

# 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



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.



ISBN 978-1-64368-304-1 (print)

ISBN 978-1-64368-305-8 (online)

ISSN 0926-9630 (print)

ISSN 1879-8365 (online)

TRANSFORMING OUR WORLD THROUGH  
UNIVERSAL DESIGN FOR HUMAN DEVELOPMENT

# Studies in Health Technology and Informatics

International health informatics is driven by developments in biomedical technologies and medical informatics research that are advancing in parallel and form one integrated world of information and communication media and result in massive amounts of health data. These components include genomics and precision medicine, machine learning, translational informatics, intelligent systems for clinicians and patients, mobile health applications, data-driven telecommunication and rehabilitative technology, sensors, intelligent home technology, EHR and patient-controlled data, and Internet of Things.

Studies in Health Technology and Informatics (HTI) series was started in 1990 in collaboration with EU programmes that preceded the Horizon 2020 to promote biomedical and health informatics research. It has developed into a highly visible global platform for the dissemination of original research in this field, containing more than 250 volumes of high-quality works from all over the world.

The international Editorial Board selects publications with relevance and quality for the field. All contributions to the volumes in the series are peer reviewed.

Volumes in the HTI series are submitted for indexing by MEDLINE/PubMed; Web of Science: Conference Proceedings Citation Index – Science (CPCI-S) and Book Citation Index – Science (BKCI-S); Google Scholar; Scopus; EMCare.

## Series Editors:

B. Blobel, O. Bodenreider, E. Borycki, M. Braunstein, C. Bühler, J.P. Christensen, R. Cooper, R. Cornet, J. Dewen, O. Le Dour, P.C. Dykes, A. Famili, M. González-Sancho, E.J.S. Hovenga, J.W. Jutai, Z. Kolitsi, C.U. Lehmann, J. Mantas, V. Maojo, A. Moen, J.F.M. Molenbroek, G. de Moor, M.A. Musen, P.F. Niederer, C. Nøhr, A. Pedotti, N. Peek, O. Rienhoff, G. Riva, W. Rouse, K. Saranto, M.J. Scherer, S. Schürer, E.R. Siegel, C. Safran, N. Sarkar, T. Solomonides, E. Tam, J. Tenenbaum, B. Wiederhold, P. Wilson and L.H.W. van der Woude

## Volume 297

### *Recently published in this series*

- Vol. 296 R. Röhrig, N. Grabe, V.S. Hoffmann, U. Hübner, J. König, U. Sax, B. Schreiweis and M. Sedlmayr (Eds.), German Medical Data Sciences 2022 – Future Medicine: More Precise, More Integrative, More Sustainable! – Proceedings of the Joint Conference of the 67th Annual Meeting of the German Association of Medical Informatics, Biometry, and Epidemiology e.V. (gmds) and the 14th Annual Meeting of the TMF – Technology, Methods, and Infrastructure for Networked Medical Research e.V. 2022 online in Kiel, Germany
- Vol. 295 J. Mantas, P. Gallos, E. Zoulias, A. Hasman, M.S. Househ, M. Diomidous, J. Liaskos and M. Charalampidou (Eds.), Advances in Informatics, Management and Technology in Healthcare

ISSN 0926-9630 (print)  
ISSN 1879-8365 (online)

# Transforming our World through Universal Design for Human Development

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

Edited by

**Ilaria Garofolo**

*University of Trieste, Italy*

**Giulia Bencini**

*Ca' Foscari University of Venice, Italy*

and

**Alberto Arengi**

*University of Brescia, Italy*



**IOS Press**

Amsterdam • Berlin • Washington, DC

© 2022 The authors and IOS Press.

This book is published online with Open Access and distributed under the terms of the Creative Commons Attribution Non-Commercial License 4.0 (CC BY-NC 4.0).

ISBN 978-1-64368-304-1 (print)

ISBN 978-1-64368-305-8 (online)

Library of Congress Control Number: 2022943405

doi: 10.3233/SHTI297

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.

*Publisher*

IOS Press BV

Nieuwe Hemweg 6B

1013 BG Amsterdam

Netherlands

fax: +31 20 687 0019

e-mail: [order@iospress.nl](mailto:order@iospress.nl)

*For book sales in the USA and Canada:*

IOS Press, Inc.

