

# Towards a Universal Design Evaluation for Assessing the Performance of the Built Environment

ERICA ISA MOSCA<sup>a,1</sup> and STEFANO CAPOLONGO<sup>a</sup>

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

**Abstract.** Universal Design is a recent and innovative strategy aimed at designing spaces that are as accessible and inclusive as possible. It considers the broadest range of users, and goes beyond the prescriptive approach of accessibility legislation. Theoretical research on this strategy is currently increasing, but the reliability of its principles remains limited in design practice and it struggles to guarantee performance-based knowledge to designers. Therefore, a practical evaluation method based on reliable performance criteria is required.

The purpose of the research is to investigate which means, methods, and principles of Universal Design and Design for All are currently used to evaluate the accessibility and inclusion of the built environment. The paper describes a literature review aimed to select methodologies and reflect on instruments that are inherent to the thematic.

The research's outcome is therefore the definition of both open issues and gaps in this field, which is based on the comparison of the studies analysed. In addition, the potential outlooks on the issue of Universal Design and Design for All evaluation are discussed.

The current results provide a basis for further research on the development of evaluation and support tools for designers that are able to improve the accessibility and inclusion of the built environment, and the reliability of Universal Design performance criteria in design practice

**Keywords.** Universal Design, Design for All, Evaluation, Performance, Built Environment, Architecture

## 1. Introduction

The contemporary transformation of society is generating an increase in the user needs of different user groups due to political, social, and economic changes. Cities have been characterized by diversity in terms of use, users, urban features, and governance, but this diversity is now being pushed towards its limits. Indeed, the age level is constantly increasing [1] and approximately 28% of people in the EU report a longstanding health problem, a basic activity difficulty, or both [2]. Moreover, more than a quarter of the EU population face daily accessibility problems due to various impairments, which may be

---

<sup>1</sup> Erica Isa Mosca, Architecture, Built environment and Construction engineering Department, Politecnico di Milano, E. Bonardi street 9, 20133 MI Milan, Italy; E-mail: ericaisa.mosca@polimi.it

permanent, temporary, situational, or generated by their relation to the built environment (e.g., pregnant woman, parents carrying a stroller, or tourists with bags).

For these reasons, the Universal Design (UD) strategy was official launched by Ron Mace in 1995. It was defined as “the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” [3]. With regard to architectural practice, this strategy aims to ensure that different users have the same experience of the built environment and that they are not excluded. Moreover, UD is currently integrated into European policy for working together with the common legislation on accessibility in order to overcome architectural barriers through a descriptive and performed-based approach [4][5].

The evaluation of inclusion and accessibility of the built environment quality become relevant criteria to consider in architectural practice. This is seen, for example, when it comes to defining national and international norms and standards, for which a more objective view is required [6]. Furthermore, the objective criteria provided by assessment practices are essential for comparing data between countries [7]. In this regard, this paper addresses the theme of the evaluation of the built environment in relation to UD, questioning how it is possible to measure and evaluate the extent to which the built environment is inclusive from a UD perspective. The first step in bridging this gap and defining the research problem involved conducting a literature review.

## 2. Methodology

This section describes the process that was followed in conducting a literature review, which was intended to locate the existing knowledge and identify potential research gaps in a qualitative way. The literature review’s methodology is presented by showing how the articles were selected and how the data were collected and analysed.

In particular, the literature analysis sought to investigate the relationship between UD strategy and the evaluation of accessibility and inclusion. The purpose was to investigate the current existing studies on UD evaluation in order to define the research problem by identifying the significant gaps and open issues. As a result, the relevant findings are provided that contribute to the objectives of the research.

The collection of the articles for the literature review was conducted using Scopus, Web of Science, and also by using grey literature such as book chapters. Therefore, among the **eligibility criteria** adopted there are the main research fields investigated: 1. Universal Design, Design for All, Inclusive Design - 2. Evaluation, Assessment - 3. Architecture, Built environment. Different keywords were searched in title and abstract through the databases: "*Universal Design*" OR "*Design for All*" OR "*Inclusive Design*" AND *Evaluation* OR *Assessment* OR *Performance* AND *architectur\** OR *built* OR *space*. The ‘inclusion criteria’ considered were: English language; time: article from 1995 (UD definition). While the ‘exclusion criteria’: no educational issue; no specific studies on the group of users (children, aging, etc.) or products.

