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Transforming our World through Universal Design for Human Development

Proceedings of the Sixth International Conference on Universal Design (UD2022)

Editors: Ilaria Garofolo
Giulia Bencini
Alberto Arenghi

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An environment, or any building product or service in it, should ideally be designed to meet the needs of all those who wish to use it. Universal Design is the design and composition of environments, products, and services so that they can be accessed, understood and used to the greatest extent possible by all people, regardless of their age, size, ability or disability. It creates products, services and environments that meet people's needs. In short, Universal Design is good design.

This book presents the proceedings of UD2022, the 6th International Conference on Universal Design, held from 7 - 9 September 2022 in Brescia, Italy. The conference is targeted at professionals and academics interested in the theme of universal design as related to the built environment and the wellbeing of users, but also covers mobility and urban environments, knowledge, and information transfer, bringing together research knowledge and best practice from all over the world. The book contains 72 papers from 13 countries, grouped into 8 sections and covering topics including the design of inclusive natural environments and urban spaces, communities, neighborhoods and cities; housing; healthcare; mobility and transport systems; and universally-designed learning environments, work places, cultural and recreational spaces. One section is devoted to universal design and cultural heritage, which had a particular focus at this edition of the conference.

The book reflects the professional and disciplinary diversity represented in the UD movement, and will be of interest to all those whose work involves inclusive design.

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The image on the front cover represents the Winged Victory of Brescia, a bronze statue from the first century CE. The statue is preserved in the Roman Archaeological Park in Brescia.

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Contents

Section 2. System and Standards for Universal Design

Section 3. Universal Design for Inclusive Communities and Urban Spaces

Section 8. Universal Design to Create Inclusive Educational Environments

Transforming our World through Universal Design for Human Development
I. Garofolo et al. (Eds.)

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Evaluation Methodology for Inclusive Schools Environments. A Comparative Analysis Towards Goals and Strategies for Urban Design

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Abstract. The paper deals with the issue of social inclusion in the scholastic environment where children begin to learn the set of rules that manage social life. The design of the spaces impact on people and becomes crucial to address a community behavioural change in terms of social inclusion. In line with Universal Design strategy, the paper presents a method developed for evaluating the degree of inclusion of primary schools' spaces, which consists of the definition of an evaluation matrix. The matrix makes possible to analyse quantitative-qualitative characteristics for each school and compare them objectively. It asses the level of accessibility and inclusion of the schools through four main categories (Outdoor space, Orientation, Movement, Spatial quality) and related criteria and indicators. The reliability of the evaluation matrix has been verified through its application in seven case studies (Italian and EU), and the analysis of one of them is described in the results. The present study proposes a basis to introduce a method able to support designing educational spaces that satisfy the needs of a wide range of users according to Universal Design strategy.

Keywords. Inclusive design, Universal Design, school, assessment method, evaluation tool.

1. Introduction

The school represents a socialisation environment, a crucial space for didactic and relational learning, where children 'absorb' behaviour and learn by looking at the reality around them. In particular, primary school is considered the first environment where children begin to understand the norms and rules that govern life. The paper considers the school as the institution to initiate the first step for a fundamental change toward social inclusion, promoting a fair community without discrimination and based on equal rights. Nowadays, Italy presents itself as an inclusive country in terms of schooling. However, as we can see from the research carried out by Merlo [1], there is again a

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growing trend of 'special schools'. Those institutes has its roots in the 16th century, recognising for the first time the right to education for people with sensory disabilities, and then extending in the 20th century to those with psycho-physical disabilities. However, those schools refer only to special children education, meaning people with physical, sensory and cognitive impairments. Nowadays they should be replaced by inclusive schools to embrace differences and create an environment where every student can learn regardless of any diversity, culture, ability, or disability.