6751 Tepper Drive

Clifton, VA 20124

USA

Tel.: +1 703 830 6300

Fax: +1 703 830 2300

[sales@iospress.com](mailto:sales@iospress.com)

LEGAL NOTICE

The publisher is not responsible for the use which might be made of the following information.

PRINTED IN THE NETHERLANDS

# Contents

Preface	v
<i>Ilaria Garofolo, Giulia Bencini and Alberto Arenghi</i>	
About the Conference	vii
<b>Section 1. Ethical and Philosophical Perspectives in Universal Design</b>	
The Emancipatory Design Manifesto: Let's Suppose That Disability Does Not Exist	3
<i>Jon Dag Rasmussen and Anne Britt Torkildsby</i>	
Understanding Person-Environment Relationships as Criteria to Support the Operationalization of Universal Designing	12
<i>Oskar Jonsson</i>	
State of Art and Perspectives of Universal Design: The Libyan Approach	20
<i>Ahmed El Rida Al Sharif</i>	
'Frontrunners' Understanding of Universal Design in Architecture	28
<i>Sidse Grangaard and Victoria Linn Lygum</i>	
User Insights for Better and More Inclusive Online Public Services: A Survey Study	36
<i>Till Halbach, Kristin Skeide Fuglerud and Mikael Snaprud</i>	
Methodologies for the Design of University Teaching Spaces in Covid/19 Regime. A BIM Oriented Approach, Defined for the Case Study of the Buildings of the Department of Architecture of the University of Florence (DiDA)	44
<i>Luca Marzi and Shirin Amini</i>	
Understanding the Quality of Life of Indian Elderly During COVID-19 Pandemic from Universal Design Perspective	53
<i>Iram and Gaurav Raheja</i>	
Public Space Accessibility in Vulnerable Areas in Post-Covid Times	61
<i>Deborah Guadalupe Garay Gutiérrez, Emanuele Giorgi and Virginia del Socorro Aceves Tarango</i>	
The Missing Voices of Disabled People	69
<i>Masashi Kajita and Emil Ballegaard</i>	
Making Research More Inclusive: Is Universal Design of Research the Answer?	77
<i>Gerd Berget and Birgit Kvikne</i>	
Towards 3rd Generation Universal Design: Exploring Nonclusive Design	85
<i>Per-Olof Hedvall, Margaret Price, Johnna Keller and Stina Ericsson</i>	
Adaptive Refurbishment for Aging in Place: Design Scenarios of Case Studies in Turin, Italy	93
<i>Elena Montacchini, Silvia Tedesco and Lorenzo Savio</i>	

## Section 2. System and Standards for Universal Design

Can I Get There? Can I Play? Can I Stay? Creating an Inclusive Playspace Guide in Australia <i>Jane Bringolf and Phillipa Carnemolla</i>	103
Accessible-to-All Cities. A Project of Networking Italian Experiences to Raise Awareness and Promote Universal Design <i>Francesco Alberti and Barbara Chiarelli</i>	111
Universal Design in Exhibit <i>Mark Trieglaff</i>	120
360-Degree Films for Cognitive Inclusion at Workplaces <i>Håkan Efring and Sara Kjellstrand</i>	127
Mapping Accessibility in Norway – A Tool and Method to Register and Survey the Status of Accessibility in Urban Areas and Recreational Areas <i>Sven Michaelis and Kathrin Bögelsack</i>	135
Personalised Solutions for Universal Goals. A Home Adaptation Project for Disabled People in Italy <i>Antonio Laurià, Paolo Costa and Leonardo Chiesi</i>	143
Universal Design in Housing in Australia: An Example of People Power <i>Margaret Ward and Jane Bringolf</i>	151
Housing Development for All? Learnings from the Ars Longa Case <i>Antti Pirinen</i>	159
Perspectives on Accessibility and Its Users Amongst Practicing Danish Landscape Architects <i>Marcus Tang Merit and Marie Christoffersen Gramkow</i>	167