The articles were selected by analyzing the keywords, titles, and abstracts, after which the full text was read. The data collection was made using an Excel table to extract data. This included the most important papers found, which were used to conduct the critical analysis. An example is provided in Figure 1. In the integral table, the articles are grouped into four categories, which provide their contents in clusters. These are:

- **Assessment theory:** the article describes theories of the assessment of accessibility, UD, Design for All (DfA), or Inclusive Design (ID). This category also includes explanations about the relevance of the topic or the need to investigate it.
- **Criteria:** the criteria and principles that are useful evaluating UD performance are presented.
- **Evaluation method:** the assessment methods related to accessibility or UD are described or applied in the case studies.
- **Tool:** the development or application of UD, DfA, or ID evaluation tools. These are relevant for understanding how criteria and methods can be applied in practice.

The table contains descriptive data (authors, title, year, source, source details), categories (assessment theory, criteria, evaluation method, tool) and notes for each article, which summarize its main contents.

AUTHORS	TITLE	YEAR	SOURCE	SOURCE DETAILS	CATEGORY	NOTES
Wolfgang F.E. Preiser	Toward universal design performance assessments	2010	Book chapter	UD Handbook 2 <sup>nd</sup> ed, chapter 38 pp. 38.1-38.8	Assessment theory	The study describes the growing attention to UD assessment and the current limits. It provides a framework for UD assessment methods (observation, mechanical recordings, visual recordings, etc.) that are not meaningful for our research. Of interest are the open issues he proposes to investigate (glossary of terms, collection of best practice, standards development).

Figure 1. Extract of the literature review data collection table.

### 3. Findings

The findings of the literature review show the current state of the evaluation of the built environment from the perspective of UD and DfA. The *Assessment Theory* section provides an overview on UD and DfA evaluation according to the literature. This is followed by the *Criteria* section, which analyses the principal performance criteria that attempt to capture UD and DfA. Finally, the *Evaluation Methods* section introduces a systematic analysis of existing evaluative methods, and highlights the strengths and weaknesses of the current approaches.

#### 3.1. Assessment theory

There is an increase in theoretical studies of UD, DfA, ID fields, however ways of linking this knowledge and to architectural practice are yet to be found. Moreover, reliability of these strategies remains limited and they struggle to guarantee the provision of performance-based knowledge to designers [8]. Tools are therefore required in the assessment of space quality with regard to accessibility and inclusion. Indeed, such strategies need to be able to demonstrate objectively measurable performance criteria [8].

The history of assessment research in these fields is rather short and consists primarily of case study evaluations of built projects or developed products, together with the use of expert judgments and verbal user feedback [8]. In particular, the assessment of accessibility in the built environment is often conducted by means of the subjective evaluations of experts (through national and international awards), but a more objective view is required when it comes to defining norms and guidelines [6]. According to Preiser, UD “to be taken seriously in the pragmatic world of planning, designing, and

construction, a rigorous and accountable approach must be taken in measuring and analyzing” their performance [8]. Furthermore, building evaluation involves identifying the values by which a building should be judged, and these differ according to where the evaluators place this value [9]. Evaluations are based on measurable criteria, which need to be investigated and defined. In this case, they need to be defined within the field of UD and DfA.

### 3.2. Criteria

Many of the articles analysed propose the **7 Universal Design principles** [3] as the main criteria for UD or DfA assessment. They are as follows: Flexibility in Use, Simple and Intuitive Use, Perceptible Information, Tolerance for Error, Low Physical Effort, and Size and Space for Approach and Use.