Currently, special schools are still chosen because of the lack of supply and support from traditional schools. Despite this, many schools still have architectural and sensorial barriers in the facilities. There is a need for a radical change, where Universal Design (UD) [2-3] becomes the means by which inclusion can be affirmed. In the 21st century, the concept of UD has been defined by Mace providing a new concept of designing to the greatest extent possible of people, without the need for adaptation or specialized design. Disability can be permanent, temporary (limb injury, pregnancy, carrying heavy objects), or caused by the context (inaccessibility to services, not understanding language, etc.). For this reason, the design process should create an inclusive space where each user feels represented and can experience it without discrimination.

Social inclusion is a topic addressed by many scholars. However, they have always dealt with the pedagogical and not the spatial and design aspect of schools. They have mainly analysed the tools to support teaching (expressive, technological, and symbolic) and the strategies for learning, summarised by the *Universal Design for Learning* methodology [4].

A few research has approached the topic from an architectural and urban design point of view, proposing more or less specific solutions. Abouelsaad and Shafik [5] suggest different design strategies according to the needs and characteristics of each child. However, they do not provide a univocal space organization, but the solutions always remain categorised according to the users' needs. This limitation is also found in two other research concerning the design of schools for autistic and intellectually impaired children [6, 7]. Despite their excellent and interesting proposals, these studies consider the architectural solutions typical of special schools without adopting a UD approach. At last, Agarwal [8] reports on the research project developed by UNESCO on the design of inclusive schools in India.

The research carried out in 2021 at Politecnico di Milano, studied social inclusion within the school environment. The output is an assessment tool for spatial inclusiveness in schools developed. The aim is to assess quantitative and qualitative aspects of the environment, including physical accessibility, orientation, and sociability, which are key factors in assessing inclusive environments [9]. A matrix is a potential tool to evaluate the degree of inclusion of schools objectively be used both during the design phase of school buildings or test possible improvements during the rehabilitation of existing buildings. Using the matrix would allow one to be aware of the most deficient categories in the field of spatial inclusion in the school and, therefore, improve them following the proposed indicators.

2. Methodology

The research work has been set in three macro-phases: i) preliminary phase: state of the art definition, through the comparison with reference scientific bibliography; ii) proposal phase: calculation of the evaluation matrix to evaluate the degree of inclusion of school;

iii) empirical phase: application of evaluation matrix in seven case studies. Although the UD topic is currently known and investigated in different researches, the literature review shows the lack of specific tools in the school context.

In the second phase, an 'evaluation matrix' (Figure 1) was developed through the analysis of the literature, referring to the *Accessibility in Building Design Guideline* [10] and the *Principles* [11] and *Goals* [12] of UD. The evaluation matrix includes four categories:1) Outdoor space, 2) Orientation, 3) Movement, and 4) Spatial quality.

The categories summarise users' needs to use a building independently: to be reachable from the outside, to enter and use each space equally. Aspects such as accessibility to the area by public transport, parking near the entrance, overcoming morphological differences, and orientation support are considered in the matrix to assess spatial quality. In addition, the categories Orientation and Movement have been evaluated for both indoor and outdoor spaces, only the mathematical average between the two values being reported in the matrix Each category presents different criteria, and each criterion is composed of four indicators for defining the degree of inclusion of school environments. The presence or absence of indicators determines the score for each criterion (evaluation from 0 to 4).

In the third phase, seven case studies were analysed through the evaluation matrix. The 4 Italian case studies are: Scuola Primaria A. Volta (Chiarano, TV), Scuola Primaria R. Mazzetti (Loiano, BO), Scuola Primaria Bassi e Graziani (Zugliano, VI), Scuola Primaria G. Parini (Camparada, MB). While the three European case studies are: Kirkmichael Primary School (Scotland), UK Marlborough Primary School (London), UK Unterdorf Elementary School (Höchst, Austria).

Each case study was also mapped using descriptive sheets. The 'descriptive analysis' is made up of aspects that report objective data about each school, such as access to the building, number of students, shape of the building, number of floors, classroom layout, and open space. It allows a more synthetic reading and framing of the space outside and inside the building, based on architectural specific criteria. It is essential to give an idea of the size of the building concerning its use (the number of common areas, bathrooms, distribution components, etc.).