## Section 3. Universal Design for Inclusive Communities and Urban Spaces

Systemic Approach to Universal Design of Urban Spaces – Case Study of Trbovlje, Slovenia <i>Kristijan Lavtižar, Janez Grom, Neli Zajc and Alenka Fikfak</i>	177
SMARTAGING in Venice. Toward a Definition of Age-Friendly Neighbourhood <i>Rosaria Revellini</i>	185
Aging Neighborhood and Social Inclusion – A Case Study <i>Ira Verma</i>	193
«Progetto di Vita» and Universal Design for Persons with Disabilities <i>Cristiana Perego, Iliaria Oberti and Angela Silvia Pavesi</i>	201
Communities, Sport, Inclusion. Strategies for Parish Complexes — Social Reactivation Through Sport Practice Promotion <i>Francesca Daprà, Erica Isa Mosca, Marco Gola, Andrea Rebecchi, Maddalena Buffoli, Marika Fior, Maria Pilar Vettori and Stefano Capolongo</i>	209



Rethinking Play Environments for Social Inclusion in Our Communities <i>Michela Dalpra</i>	218
A “Best Practice” for Inclusive Art Cities: The Case Study of the I-Access Project <i>Aldo R.D. Accardi and Renata Prescia</i>	226
Everyone Inside. Transformation of an Inaccessible Heterotopy. The Case of Buoncammino’s Prison <i>Francesca Musanti</i>	235
<b>Section 4. Urban Scale, Mobility and Service Planning in a Universal Design Perspective</b>	
Policies and Processes for Accessibility from a UD Perspective: The Integrated Approach Supported by the Friuli Venezia Giulia Region (IT) <i>Amanda Burelli and Consuelo Simone</i>	247
Beyond the Norm, the PEBA to Live in Udine <i>Christina Conti, Silvia Cioci and Teresa Sambrotta</i>	255
The City of Lecce (ITA) Accessibility Plan. The Innovative Experience of the Municipal Accessibility Lab <i>Francesca Raimondi, Monica Bercigli, Dora Uricchio and Giuseppe Gaballo</i>	263
Plans for the Removal of Architectural Barriers (PEBAs) from a UD Perspective. An Interdisciplinary Process in the Italian Region Friuli Venezia Giulia <i>Elena Marchigiani, Barbara Chiarelli, Valentina Novak and Andrea Peraz</i>	271
Improving Accessibility and Usability in the Built Environment. Case Study: Guide Lines by the Lombardy Region, Italy <i>Isabella Tiziana Steffan, Armando De Salvatore and Fulvio Matone</i>	280
The Level of Inclusiveness of Current 15-Minute City Models. A Qualitative Analysis on How Far City of Proximity Strategies and Design for All Are Merging <i>Alba Ramírez Saiz, Delfín Jiménez Martín, Patxi Lamíquiz and Andrea Alonso</i>	288
Inclusive Path Through Pavia: A Study to Link the Langobardic Heritage <i>Alessandro Greco, Valentina Giacometti and Elisa Bifano</i>	296
Metropolitan MaaS and DRT Schemes: Are They Paving the Way Towards a More Inclusive and Resilient Urban Environment? <i>Ilaria Delponte and Valentina Costa</i>	304
<b>Section 5. Universal Design for Healthcare</b>	
Interpreting Inclusion for Sanitation Perspectives from India: A Contextual Approach to Universal Design <i>Divyang Purkayastha and Gaurav Raheja</i>	315

Healthcare Facilities and Dementia Development of a Framework to Assess Design Quality <i>Silvia Mangili and Stefano Capolongo</i>	323
Designing Hospitals Through the Lens of Universal Design. An Evaluation Tool to Enhance Inclusive Healthcare Facilities <i>Erica Isa Mosca, Jonathan White, Edward Steinfeld and Stefano Capolongo</i>	331
Developing Innovative Solutions for Universal Design in Healthcare and Other Sectors <i>Jonathan White and Erica Isa Mosca</i>	340
Home-Based Primary Care: Adaptability Criteria for the Bedroom Layout and the Furnitures/Technological Equipments <i>Cristiana Cellucci</i>	348
 <b>Section 6. Universal Design in Products and Information and Communication Technologies</b>	
Developed an Innovative Handbike Fork Made of Composite Material <i>Luigi Solazzi, Giuseppe Schinetti and Riccardo Adamini</i>	359
A Pattern Language for Inclusive Design: A Set of Patterns for Designing Reusable Accessible Solutions <i>Stefano Valtolina and Alessandro Vivian Sisto</i>	367
Unidirectional Tactile Paving: Circulation for the Visually Impaired <i>Juan Fernández González and Ankit Gongal</i>	375
Toward an Inclusive and Independent Fruition of Architecture: The Use of Scale Models and Augmented Reality <i>Federico Cavalieri, Marianna Rotilio and Pierluigi De Berardinis</i>	383
Towards eXtended Universal Design <i>Joschua Thomas Simon-Liedtke and Rigmor Baraas</i>	391
Technology Use and Familiarity as an Indicator of Its Adoption in Museum by People with Intellectual Disabilities <i>Marilina Mastroguseppe, Leandro Soares Guedes, Monica Landoni, Stefania Span and Elena Bortolotti</i>	400
A Multisensorial Storytelling Design Strategy to Build Empathy and a Culture of Inclusion <i>Janice Rieger and Marianella Chamorro-Koc</i>	408
 <b>Section 7. Universal Design and Cultural Heritage</b>	
Does Pure Contemplation Belong to Architecture? The Denied Ramps at the Church of San Salvatore in the Santa Giulia Museum in Brescia <i>Alberto Arengi and Carlotta Coccoli</i>	419

