Developing Innovative Solutions for Universal Design in Healthcare and Other Sectors

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Abstract. For over half a century, researchers have sought to better understand the needs of people with disabilities in the built environment, and for more than a quarter century, they have sought to understand the effectiveness of universal design (UD) on a wide range of people and populations. This research led to the creation of the *innovative solutions for Universal Design (isUD)* building certification program, which addresses knowledge gaps in the practitioner's field with UD criteria. The *isUD* focuses on commercial buildings but aims to expand to other sectors including healthcare and residential settings. The research and outcomes used in the development and evaluation of the *isUD* combined with lessons learned from implementation of the *isUD* program suggest a path forward to improve and expand the program. Several research studies have evaluated the effectiveness of UD standards. One study compared university residence halls, one of which was built using a draft version of UD standards using a guided tour and online surveys among other methods.[1] Another study used online surveys to compare a workplace built using the *isUD* with the former workspace.[2] Another study used in-person surveys to compare public right-of-way features pre- and post- design intervention.[3] Lastly, an innovative doctoral dissertation that proposes a new methodological tool to evaluate UD in healthcare settings [4-5] has been analyzed to inform the *isUD*'s expansion into the healthcare sector. The results indicate there is value in using UD to address equal access to and use of facilities for people with and without disabilities, and people of diverse social, cultural, and economic backgrounds. Facilities built using UD standards and tools are more usable, comfortable, and satisfying for users. However, the results also indicate there is room for improvement to make the *isUD* tool more effective. These improvements will better enable expansion of the tool to be usable in settings with more specialized requirements. While UD is often effective at improving human performance, health and wellness, and social participation across some measures, and while tools that assist with UD implementation may further help achieve these outcomes, to gain widespread adoption across multiple sectors, such tools must be shown to be consistently effective in achieving UD outcomes across all measures. These improvements can help expand availability of UD to a wider, more diverse audience.

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1. Introduction

The effectiveness of universal design (UD) can be ascertained by measuring performance of users of an environment and the extent to which the environment enables full participation, inclusion, integration, and equality for users, regardless of users' age, size, gender, abilities, or circumstance.[6] Benchmarking for UD in practice is often frustrated by the lack of standardized data types and quality, particularly for post-occupancy evaluations and action research addressing case-specific problems.[6] However, improving generalizability is only part of the difficulty in benchmarking UD. One definition of UD is "a *process* [emphasis added] that enables and empowers a diverse population by improving human performance, health and wellness, and social participation."[7] Its authors explain that "[UD] should recognize the context in which design takes place rather than posing an absolute standard to every situation."[7] Other definitions also recognize the utopian nature of UD, but often include the caveat that the pursuit of inclusion be reasonable. [7] Thus, UD is an ideal in the long-term, but must also be realistic to be practiced in the short-term.[7] So, in addition to generalizability, another challenge is the ability of researchers to identify whether or not a particular design is in-fact UD, given that UD is a continual and contextual process.

One means is to measure the relative success of a design in achieving specific UD *outcomes*, as expressed in the definition, "to improve human performance, health and wellness, and social participation."[7] The definition's authors also specify eight *Goals of Universal Design*: body fit, comfort, awareness, understanding, wellness, social integration, personalization, and cultural appropriateness.[7] It is reasonable for researchers to measure UD outcomes by comparing user performance in one setting to user performance in another setting specifically designed to achieve UD outcomes. One challenge is that each setting must be similar in as many aspects as possible but different enough in key UD criteria such that one setting can be defined as UD while the other cannot. It is not enough to measure whether outcomes have been achieved in one setting but not another. One setting must have implemented UD criteria aimed at achieving those outcomes and the other setting must not, but be otherwise similar. Additionally, the study instruments must be sufficiently narrow to elicit responses related to those UD criteria. Thus, determining the specific UD criteria existing in a setting is critical to evaluating the effectiveness of UD.

In the U.S., civil rights legislation and building codes offer minimum criteria to accommodate people with disabilities.[1] These criteria do not identify how to address best practices related to UD outcomes, nor usability, comfort, and convenience for the population at-large.[1] Until as recently at 2015, there were no evidence-based standards on how to achieve the desired outcomes of UD – only informal checklists.[1] Subsequently, standards have been developed for benchmarking UD, such as the *innovative solutions for Universal Design*, (*isUD*).[8] *isUD* is described as a set of research-based solutions for public and commercial buildings paired with a certification program.[8] However, *isUD* currently focuses only on public and commercial buildings, but does not address other settings such as residential or healthcare. Previous research exists examining individual UD features [9] and examining buildings as a whole [1-2], but this research is still limited to specific settings. Research is needed in various settings to validate the findings of initial research on the value of UD standards.[2] Research in university residential life [1], workplace [2], public rights-of way [3], and healthcare settings [4-5] has now been completed. The latter research proposes a new performance-

based *Design for All A.U.D.I.T.* tool to evaluate UD in healthcare settings through a framework of criteria and indicators.[4]

While these four settings cannot represent all of the settings that exist in the built environment (so more research will still be needed), now is an appropriate time to begin to compare the research across these various settings to determine the commonalities and differences between the studies. Are the data types and quality standardized? What improvements can be made to future research in different settings too improve the generalizability of results, if any? If UD is an iterative "process," [7] does this research suggest any directions for improvement? How can the research inform improvements to UD standards to ensure they are reliable benchmarks for future research and expansion?