3. Results

3.1. Categories and criteria of the Evaluation Matrix

Categories and criteria of analysis are based on the users' needs (children from 6 to 11 years old). In this age group, children begin to develop their first basic skills in school (reading and writing) and in life (starting to orient themselves, moving independently, and expressing their needs). The supports and stimuli offered by the school must accommodate as many of the user's characteristics as possible. These characteristics are linked to different learning times and where the child comes from, whether he/she speaks a foreign language, etc. Moreover, it is crucial to ensure that the child can express his/her needs at the right time. In addition, physical, cognitive, and sensory characteristics must also be considered, including different types of abilities. The result is a design capable of taking into account the different needs without thinking of specific solutions that only highlight the differences between non-disabled and disabled people. Based on these assumptions, the categories chosen (Figure 1) refer to areas that are indispensable for school design, while the criteria ensure that they are developed inclusively.

	CRITERIA	INDICATORS	CHECK OF INDICATORS	GRADE OF CRITERIA	GRADE OF CATEGORY	
CATEGORY 1\ OUTDOOR SPACES	ACCESS ARRANGEMENTS	At least one **public transport** system (bus, tram, metro, train) supporting fragile families to reach school	Yes/No	0 to 4	Mean of the criteria's grade (0 to 4)	GRADE OF SPATIAL INCLUSION Mean of the categories' grade (0 to 4)
		At least one **public transport stop within 100 m** from the school to limit physical effort and ensure children's safety on the way to school	Y/N			
		Public transport stop should be easily recognisable with sign that use symbols, images or audio message even for children who cannot read or have cognitive difficulties. The height of the information should allow children to be seen.	Y/N			
		A **cycle and pedestrian paths** are present allowing to reach the school walking or cycling.	Y/N			
	PARKING AREAS	**Presence of parking spaces** just for the school in order to facilitate people with limited abilities to reach the building comfortably. (e.g. a parent with more than one child).	Y/N	0 to 4		
		There are **continous walkways** with marked crossing wherever the pedestrian route crosses a vehicular way for children/adults to **safe reach the school entrance.**	Y/N			
		Parking for people with disabilities or fragile users (elderly, pregnat women, etc.) **should be within 10 m from the main entrance**, to limit the physical effort of the children/adults who require it.	Y/N			
		There is a **1:20 ratio** between parking lots (4.5 m x 2.3 m) and accessible parking lots, supporting children/adults whit physical disabilities.	Y/N			
	ENTRANCE	**Recognisable doorway** are used including for children with sensory and cognitive impairments (e.g. colored/symbolic/audio/tactile design solutions, color contrast, totem etc.).	Y/N	0 to 4		
		Entrance design solutions protect against the weather creating a suitable and safe place for children/parents/caregivers/teachers wayting.	Y/N			
		Gathering shaded and unshaded areas with seats and vegetation are present in front of the entrance to create a safe and enjoyable place for children/parents/caregivers/teachers wayting	Y/N			
		Recognisable secondary service entrance so that children are not mistaken when entering the school.	Y/N			
CATEGORY 2\ WAYFINDING	MATERIALS AND COLOURS	**different materials for walls and floors** according to the room's function help orienting children, even those with visual impairments (e.g. a tiled floor for the classrooms creates a sharp contrast to the wooden floor of the corridors, making it easier to distinguish the two areas)	Y/N	0 to 4	Mean of the criteria's grade (0 to 4)	
		different colours, tonal contrast and images for walls and floors according to the room's function help children to identify spaces, regardless of cognitive ability (e.g. a warm colour for classrooms and a brighter one for commor areas)	Y/N			