These criteria are commonly accepted by the scientific community, however, certain criticisms constitute barriers to their use in practice. These include the fact that they lack of a body of evidence and clarity of purpose, that they still require measurable outcomes, and that they are not based on empirical data and are therefore open to interpretation [10]. For these reasons, Steinfeld [10] proposes the use of the **8 Universal Design goals**, which are body fit, comfort, awareness, understanding, wellness, social integration, personalization, and cultural appropriateness.

While UD principles do not address psychological and social elements, the UD goals have actively sought to address the intersection of human performance (Goals 1-4) and social participation (Goals 5-8), where wellness (health) represents a bridge goal that addresses both themes. The UD goals are less known by the scientific community, but they are considered more appropriate for performance evaluation, and have indeed also been adopted in the Global Universal Design Commission standards and certification [11].

Similarly to Steinfeld’s goals [10], Preiser’s “**Habitability framework**” of 10 UD performance criteria [12] deals with the social and psychological factors that are absent in the UD principles. Preiser’s framework identifies three levels of needs in its criteria. The first order of need is addressed by basic building regulations (health, safety, security), the second order is addressed by technological “state-of-the-art” knowledge (functional, efficiency, workflow), and the third order of needs encompasses less codifiable social and experiential factors (psychological, social, cultural, aesthetic). This approach seeks to clearly illustrate the layered interrelationships between the orders of need, and differentiates between the different layers in a building.

**User capabilities** are criteria that are used in many evaluation studies. They are largely focused on product design, basing the assessment on product’s features and the user’s interaction with it [13]. There are seven user capabilities, which are divided into three main categories: *Motion* (Locomotion, Reaching, Stretching, Dexterity); *Sensory* (Seeing, Hearing) and *Cognitive* (Communication, Intellectual, Functioning).

The 7 capabilities are derived from the 13 capabilities of the Survey of Disability in Great Britain and the Disability Follow-up (DFS) [13], which was carried out between 1985 and 1988 and based on those identified in the ICIDH [14].

Preiser [8] makes an interesting suggestion concerning the development of performance criteria. He states that they should involve “hard and quantitative as well as subjective and qualitative measures with a focus on human environment interface”. Indeed, the criteria should take into account both the users’ needs and their relation to

the built environment, which are qualitative features. At the same time, they should be used to obtain objective and quantitative measures.

To summarise, the criteria are collected in the Figure 2. This leads to a reflection regarding the choice of the best criteria to use in the evaluation.

UD Principles (CUD, 1997)	UD Goals (Steinfeld, 2012)	Habitability Framework (Preiser, 2001)	User Capabilities (Keates et al., 2003)
Equitable Use	Body fit	1st order of need	Health
Flexibility in Use	Comfort		Safety
Simple and Intuitive Use	Awareness		Security
Perceptible Information	Understanding	2nd order of need	Functional
Tolerance for Error	Wellness		Efficiency
Low Physical Effort	Social integration		Workflow
Size and Space for approach and Use	Personalization	3rd order of need	Psychological
	Cultural appropriateness		Social
			Cultural
			Aesthetic
			Locomotion
			Motion
			Reaching
			Stretching
			Dexterity
			Sensory
			Seeing
			Hearing
			Cognitive
			Communication
			Intellectual
			Functioning

Figure 2. Comparison of the criteria for evaluating DfA and UD.

### 3.3. Evaluation methods

Various authors propose frameworks for gathering UD or DfA assessment methods in order to understand which method is most suitable for built environment evaluation. Preiser [8] develops an evaluation framework that collects different methods for assessing UD, such as behavioural observation, verbal response measurement, recordings, etc. However, these assessment methods only require direct user engagement. They do not cover the overall area of investigation of this research, which is concerned with assessment methods that also apply to evaluation tools, such as building survey and checklists. For this reason, Sanford [15] distinguishes between UD evaluation methods that assess the *potential* demands placed on buildings and those that assess the *actual* demands. Evaluation methods based on potential demands involve the existing standards and guidelines as the objective basis on which to measure the success of a building. They use a more prescriptive approach and are based on predefined assumptions of the activity performance of individuals. By contrast, evaluation methods based on actual demands analyse how people perform in a given building, which is verified by direct observation or testimony. They are based on tangible interactions between individuals and their environment.