2. Methods

A researcher reviewed the methods and results of four studies, each involving evaluations of the effectiveness of design in achieving desirable UD outcomes. The involved different settings: university residential life [1], workplace [2], public right-of-way [3], and healthcare[4]. A researcher reviewed the methods, results, and conclusions to determine similarities and differences, and identify areas where greater uniformity could improve the generalizability of results. The researcher also evaluated each study to determine what improvements to UD standards or new UD benchmarks could be beneficial for future research and future standard development.

2.1. University Residential Life

This study used a post-occupancy evaluation "to determine if a universally designed building provides a significantly better user experience than a similar building that was not."[1] Other objectives included "determin[ing] if the draft [UD] standards were effective in contributing to the improved experience."[1]

One of the evaluation methods was a guided tour of people with little or no experience in two buildings: one built using draft UD standards, and the other not, while collecting task ease/difficulty ratings on a seven-point Likert scale, along with structured interview responses. Researchers compared responses using a two-tailed paired samples t-test. Another method collected online surveys of people residing in each building, asking residents to evaluate specific features in terms of satisfaction, safety, and comfort on a five-point Likert scale, and open-ended feedback. Researchers compared responses using a two-tailed independent samples t-test. Additionally, three expert evaluators assessed the extent to which a specific UD feature was present in each facility, with their scores weighted on five-point "level of agreement score."[1]

2.2. Workplace

This study also used a post-occupancy evaluation to compare two workplaces for the same employer, one designed with UD features, which replaced a non-UD facility. Employees at both sites completed an online survey before and after occupancy of the new facility. The survey used some of the same questions from the first study, but also new pilot-tested questions on physical spaces, environmental conditions, and alignment with outcomes of comfort, health/well-being, safety from accidents, work collaboration, informal interaction, productivity, and satisfaction. The response format was a five-point

Likert scale, with open-ended feedback in each section. Researchers compared sites using the Mann-Whitney *U* test, and examined the relationship of overall UD outcomes to outcomes in specific areas using the Spearman rank correlation test.[2]

2.3. Public Right-of-Way

This study evaluated a public streetscape before and after an improvement project to determine user perceptions of satisfaction, convenience, and safety. The study also evaluated specific opinions on elements of the environment and design preferences. The study used an in-person interview of pedestrians using the streetscape both before and after the project, which included sidewalks, crosswalks, landscape, signals, and installation of bulb-outs at crossings. The response format consisted of a five-point Likert scale, and general open-ended feedback. Researchers compared participant demographics using the Mann-Whitney *U* test and Chi-square tests, and captured impact on the outcome variables using a series of ordinal logistic regression models.[3]

2.4. Healthcare

This study outlined a UD assessment tool proposing a new evaluation framework able to assess different buildings' typology, focusing on healthcare facilities.[4] The new hierarchical framework includes three categories of UD qualities (physical-spatial; sensorial-cognitive, and social qualities) with related criteria, indicators, and requirements resulting from multiple methods: a systematic literature review on UD evaluation, workshops with users and experts [5], and analysis of four existing hospital settings. Data were gathered following a multi-criteria analysis approach. The tool has been applied in two hospitals' pilot case studies. The first application (U.S.) allowed testing of the first version of the rating system, which was reviewed by an expert focus group. The second version was validated in a second pilot case study in Milan, Italy. In addition, researchers used a questionnaire in the first hospital to test whether or not the objective evaluation of the proposed tool aligns with the subjective user experiences.

2.5. Summary

The first three methods use qualitative ordinal data to compare one setting to another, while the latter uses a mix of qualitative and quantitative indicators and measurable requirements arranged on a rating system. The statistical analysis models varied amongst the studies. In some cases, the design settings are different facilities with different users. In others, different settings with *some* of the same users are measured. In one case, the same setting was used pre- and post-intervention. In all cases, there was no *direct* relationship between the survey questions and specific Goals of UD or improvement areas, but there was *a* relationship. The tool used in the healthcare setting did establish a framework organizing the design requirements by category, criteria, and indicators, that assesses the quality of buildings in multiple areas, and allowing a mapping to the UD improvement areas and Goals of UD. The studies all account for user familiarity with the settings but not all report on the significance of this.