		different materials of doors/furnishings help children, even those with visual impairments, recognise rooms' entrance according to their functions (e.g. wooden door for toilet and a glass door for classroom)	Y/N			
		different colours and tonal contrast of doors/furnishings help children, regardless of cognitive ability, recognise rooms' entrance according to their functions (e.g. blue doors for labs and red door for the gym)	Y/N			
	ENVIRONMENT'S SHAPE	Different **architectural solutions** are needed according to the functions (e.g. distinction between classrooms and services, collective and private spaces), in order for the **child to recognise the space** (e.g. alternating opaque and glazed walls, projecting and recessed elements, different windows position or shape, different materials, a circular design for classrooms while a more square shape for common areas, etc.).	Y/N	0 to 4		
		Function-based floor plan and distribution system helping children's orientation through an organised mental map of the school.	Y/N			
		Hierarchical interior spaces avoiding confusion in the use of rooms by the child.	Y/N			
		Symbolic design building helping children to recognize the school from a distance (e.g. prominent entrance cover, materials, etc.)	Y/N			
	SUPPORT SYSTEMS	At least **two support systems** among tactile, visual, auditory and symbolic are present.	Y/N	0 to 4		
		Clearly visible signs and lettering (e.g. color contrast between lettering/symbol and background) are used.	Y/N			
		Simple and intuitive language reduce ambiguity in the child's understanding is used.	Y/N			
		Placement of support systems at different heights helping children to read them is adopted.	Y/N			
CATEGORY 3\ MOVEMENT	USE OF SPACE	**Paving materials** in collective areas support children/adults with reduced mobility (e.g. alternation of green and paved materials in courtyards, auntitrauma for playgrounds).	Y/N	0 to 4	Mean of the criteria's grade (0 to 4)	
		Distribution of functions according to the principle of limiting the **child's physical effort.**	Y/N			
		Distribution of functions supports organising and rationalising **users's flows** reducing the confusion.	Y/N			
		Shared toilets for children and disabled-children are present improving the equal accessibility.	Y/N			
	VERTICAL DISTRIBUTION	**Indoor and outdoor space are at the same level of the ground** to facilitate children's entry/exit.	Y/N	0 to 4		
		Different types of lift systems (lifts, elevating platforms, escalators, ramps) avoiding discrimination between children	Y/N			
		Equal arrangement of lifting systems placed next to each other and related to each other allowing children to take the same paths	Y/N			
		Arrangement of the lifts to limit the physical strain on children from/to the classrooms	Y/N			
CATEGORY 4\ SPATIAL QUALITY	FLEXIBILITY	**Calm and relaxing spaces** are integrated in collective areas both for children, especially with cognitive impairments (e.g. autism disorder), and for teachers to have privacy and rest.	Y/N	0 to 4	Mean of the criteria's grade (0 to 4)	
		Presence of **multiple outdoor areas** (with or without facilities) that allow everyone to enjoy external space at all floors of the building (courtyards, gardens, terraces, balconies etc.)	Y/N			
		Classroms have **flexible layout** and furniture to guarantee different activities for children with different needs	Y/N			
		Combined furnishing of **different height** support children of different statures (e.g. double handrails, sanitary facilities height, windows, tables).	Y/N			
	OUTDOOR/INDOOR RELATIONSHIP	**Location of the school in areas with high environmental quality** (e.g. vegetation) to ensure psychological well-being for the children.	Y/N	0 to 4		
		Classrooms have at least one external views on landscape/vegetation to guarantee a contact with the nature to ensure better psychological well-being for children and teachers.	Y/N			
		Collective spaces have at least one external views on landscape/vegetation to guarantee a contact with the nature to ensure better psychological well-being for children and teachers.	Y/N			
		Rooms must benefit from **natural light**, provided by large windows, skylights or internal shafts	Y/N			

Figure 1. Evaluation Matrix.

