THE UNIVERSAL DESIGN OF BUILDINGS: AN EMPIRICAL TEST OF THE PRINCIPAL CLAIMED BENEFIT *

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There is an emerging consensus about seven Principles of Universal Design that define universally designed products and environments not only as being (1) equitable in use, (2) flexible in use, (3) simple and intuitive in use, (4) easy to perceive, and (5) tolerant of error, but also as (6) requiring low physical effort and (7) being better sized and arranged to accommodate all users (Connell, et al, 1997)(Danford, 2001)(IDEA Center, 2001).

A principal claimed benefit of designing products and environments following these principles is that they will be more usable for everyone. To test that claim, a research project was initiated to examine people's experiences with universal design through a case study of a universally designed building currently in use.

The Ideals of Universal Design

Universal design is an approach to the development of "products and environments that can be used effectively by all people, to the greatest extent possible, without the need for adaptation or specialized design" (North Carolina State University, 1997). Its goal is designs that can approach two ideals: "universal usability" (i.e., designs that are usable by everyone) and "equal usability" (i.e., designs that do not privilege one person/group over another).

Because that goal is unattainable in any "absolute" sense, universal design can be more accurately characterized as a continuous, iterative process that approaches those ideals asymptotically. And the reason is simple: with each iteration, with each lesson learned, and with each success achieved, the inclusive aspirations underlying universal design's ideals grow higher.

Objective and Hypotheses

The objective of this research project was to examine and document the ability of universal design to produce a building that is indeed usable by all people. Toward that end, three hypotheses about this claimed benefit of universal design were tested:

1. Compared to people without impairments, people with impairments will consider most other buildings they have experienced (i.e., non-universally designed buildings) to be less usable;
2. Both people with impairments and people without impairments will perceive a universally designed building to be more usable than most other buildings they have experienced (i.e., non-universally designed buildings); and
3. People with impairments will experience the same usability as people without impairments in a universally designed building.

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Research Design

This project examined the extent to which the principal claimed benefit of universal design is actually realized through a case study of Lighthouse International's New York City headquarters building by Mitchell/Giurgola Architects. Lighthouse International is an organization that primarily serves people with vision impairments. Its headquarters building was selected because it was one of the first buildings explicitly designed to embrace the concept of universal design.

The case study utilized a multi-method combination of recorded behavior observations and follow-up interviews. The case study examined subjects' "general attitudes" about the typical usability of most other buildings (i.e., non-universally designed buildings) as well as their on-site "environmental perceptions" and "functional performance" as indicators of the case study building's relative and actual usability respectively.

Subjects

Twenty-four adults with single impairments (i.e., eight with mobility impairments, eight with hearing impairments and eight with vision impairments) and eight adults without impairments - none of whom were users of the case study building - were recruited as subjects. The four groups of eight were matched to ensure their general equivalence (i.e., equal numbers of males and females, all of whom were adults 21-65 years old, capable of self-directed functional independence, English speaking U.S. Citizens, etc.) with the exception of their impairments. All subjects were paid $50 to compensate them for their participation in the research project.

Data Collection Procedures

The subjects were first greeted and provided an innocuous scripted overview of the study (which only revealed that they would be asked a few questions after performing specified tasks at a local building) after which informed consent was obtained. Subjects were then individually escorted into and through the case study building by one member of the on-site research team who functioned as a tour guide (and provided assistance when requested/required) while a second member recorded the tours on a digital video camera. The guided tour typically took 30-45 minutes.

The resulting videotaped record captured the subjects' observable behaviors during and verbal responses to subsequent questions about a scripted sequence of fourteen person-environment transactions in the presence of nominal universal designed features in the public areas of the building:

1. Transaction: Locating the building
   Feature: Multi-sensory landmark
2. Transaction: Finding the entrance
   Feature: Talking signs system
3. Transaction: Entering the building
   Feature: Automatic door with motion detection activator
4. Transaction: Getting to the information desk 1
   Feature: High-contrast carpet runner

