	Half-day follow-up session(s)
3	One-day close-out session	One-day close-out session

5.2 Add a ‘Special Provision’ for the New Methodology on a Per Project Basis

For this proposed methodology to be implemented or tested, a change to existing DOT contracts would be required. Such changes are easily incorporated to contracts with Special Provisions. Supplemental Conditions to the contract are project-specific ‘special’ provisions which amend or override standard specifications which apply to all contracts in general for a particular transportation agency. Since the traditional partnering process described in this paper is typical for several agencies, a Special Provision would be required for inclusion into the project’s Bid Advertisement describing the alternate process displayed in Table 1. This will also require, obviously, approval and buy-in from an agency’s Contracting Officer in order to be implemented effectively.

6 Conclusion

The authors propose amendment of the traditional partnering arrangement for projects of considerable size and complication. Large projects such as Design-Build (which require intensive deliberation and cooperation of stakeholders in the entire project life-cycle) have much at risk for non-productive work groups. Authentic Community addresses the mundane prejudices that exist between group members that can poison effective synergy and communication. A methodology which mitigates the risk of non-cooperation, while maintaining the benefits of the proven traditional process, appears to be a considerable return on investment. By utilizing the best of both approaches, the existing processes can be maintained while the interpersonal ‘land mines’ (group assumptions) which so often hinder effective group synergy are removed or mitigated.

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