Similar results are also defined by a more recent study by Shea et al. [9]. They outlines four types of assessments: checklist evaluations based on evaluations of potential user needs, value evaluations based on actual user needs, and holistic evaluations and invisible evaluations based both on potential and actual user needs. By critically referring to the Shea et al. study [9], it is possible to define three main ways of distinguishing evaluation methods Figure 3:

**A - Potential user needs evaluation:** Building survey and documented analysis are the methods that evaluate potential user needs (indirect methods) and they outline checklists that rely on a set of simplified criteria (e.g., seven UD principles, eight UD goals), and tools based on a rating system (in which more graduated responses are allowed rather than the simple binary choice of yes/no). These assessment methods are easy and practical to use, but are based on potentially un-validated data that concentrate

on expected demands [15]. Furthermore, they comprise a modelled interaction between user needs and the built environment, rather than an empirical observation [9].

**B - Actual user needs evaluation:** Questionnaires, interviews, observations, and workshops are used to evaluate actual user needs (direct methods). As already noted, these methods are characterized by direct involvement of people. They are therefore based on empirical evidence and are able to establish indicators of a building's empathy towards its users [9].

**C - Actual/Potential user needs evaluation:** The evaluation methods used include both building survey, documented analysis and questionnaires, interviews, observations, and workshops. One evaluation approach to intersecting both actual and potential demands is that of POE (Post Occupancy Evaluation) [8][5], in which different methods are used and people with disabilities are considered as "experts". These methods are able to analyse the point of interaction between people and a building, but they are time consuming and demand resources [9].

	Type of method	Data sources used	Outcomes	STRENGTHS	WEAKNESSES
<b>A) Potential user needs</b>	Building survey; document analysis	Documents; normative standards, guidelines and regulations; physical building layout; professional experts	Evaluation of building based on existing knowledge	Easy and practical in use	Based on potentially unvalidated data concentrated on expected demands. Use of modeled interaction between user needs and built environment.
<b>B) Actual user needs</b>	Questionnaires, interviews, workshops	User feedback and testimony (user-experts)	Evaluation of buildings based on existing knowledge, generation of new knowledge	Direct involvement of people, based on empirical evidence. Useful to identify indicators of empathy between users and built environment.	Can't provide large evaluation strategies. Time consuming and demanding of resources.
<b>C) Actual/potential user needs</b>	Document analysis, buildings survey, questionnaires interviews, observational studies, workshops	A cross section of normative sources and user feedback, (user experts and professional experts)	Evaluation of buildings based on existing knowledge, generation of new knowledge	Can analyze the point of interaction of people and building. Can analyze both potential and actual needs of users.	Time consuming and demanding of resources.

Figure 3. Comparison of evaluation methods (table developed referring to Shea et al. (2014)).

Given that all these methods have both strengths and weaknesses, a combination of some of them may be more successful [9]. According to Shea et al. [9], "The advantage of pairing scoping methodologies with the production of instruments that are calibrated to specific locations, and possibly to specific building types, is that contextualized evaluation criteria can be produced for each site of evaluation" (pag. 18). Similarly, according to Ryhl et al. [16], a systematic and multifaceted method can contribute to the development of a new assessment system. The best assessment of UD or DfA would be the measurement of functionality/usability and inclusiveness/contextual appropriateness of a particular design feature for all the features of all the users under conditions of actual use [5]. Therefore, a method is required for producing both potential and actual criteria by means of a simple instrument that will carry out the evaluation.

#### 4. Discussion

What has emerged in the previous analysis is that evaluations characterized by objective and performance criteria are provided by tools, such as questionnaires, checklists etc., and that these use an indirect evaluation based on *potential* needs. The challenge is

therefore to not lose the direct involvement of the users in the evaluation, and to also consider their *actual* needs. Indeed, according to various authors, it is important to consider both potential and actual needs in the evaluation of UD and DfA performances [9][16]. In this regard, various assessment tools applied to the built environment [17][18][19][20], can provide an objective evaluation of performances, and at the same time, involving the users both in the decision making process and for the criteria weights' assignment.