3. Results

The results indicate that settings using UD concepts are generally equivalent to or rated more favorably than comparison settings as it relates to users' perceptions of usability, satisfaction, safety, comfort, health/well-being, collaboration, interaction, productivity, and convenience, with some notable exceptions.[1-3]

3.1. University Residential Life

The guided tour and online survey both found the UD building rated significantly higher (p=0.05 or better) than the comparison on 86 comparison items (Table 1). The comparison building rated higher on 5 comparison items. There were no significant differences for the remaining 41 comparison items. This supports the hypothesis that the UD building would provide a better user experience than the comparison building.[1]

Table 1. Number of university residential life comparison items with significant differences (p=0.05 or better)

Number of Items	Guided Tour Method	Online Survey Method
Universally Designed Building Rated Higher	56	30
Comparison Building Rated Higher	2	3
No Significant Difference	27	14

Researchers did not conclusively determine if the draft UD standards contributed to the improved experience; however, a preliminary analysis used expert evaluator assessments to identify whether or not a UD feature was present in each building. Researchers calculated an "incorporation rate" based on these assessments, and compared the user ratings to the incorporation rate, finding at least twice as many items with significantly higher user ratings above the incorporation rate as below (Table 2). This may indicate a relationship between number of UD features and positive user ratings.[1]

Table 2. Number of items with significant differences (p=0.05 or better) by presence of UD strategy

Number of Items	Guided Tour Method		Online Survey Method	
Relationship to Mean Incorporation Rate	% Higher	% Lower	% Higher	% Lower
Universally Designed Building Rated Higher	15	7	17	6
Comparison Building Rated Higher	0	0	2	1
No Significant Difference	4	11	4	9

3.2. Workplace

The results indicate employee perceptions of UD outcomes were generally positive at both sites. For many UD outcomes and features, the UD site rated higher (Table 3). However, depending on the area of the building evaluated, sometimes the non-UD site rated higher. No significant differences were found in terms of overall comfort, health/well-being, safety from accidents, and satisfaction. The UD building rated higher in terms of collaboration and interaction, but lower in terms of productivity, likely because this building had more open workspaces and fewer private workspaces. Ultimately, the research showed that a higher UD certification score does not necessarily result in satisfying *all* UD outcomes. It suggests that introducing UD features alone may not offset negative outcomes caused by other design decisions not addressed by UD standards (but perhaps should be) and that user surveys may still be necessary to

determine if UD outcomes have been achieved, rather than presence of UD features alone.[2] It also supports weighing certification scores to give more importance to primary function areas.

Table 3. Number of workplace comparison items with significant differences (p=0.05 or better)

Number of Items per Category	UD Site Rated Higher	Comparison Site Rated Higher	No Significant Difference
Overall UD Outcomes	2	1	4
Workspace UD Outcomes	0	6	1
Workspace Features	4	4	1
Cafeteria UD Outcomes	6	0	1
Cafeteria Features	3	0	2
Interior Circulation UD Outcomes	0	0	4
Interior Circulation Features	3	1	5

3.3. Public Right-of-Way

Post-construction participants reported greater satisfaction than pre-construction, particularly amongst frequent walkers, with pedestrian-level improvements contributing most to this finding, such as sufficient crosswalks, pedestrian signals, and new landscaping. However, reported frequency of walking activity pre- and post-construction was unchanged (Table 4). Perceived safety and convenience of biking and walking remained unchanged (no change to bicycling was expected, as the project did not focus on bicycling). Pedestrians' perceptions of excessive traffic speed increased after the improvements, possibly due to pedestrians being closer to traffic at the new bulb-outs and mid-block crossings, and the unchanged posted speed limit. Future areas of research should include similar studies on highways with additional traffic calming measures such as reduced speed limits, bicycling improvements, and diverting traffic to alternate routes. Another area for future study is the impact complete streets measures may have on highways that are not major arterials (such as smaller, residential streets).[3]

Table 4. Public rights-of-way improvement perceptions listed by significant difference (p=0.05 or better)

Sample	Post-construction Rated Significantly Better	Pre-construction Rated Significantly Better	No Significant Difference
Full sample	Overall satisfaction Enough crosswalks	Exceed Speed Limit	Safety walking Safety biking Convenience walking Convenience biking Traffic supports walking Traffic supports biking
Frequent walkers	Overall satisfaction Convenience walking		Safety walking

3.4. Healthcare

Researchers used the *Design for all A.U.D.I.T.* tool to evaluate two private hospitals, one in Buffalo (U.S.) and one in Milan (Italy).[4] The rating system allowed researchers to analyze spaces in both facilities including: outdoor spaces, entrance, interior circulation, support spaces, core spaces, and overall service; and to analyze UD qualities through the tool's eight criteria: usability, functionality, safety and security, wayfinding, understanding, environmental factors, well-being, and social inclusion.