World Heritage-Universal Heritage. The Commitment of Brescia Museums Foundation and Brescia Council to Enhance Museums and Public Archaeological Areas	427
<i>Francesca Morandini</i>	
How Can We Ensure Accessibility of Cultural Heritage? Toward Better Utilization of Existing Assets in Japanese Context	435
<i>Satoshi Kose</i>	
The Accessibility of Cultural Heritage. A New Perspective Between Relational Gaze and the Philosophy of Gesture	443
<i>Fabio Ferrucci</i>	
Outside, Around, Inside. New Paths to Discover San Michele Castle (Cagliari, Sardinia)	451
<i>Raffaele Argiolas, Elisabetta Mannai and Valentina Pintus</i>	
Universal Design and Interoperable Digital Platforms Between Conservation and New Fruition Opportunities. The Case Study of Arianna's Domus in Pompeii	459
<i>Renata Picone</i>	
NEAR PROJECT – Accessibility Plan for the Monumental Complex of the Opera di S. Maria del Fiore in Florence. Accessibility as an Element of Social	467
<i>Luigi Vessella</i>	
Values-Based Conservation in Practice – Accessibility at Akershus Castle	475
<i>Christian Ebbesen and Marianne Brenna</i>	
Usability of Visiting Routes in Heritage: The Case Study of Mercati di Traiano	483
<i>Luigi Biocca, Teresa Villani and Federica Romagnoli</i>	
The Economic Impact of Universal Design on Cultural Heritage Contribution to SDGs: Evidence from Italian Museums	491
<i>Renato Camodeca, Alex Almici and M. Cristina Vannini</i>	
Urban Accessibility in World Heritage Cities. Accessibility Considerations in Pedestrian Routes in Historic City Centres	499
<i>Delfín Jiménez Martín, Alba Ramírez Saiz and Miguel Angel Ajuriaguerra Escudero</i>	
Improving the Accessibility of Cultural Sites During Pandemic Through Microclimate Control. The Case of CapsulART Applied to the MANN Museum in Naples	507
<i>Marco Pretelli, Leila Signorelli and Maria Antonietta De Vivo</i>	
Innovative Accesibility Data Inventory Tools for Urban Environments in Historic Sites	515
<i>Daniele Treccani and Sebastiano Marconcini</i>	

## Section 8. Universal Design to Create Inclusive Educational Environments

Universal Design in Primary Schools <i>Karine Denizou</i>	525
Towards a More Inclusive Learning Environment: The Importance of Providing Captions That Are Suited to Learners' Language Proficiency in the UDL Classroom <i>Shamira Venturini, Michaela Mae Vann, Martina Pucci and Giulia M. L. Bencini</i>	533
Universal Design for Learning at University: Technologies, Blended Learning and Teaching Methods <i>Federica Baroni and Marco Lazzari</i>	541
The Future of eXtended Reality in Primary and Secondary Education <i>Joschua Thomas Simon-Liedtke and Rigmor Baraas</i>	549
Challenges in Implementing Universal Design of ICT Among Teachers in Higher Education in Norway <i>Adil Hussain and Norun Christine Sanderson</i>	557
Accessible University: Architectural Design for Special Needs Users Integration. Design Proposals for Politecnico di Torino <i>Angela Lacirignola, Cristina Azzolino and Lorenzo Savio</i>	565
Higher Education and Universal Design in Tanzania. A New Model of Inclusion and Sustainable Development <i>Mariachiara Bonetti and Martin Noel</i>	573
UNIVERCITY. The University as a Metaphor for the City. Processes, Methods, and Tools for Contemporary Design <i>Cognigni Marta, Faroldi Emilio and Vettori Maria Pilar</i>	581
Accessibility Improvement of Public Schools Through User Involvement in JAPAN <i>Maiko Sugawara</i>	589
Evaluation Methodology for Inclusive Schools Environments. A Comparative Analysis Towards Goals and Strategies for Urban Design <i>Maddalena Buffoli, Marika Fior, Federica Delogu, Chiara Donato and Erica Isa Mosca</i>	597
Subject Index	605
Author Index	609