Another issue to consider is the choice of proper performance criteria for the research tool. Indeed the UD principles are still considered too general and they lack operational performance criteria. Indeed, "they are helpful in pointing the designer into the right direction, but not adequate to let him or her know what to do in a specific situation" [8]. For this reason, the seven principles cannot be used on their own to assess accessibility and inclusion in the built environment, and they need to be both compared to other performance criteria, such as UD goals. Above all, they need to be made measurable. Furthermore, as Shea et al. [9] assert, there is a conflict in how terms are employed in the UD literature.

As the research of Ryhl et al. [16] indicates, the evaluation of the accessibility and inclusion of the built environment involves many aspects that are both qualitative and quantitative. This raises the question of how they can be compared. Many of the studies found in the literature review demonstrated that is very difficult to organize the various qualitative and quantitative items involved in UD assessment in a unique instrument [9][15][16]. However, some UD evaluation tools characterized by different methods were already proposed [6][15][21][22].

Finally, the two main aspects addressed in the analysed articles about UD evaluation, namely, are the users' needs and the architectural elements of the built environment [21][23][24]. Accordingly, Steinfeld [10] states that "assessment methods should provide objective identification of mismatches between the demands of the environment and the capacities of the user". Therefore, a UD or DfA tool that seeks to measure inclusion must consider the relationship between people and the built environment, including in the evaluation of the users' actions in relation to spaces.

## 5. Conclusions

The current paper has dealt with UD evaluation to critically understand how to define a new UD assessment tool. Indeed, this investigation is intended to be a support basis in the outlining of an evaluation method that can measure the determinants of accessibility and inclusion in the built environment.

The analysis reveals that an indirect evaluation method is needed in order to provide objective criteria. At the same time, however, the involvement of the users is required in the evaluation process in order to consider even their *actual* needs.

Specific performance criteria still need to be fixed in relation to UD principles and goals. A ranking system could be adopted in order to increase their objectivity and make them measurable [11][17][19][20][25]. Moreover, a UD or DfA evaluation tool should be based on the users' needs, functioning and actions beyond the elements of the built environment in order to measure both the inclusion of spaces and their accessibility.

This research therefore forms the basis for the development of an objective assessment methodology for a tool that is able to evaluate the quality of the built environment in terms of inclusion. Its aim is to stimulate the continuous and lasting

improvement of inclusion from a UD perspective through the application of shared and measurable criteria.