Category 1 \ Outdoor Space. The category analyses the environment around the school about making it fully accessible and inclusive. It is the first physical space where the child relates to the school environment. The related criteria are as follows:

- Access arrangements. The presence or absence of public transport service is studied, and the distance and quality of the routes from the stop to the school entrance (the presence of sidewalks, green spaces). To increase the child's independence, it is necessary to guarantee the possibility of reaching the school freely, with efficient transport and the stop located close to the entrance, to protect the user on his/her way.

- Parking areas. The presence or absence of a parking space is assessed, specifically the presence of parking spaces for fragile categories (disabled people and pregnant women) and the distance and quality of the connecting routes to the school entrance. It facilitates the carer and the child, reducing physical effort.
- Entrance. The analysis focuses on the entrance's design, which must be recognisable by its shape, regardless of whether orientation and signage are provided. The hierarchy of spaces includes a distinction between primary and secondary entrances, always evaluated from an architectural point of view. A gathering space promotes aggregation and meeting between parents and children, favouring inclusion, which is also functional as a waiting place.

Category 2 \ Orientation. The category facilitates the child's understanding of the school space. It is based on the ease with which the different areas of the building can be reached, making movement as autonomous as possible. In addition, the presence of multiple orientation support systems (visual, tactile, sound) facilitates all children, even those without specific needs. Its criteria are as follows:

- Material and colour. Different materials and colours can help the user orientate in space, associating them with functions or environments.
- The environment's shape. The space layout is assessed and must be clear and intuitive concerning the function it houses.
- Support systems. Support devices are sought that provide functional and spatial indications (tactile maps, use of symbols and/or writing, auditory aids, tactile-plantar routes, vertical signage). The language used should be intuitive and straightforward, reinforced by multiple types of expression.

Category 3 \ Movement. It is understood as the possibility for the child to use the space autonomously, without depending on external help. Ensuring independence is not easy, but it is fundamental for an inclusive school. It is achieved by providing the child with the possibility to move, play and relate to others by eliminating impediments and obstacles (physical and sensory). Its criteria are as follows:

- Use of space. Free movement within the floor is preferred, without differences in level. If there are any, they must be surmountable by everyone. The choice of material can also limit or help the user move through the space.
- Vertical distribution. The presence or absence of differences in level is analysed and how they are resolved. It is necessary to have at least two lifting elements, at least one of which everyone can use.

Category 4 \ Space quality. The quality of the environment is essential for the child to experience the school space well. It translates into the possibility of meeting children's needs in relation to their growth, through areas that can be modified over time. At the same time, ensuring that everyone has the same experience through inclusive design (double handrails, coat rails at different heights, etc.). The criteria are as follows:

- Flexibility. The spaces must adapt to the needs and characteristics of each individual, leaving freedom in the choice of use. The spaces created are designed to respond fairly to different needs without discrimination or limitations. The design of the spaces must guarantee the possibility of reorganising them according to the functions and conditions of the moment, preferring simple shapes.
- Indoor-outdoor relationship. Regarding the pupils' educational needs, the visual connection with the outside space is essential, as it promotes learning and

stimulates the learner. Spaces are assessed according to the windows' orientation, size and positioning, the quality of the view, and the panorama.

3.2. Indicators and scale of values

In order to make practical use of the evaluation matrix, each of the ten criteria identified was evaluated using a scale of values in ascending order: insufficient (0), sufficient (1), fair (2), good (3), and excellent (4). Scoring is based on the presence or absence of the identified indicators. Four indicators have described each criterion. Therefore, for example, if the criterion 'access arrangements' (category: Outdoor space), gets three out of four indicators, then the evaluation assigned to this criterion will correspond to a good grade (value 3) (Figure 2).

CRITERIA	INDICATORS	CHECK OF INDICATORS	GRADE OF CRITERIA
ACCESS ARRANGEMENTS	At least one **public transport** system (bus, tram, metro, train) supporting fragile families to reach school	Yes	3
	At least one **public transport stop within 100 m** from the school to limit physical effort and ensure children's safety on the way to school	Yes	
	Public transport stop should be easily recognisable with sign that use symbols, images or audio message even for children who cannot read or have cognitive difficulties. The height of the information should allow children to be seen.	Yes	
	A **cycle and pedestrian paths** are present allowing to reach the school walking or cycling.	No	

Figure 2. Example of 'Access arrangements' criterion evaluation.