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

Maddalena BUFFOLI<sup>a</sup>, Marika FIOR<sup>b</sup>, Federica DELOGU<sup>c</sup>, Chiara DONATO<sup>c</sup> and Erica Isa MOSCA<sup>a,1</sup>

<sup>a</sup>*Department of Architecture Built environment and Construction engineering, Politecnico di Milano*

<sup>b</sup>*Department of Architecture and Urban Studies - Politecnico di Milano*  
<sup>c</sup>*Politecnico di Milano*

**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 assesses 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

---

<sup>1</sup> Corresponding author, Department of Architecture Built environment and Construction engineering (ABC), Politecnico di Milano, 31 Ponzio street, Milan, 20133 ITA; E-mail: erica.isa.mosca@polimi.it

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 <b>public transport</b> 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)
		At least one <b>public transport stop within 100 m</b> from the school to limit physical effort and ensure children's safety on the way to school	Y/N		
		<b>Public transport stop should be easily recognisable</b> 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		
	PARKING AREAS	A <b>cycle and pedestrian paths</b> are present allowing to reach the school walking or cycling.	Y/N	0 to 4	
		<b>Presence of parking spaces</b> 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		
		There are <b>continuous walkways</b> with marked crossings wherever the pedestrian route crosses a vehicular way for children/adults to <b>safe reach the school entrance</b> .	Y/N		
		<b>Parking for people with disabilities or fragile users</b> (elderly, pregnant women, etc.) <b>should be within 10 m from the main entrance</b> , to limit the physical effort of the children/adults who require it.	Y/N		
	ENTRANCE	There is a <b>1:20 ratio</b> between parking lots (4.5 m x 2.3 m) and accessible parking lots, supporting children/adults with physical disabilities.	Y/N	0 to 4	
		<b>Recognisable doorway</b> are used including for children with sensory and cognitive impairments (e.g. colored/symbolic/audio/tactile design solutions, color contrast, totem etc.).	Y/N		
<b>Entrance design solutions protect against the weather</b> creating a suitable and safe place for children/parents/caregivers/teachers waiting.		Y/N			
<b>Gathering shaded and unshaded areas with seats and vegetation are present in front of the entrance</b> to create a safe and enjoyable place for children/parents/caregivers/teachers waiting		Y/N			
		<b>Recognisable secondary service entrance</b> so that children are not mistaken when entering the school.	Y/N		
CATEGORY 2 \ WAYFINDING	MATERIALS AND COLOURS	<b>Different materials for walls and floors</b> according to the room's function help orienting children, even those with visual impairments (e.g. a tiled floor for the classroom 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)
		<b>Different colours, tonal contrast and images for walls and floors</b> 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 common areas)	Y/N		
		<b>Different materials of doors/furnishings</b> 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		
		<b>Different colours and tonal contrast of doors/furnishings</b> 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	<b>Different architectural solutions</b> are needed according to the functions (e.g. distinction between classrooms and services, collective and private spaces), in order for the <b>child to recognise the space</b> (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	
		<b>Function-based floor plan and distribution system</b> helping children's orientation through an organised mental map of the school.	Y/N		
		<b>Hierarchical interior spaces</b> avoiding confusion in the use of rooms by the child.	Y/N		