## References

- [1] Eurostat. (2016). Population structure and ageing - Statistics Explained. <http://ec.europa.eu/eurostat>
- [2] Eurostat. (2011). Disability statistics-health. <http://ec.europa.eu/eurostat>
- [3] Connell, B. R., Jones, M., Mace, R., Mueller, J., Mullick, A., Ostroff E., Sanford, J. et al. (1997). The Principles of Universal Design. Raleigh: NC State University, CUD.
- [4] European Commission. (2015). European Accessibility Act. <http://ec.europa.eu/social/main.jsp?catId=1202>
- [5] Froyen, H. (2012). *Universal Design, a methodological approach*. Boston: Institute for Human Centered Design
- [6] Iwarsson, S., Stahl, A. (2003). Accessibility usability and universal design positioning and definition of concepts describing person-environment relationships. Disability and Rehabilitation Informa UK Limited. 25: 57–66
- [7] Quintas, R., Koutsogeorgou, E., Raggi, A., Bucciarelli, P., Cerniauskaite, M., Leonardi M. (2012). The selection of items for the preliminary version of the COURAGE in Europe built environment instrument. *Maturitas* 71(2): 147– 153
- [8] Preiser, W. F. E. (2010). Toward universal design performance assessments. In: Preiser, W. F. E. *Universal Design Handbook*. 2<sup>o</sup> ed. New York: Mcgraw-Hill
- [9] Shea, E. C. O, Pavia, S., Dyer, M., Craddock, M., Murphy, N. (2014). Measuring the design of empathetic buildings: a review of universal design evaluation methods. *Disability and Rehabilitation: Assistive Technology* 11: 13–21 Informa UK Limited
- [10] Steinfeld, E., Maisel, J. L. (2012). *Universal Design: Creating Inclusive Environments*. Canada: John Wiley & Sons
- [11] Global Universal Design Commission (GUDC). Creating Voluntary Universal Design Standards. [http://www.globaluniversaldesign.org/sites/default/files/docs/about/creating\\_voluntary-ud-standards.pdf](http://www.globaluniversaldesign.org/sites/default/files/docs/about/creating_voluntary-ud-standards.pdf)
- [12] Preiser, W. F. E. (2001). Towards Universal Design Evaluation. In: Preiser W. F. E. *Universal Design Handbook*. 1<sup>o</sup> ed. Mcgraw-Hill.
- [13] Keates, S., Clarkson, P.J. (2003). Countering design exclusion: bridging the gap between usability and accessibility. *Universal Access in the Information Society*. Springer Nature 2 (3): 215-225
- [14] World Health Organization (WHO). (1980). *International Classification of Impairments, Disabilities, and Handicaps*. Geneva
- [15] Sanford, J. A. (2009). Assessing Universal Design in Physical Environment. In: Mpofu, E., Thomas O. *Rehabilitation and Health Assessment: Applying ICF Guidelines*. New York: Springer Publishing Company
- [16] Ryhl, C., Kajita, M., René Sørensen, R. (2016). Qualitative description of spatial quality in inclusive architecture. In: 3rd International Conference on Universal Design (UD 2016). *Stud Health Technol Inform*. 229:639-41.
- [17] Capolongo, S., Lemaire, N., Oppio, A., Buffoli, M., Roue Le Gall, A. (2016). Action planning for healthy cities: the role of multi-criteria analysis, developed in Italy and France, for assessing health performances in land-use plans and urban development projects. *Epidemiol Prev*; 40(3-4): 257-64. doi: 10.19191/EP16.3-4.P257.093
- [18] Oppio, A., Buffoli, M., Dell’Ovo, M., Capolongo, S. (2016). Addressing decisions about new hospitals’ siting: a multidimensional evaluation approach. *Ann Ist Super Sanità*. Mar: 52(1):78-87. doi: 10.4415/ANN\_16\_01\_14
- [19] M., Buffoli, S., Capolongo, M., Bottero, E., Cavagliato, S., Speranza, L., Volpatti. (2013). Sustainable Healthcare: how to assess and improve healthcare structures’ sustainability. *Ann Ig* 2013; 25: 411-418 doi:10.7416/ai.2013.1942
- [20] Capolongo, S., Buffoli, M., Oppio, A., Nachiero, D., Barletta, M. G. (2013). Healthy indoor environments: how to assess health performances of construction projects. *Environmental Engineering and Management Journal*. Nov; 12(S11): 209-212
- [21] Afacan, Y., Erbug C. (2009) An interdisciplinary heuristic evaluation method for universal building design. *Applied Ergonomics* 40: 731–744
- [22] Can, G. F., Kılıç Delice, E. (2018) A task-based fuzzy integrated MCDM approach for shopping mall selection considering universal design criteria. *Soft Comput*. doi: 10.1007/s00500-018-3074-4

- [23] Iwarsson, S. (1999). The Housing Enabler: an objective tool for assessing accessibility. *Br J Occup Ther.* 62(11): 491–7
- [24] Froyen, H., Verdonck, E., De Meester, D., Heylighen, A. (2009). Mapping and documenting conflicts between Users and Built Environments. In: *Proceedings of Include Include 2009*. Helen Hamlyn Centre. London
- [25] Buffoli, M., Capolongo, S., di Noia, M., Gherardi, G., Gola, M. (2015). Healthcare sustainability evaluation systems. In: Capolongo S., Bottero M.C., Buffoli M., Lettieri E. editor. *Improving Sustainability During Hospital Design and Operation: A Multidisciplinary Evaluation Tool*. Cham: Springer: 23-30. doi: 10.1007/978-3-319-14036-0\_3