Regarding the facilities' spaces, horizontal circulation had the best scores in both hospitals (76% Italy, 88% U.S.). Vertical circulation had the lowest score (46%) at the Italian hospital. Outdoor spaces had the lowest score in the U.S. hospital. Regarding UD qualities, the Italian hospital's highest score was in environmental factors (84%) due to sustainable design, while its lowest score was social inclusion (54%). The U.S. hospital scored highest on social inclusion (87%) because it provides diverse services for users. Both hospitals scored low on wayfinding (59% Italy, 39% US) due to layout and signs.

The analysis demonstrates that the tool can evaluate spaces and outcomes along dimensions of health and well-being, comparing different building features. The system can identify critical aspects, suggest design strategies, and define intervention priorities.

3.5. Summary

The results generally support that UD has a favorable effect on many UD outcomes, but is inconclusive on others. However, there are some exceptions where other design objectives outweighed the UD features (e.g. the open-office plan rating lower due to lack of privacy despite other UD features). Additional research is necessary where the effect of UD interventions was inconclusive. Additions or revisions to the *isUD* design criteria and/or program as a whole may be necessary to address areas where outcomes are not achieved and where competing design objectives overshadow potential UD benefits.

4. Conclusion

While studies show that UD is effective at improving human performance, health and wellness, and social participation by some measures, there is still more research necessary to ensure this will be the case for all UD measures. Tools that assist with UD implementation (e.g. *isUD*) can help achieve these outcomes, but these tools may require revision to be more effective as currently used, and to efficiently expand to other sectors. Improvements to the *isUD* tool will help expand availability of UD to a wider and more diverse audience. The following considerations for future research and improvements to the *isUD* program may aid its expansion to other sectors and improve its usability.

The user perceptions collected should be more consistent across studies, and be more consistent with the improvement areas and Goals of UD. Future studies comparing settings should primarily attempt to measure improvements to human performance (i.e. body fit, comfort, awareness, understanding), health and wellness (i.e. wellness), and social participation (i.e. social integration, personalization, and cultural appropriateness). Future studies could further identify a common set of related sub-goals (e.g. safety from accidents as a sub-goal of wellness), and overall measures such as satisfaction. Some of these sub-goals may also change based on the setting (e.g. workplace task performance, healthcare outcomes). In expanding the *isUD* to other sectors, it is likewise important to consider consistency with the Goals of UD while developing the design interventions. The *Design for All A.U.D.I.T. Tool* [4] offers one potential framework: 1) categories relating to the quality of the space (e.g. improvement areas), 2) criteria forming the desired outcomes (e.g. goals), 3) indicators of those outcomes, and 4) specific requirements intended to achieve those outcomes (e.g. UD criteria).

Future studies should clearly define the UD features definitively present in one setting but not the comparison setting, with each intervention paired to specific Goals of UD (e.g. Comfort: Setting A gives users control over temperature and setting B does not,

with users asked to rate level of thermal comfort). This could help enable researchers to determine that a particular Goal of UD was achieved, and could help determine if the UD interventions related to that Goal *may* have been a reason (to be further explored by open-ended responses, quantitative data, and/or analysis of other features). Without this, it is difficult to determine if a specific UD intervention has the intended outcome. The study may contribute to the growing body of evidence that UD *works* in a general sense, but evidence in the specific sense is necessary to improve the *isUD* criteria and better inform the program's expansion.

Participant ratings of the importance of an issue could help improve the *isUD* scoring system, in addition to the criteria. Since user rankings of importance of an issue could change based on the setting, one possible consideration is to consider a different scoring system in different settings, using a similar set of UD criteria (e.g. user control over temperature could be worth more points in a residential setting than restaurant).

Lastly, the infinite number of design interventions that could negate positive UD features raises the question of whether or not a list of specific UD criteria (such as *isUD*) could be sufficient on its own. Is it more appropriate to certify buildings based on whether the outcomes or Goals of UD have been achieved as measured by research? Or, is a combination more appropriate; i.e. a limited set of objectively measurable design interventions coupled with more subjective user experience research? These options may make marketing *isUD* more difficult because building owners and designers could not *guarantee* an outcome until after a building is constructed and occupied, which may make expert UD consultants *necessary* to ensure certification. Future expansions of *isUD* should consider the balance of the number of UD criteria necessary, the necessity of post-occupancy evaluations as part of the certification process, and the impact this has on the usability and marketability of the program as a whole.

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