		<b>Symbolic design building</b> helping children to recognize the school from a distance (e.g. prominent entrance cover, materials, etc.)	Y/N		
	SUPPORT SYSTEMS	At least two <b>support systems</b> among tactile, visual, auditory and symbolic are present.	Y/N	0 to 4	
		<b>Clearly visible signs and lettering</b> (e.g. color contrast between lettering/symbol and background) are used.	Y/N		
<b>Simple and intuitive language</b> reduce ambiguity in the child's understanding is used.		Y/N			
<b>Placement of support systems at different heights</b> helping children to read them is adopted.		Y/N			
CATEGORY 3 \ MOVEMENT	USE OF SPACE	<b>Paving materials</b> in collective areas support children/adults with reduced mobility (e.g. alternation of green and paved materials in courtyards, terraces for playgrounds)	Y/N	0 to 4	Mean of the criteria's grade (0 to 4)
		<b>Distribution of functions</b> according to the principle of limiting the <b>child's physical effort</b> .	Y/N		
		<b>Distribution of functions</b> supports organising and rationalising <b>users' flows</b> reducing the confusion.	Y/N		
		<b>Shared toilets</b> for children and disabled-children are present improving the equal accessibility.	Y/N		
	VERTICAL DISTRIBUTION	<b>Indoor and outdoor space are at the same level of the ground</b> to facilitate children's entry/exit.	Y/N	0 to 4	
		<b>Different types of lift systems</b> (lifts, elevating platforms, escalators, ramps) avoiding discrimination between children	Y/N		
		<b>Equal arrangement of lifting systems</b> placed next to each other and related to each other allowing children to take the same paths	Y/N		
		<b>Arrangement of the lifts</b> to limit the physical strain on children from/to the classrooms	Y/N		
CATEGORY 4 \ SPATIAL QUALITY	FLEXIBILITY	<b>Calm and relaxing spaces</b> 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 <b>multiple outdoor areas</b> (with or without facilities) that allow everyone to enjoy external space at all floors of the building (courtyards, gardens, terraces, balconies etc.)	Y/N		
		Classrooms have <b>flexible layout</b> and furniture to guarantee different activities for children with different needs	Y/N		
		Combined furnishing of <b>different height</b> support children of different statures (e.g. double handrails, sanitary facilities height, windows, tables).	Y/N		
	OUTDOOR/INDOOR RELATIONSHIP	<b>Location of the school in areas with high environmental quality</b> (e.g. vegetation) to ensure psychological well-being for the children.	Y/N	0 to 4	
		<b>Classrooms have at least one external views</b> on landscape/vegetation to guarantee a contact with the nature to ensure better psychological well-being for children and teachers.	Y/N		
		<b>Collective spaces have at least one external views</b> 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 <b>natural light</b> , 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 <b>public transport</b> system (bus, tram, metro, train) supporting fragile families to reach school	Yes	3
	At least one <b>public transport stop within 100 m</b> from the school to limit physical effort and ensure children's safety on the way to school	Yes	
	<b>Public transport stop should be easily recognisable</b> 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 <b>cycle and pedestrian paths</b> 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).

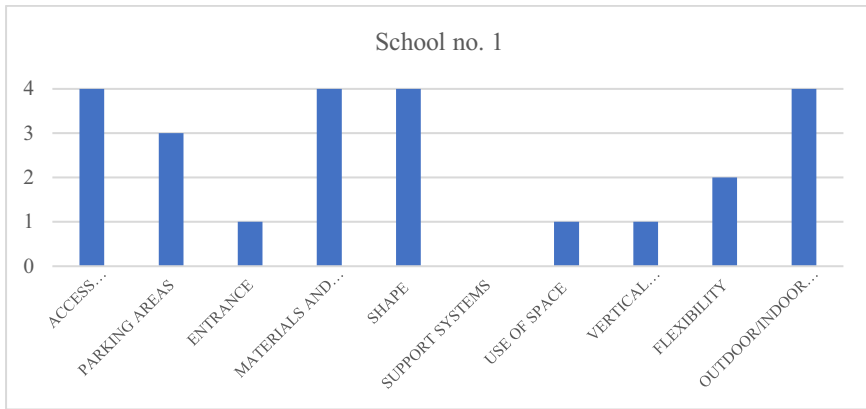


Figure 3. School n°1 results

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

Catego- ries	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
Move- ment	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
<b>Average of School</b>		<b>2,3</b>	<b>2,5</b>	<b>2,9</b>	<b>3</b>	<b>3,5</b>	<b>3,4</b>	<b>3,5</b>	

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