The attribution of a scoring scale allows evaluating the qualitative aspects found in each case study and comparing them objectively. The final evaluation of the four categories (Outdoor space, Orientation, Movement, Spatial quality) is derived from the arithmetic mean of the scores attributed to each criterion (Figures 2-3). It is therefore possible to define the average evaluation of each school and mode evaluation of each criterion to compare the level of inclusion schools analyzed (Table 1).

3.3. Applying matrices to a case study

The reliability of the evaluation matrix has been verified by applying it to seven case studies. The tool helps to analyse existing buildings and check their degree of inclusion.

The case studies were selected according to the following characteristics. Only primary schools declared to be innovative (published in architectural journals or websites, mentioned in competitions, or awarded prizes) have been selected, to understand if innovation includes or expresses the concept of inclusion. The selected case studies had to respond in whole or in part to the ten parameters taken from the literature on UD; and had sufficient material for their evaluation (plans, sections, photos, and descriptions). Starting from an initial selection of 40 schools, the criteria reduced the number to seven. The analysis of the case study can take place directly through inspections or through supporting elements such as photographs, project drawings, descriptions, and articles.

Analyzing each school, the tool results particularly useful in identifying the most urgent areas for improvement. For example, the analysis of the school no. 1, clearly shows that it would be important to improve with design interventions the following criteria: Entrance, Support system, Use of space and Vertical distribution (Figure 3). Therefore, the evaluation matrix can represent a design support tool as well.

The same evaluation method was applied for all the case studies. In this way, it was possible to draw up a comparison matrix to compare the results obtained. In particular, the method allows to identify which criteria are more reached or neglected, in addition to highlighting the best schools (no. 5 and 7) (Table 1).

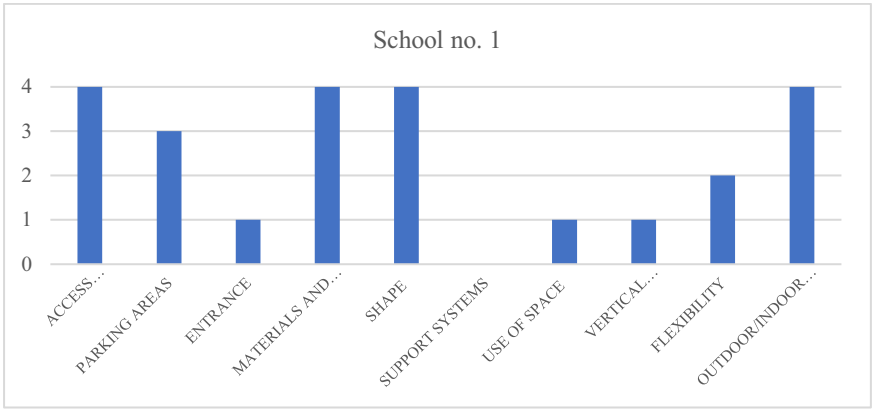

Figure 3. School n°1 results

Table 1. Average evaluation of each school and mode evaluation of each criterion.

Categories	Criteria	School (no.)							Mode of criteria
		1	**2**	**3**	**4**	**5**	**6**	**7**	
Outdoor Spaces	Access Arrangements	4	3	1	3	2	4	3	**3**
	Parking Areas	3	1	3	3	4	1	3	**3**
	Entrance	1	3	3	2	2	4	4	**3**
Wayfinding	Materials and Colours	4	2	3	4	3	4	2	**4**
	Shape	4	2	4	4	3	2	3	**4**
	Support Systems	0	2	1	3	4	2	1	**2**
Movement	Use Of Space	1	3	3	2	4	4	4	**4**
	Vertical Distribution	1	2	4	2	3	3	3	**3**
Spatial Quality	Flexibility	2	4	4	3	4	4	4	**4**
	Outdoor/Indoor Relationship	4	4	3	3	4	3	4	**4**
	Average of School	**2,3**	**2,5**	**2,9**	**3**	**3,5**	**3,4**	**3,5**	

This matrix highlights, for each school, the positive and negative aspects inherent in the individual analysis criteria. The degree of spatial inclusion in schools never reaches an excellent or insufficient rating, recording an average that fluctuates between fair and good. Above all, the criterion 'Support systems' of the 'Wayfinding' category resulted the most inadequate (column Mode in Table 1). The lack of practical communication elements and unsuitable materials prevent a complete and equitable use of space. Another important aspect to highlight is that only the category Spatial quality reached a high average score, which, however, is the category least connected to UD, while most related to new design needs.

The drafting of a comparison matrix, allows to highlight the poorest areas in schools and to be able to intervene to improve them. Furthermore, the innovative solutions

proposed by each case study can represent possible design strategies for the realization of inclusive schools.

4. Conclusions

The evaluation matrix has different potentials. It could be used for various purposes:

- for study and research, it allows to make statistics and evaluate the degree of inclusion of one or more schools;
- for analysis and design applications of existing schools;
- as design support contributing to the definition of an inclusive school.

Limitations of this study are mainly the number of the case studies that should be increased to validate to matrix in different school environments. Therefore, the developed matrix will be tested, in future research, in relation to the following uses: both to support the project and as an analysis tool to assess the degree of inclusion.

The proposed method highlights the strengths and weaknesses of projects, however the analysis can be done also together with surveys with final users, to have both an objective and subjective feedback. Future research can investigate the comparison of these two methods to validate the tool with an evidence-based approach. In the Italian context, it could be a useful method to identify the elements to be modified to increase inclusion in existing schools, in relation to PEBA *Piani di Eliminazione delle Barriere Architettoniche* protocols used by the municipalities to evaluate the accessibility level of cities.

This research represents the basis for the development of an evaluation and support tool for designers in understanding the quality of the space according to UD principles. The research has been applied to primary school buildings to create inclusive environment from an early age. It aims to raise the awareness on this issue to design educational spaces that satisfy the needs of a wide range of users.

References

[1] Merlo G, L'attrazione speciale. Milan: Maggioli Editore; 2015.
[2] Mace R, Universal Design, Barrier Free Environments for Everyone. Los Angeles: Designers West; 1985
[3] Steinfeld E & Maisel J, Universal Design: Creating Inclusive Environments. John Wiley & Sons Inc; 2012
[4] Mace R, Universal Design, Barrier Free Environments for Everyone. Los Angeles: Designers West; 1985
[5] Savia G, Universal Design for Learning, La progettazione Universale per l'Apprendimento per una didattica inclusiva. Italia: Erickson; 2016.
[6] Abouelsaad A S, Shafik Z Y, Architectural Design Criteria for Inclusive Education Schools. SSRN Electronic Journal; 2017
[7] Mostafa M, An Architecture for Autism: Concepts of Design Intervention for the Autistic User. Archnet-IJAR: International Journal of Architectural Research; 2008
[8] Tawfiq J, Yang C, The architectural strategies of classrooms for intellectually disabled students in primary schools regarding space and environment. Ain Shams Engineering Journal; 2021
[9] Agarwal A, School accessibility and universal design in school infrastructure. UNESCO - Global Education Monitoring Report Team; 2020
[10] Mosca E. I., & Capolongo, S, A Universal Design-based framework to assess usability and inclusion of buildings. In Gervasi O. et al. (Ed.), Computational Science and Its Applications–ICCSA; 2020
[11] Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Guideline Accessibility in Building Design. Berlino: (BMUB); 2014
[12] Danford G S, Center for Inclusive Design and Environmental Access, School of Architecture and Planning, University at Buffalo, The State University of New York; 2001