5. Transaction: Locating the elevator
   Feature: Multi-sensory map
6. Transaction: Calling an elevator
   Feature: Large high-contrast elevator call buttons
7. Transaction: Getting to another floor
   Feature: Dual-level elevator control panels
8. Transaction: Getting to a public restroom
   Feature: Talking signs system
9. Transaction: Getting a drink of water
   Feature: Dual-level water fountain
10. Transaction: Getting to the information desk 2
    Feature: High-contrast carpet runner
11. Transaction: Locating a public telephone
    Feature: Multi-sensory map
12. Transaction: Identifying the top step of a staircase
    Feature: Wall-mounted proximity indicator
13. Transaction: Using public seating area
    Feature: Open bench with high-contrast perimeter markers
14. Transaction: Exiting the building
    Feature: Automatic door with motion detection activator

Procedurally, the tour guide always employed scripted instructions designed to ensure each subject's awareness of the universal design feature's availability. However, there was purposely nothing in those instructions that would predispose the subject to view the design feature favorably/unfavorably or require the subject to use the design feature.

For example, for the transaction "identifying the top step of a staircase," each subject was instructed: "Next, I want you to identify the top step of the staircase. There is horizontal molding on the wall to your right. Along the rounded bottom edge of that molding there are notches at the end near the top step. Let me know when you identify the top step."

"Environmental Perceptions" as Indicators of a Building's Relative Usability

Immediately after a subject completed a transaction, the guide paused the tour to ask the subject eight follow-up questions while the second research team member continued videotaping the question/answer process.

The tour guide began by asking four "environmental perceptions" questions delivered verbally to all subjects (as well as by sign language to the subjects with hearing impairments who required an interpreter) that were simplified derivatives of a previously developed Environmental Utility Measure. That measure, developed through previous funding provided by the U.S. Department of Education's National Institute on Disability and Rehabilitation Research, includes two conventional seven-point bi-polar rating scales (scale values ranging from -3 to +3) called the Difficulty Rating Scale and Acceptability Rating Scale that are each presented in both verbal and printed forms in two steps (Danford & Steinfeld, 1999)(Steinfeld & Danford, 2000).

For example, the original Difficulty Rating Scale first asks the subject whether the transaction is "easy," "difficulty" or "moderate." After the subject makes the initial choice between these three anchor points (e.g., "easy"), the Difficulty Rating Scale then asks the subject to chose between the three closest points on the seven-point scale that pertain to that initial choice (e.g., “very easy” which is rated +3, “moderately easy” which is rated +2, or “barely easy” which is rated +1).

For this study only the first step of both the Difficulty Rating Scale and Acceptability Rating Scale was employed and the derivative language used to present the three anchor point choices for both scales was provided only verbally since not all subjects would have been able to see it in a printed form:

1. “Compared to your typical experiences (*insert transaction*) in most buildings, was your experience (*insert transaction*) in this building ‘easier,’ ‘more difficult’ or ‘somewhere in between’?”
2. “Why?”
3. “You said (*insert answer to question #1*). Would you consider that ‘acceptable,’ ‘unacceptable’ or ‘somewhere in between’?”
4. “Why?”

The subjects’ anchor point choices were rated +1 for “easier” and “acceptable” answers, -1 for “more difficulty” and “unacceptable” answers, and 0 for “somewhere in between” answers.

"General Attitudes" About the Non-Universally Designed Building's Typical Usability

Immediately after asking the four “environmental perceptions” questions about the relative usability of the universally designed building, the tour guide asked each subject a second set of four questions probing their “general attitudes” about the typical usability of “most other buildings” (i.e., non-universally designed buildings) while the second research team member continued videotaping the question/answer process. This made it possible not only to discern attitudinal differences between people with impairments and people without impairment but also to ascertain their general attitudes about the usability of non-universally designed buildings.

Posing questions that were, again, drawn from simplified derivatives of the aforementioned Environmental Utility Measure’s two ratings scales, the tour guide asked:

1. “About your experiences (*insert transaction*) in most buildings, are they typically ‘easy,’ ‘difficult’ or ‘somewhere in between’?”
2. “Why?”
3. “You said (*insert answer to question #1*). Would you consider that ‘acceptable,’ ‘unacceptable’ or ‘somewhere in between’?”
4. “Why?”

The subjects’ anchor point choices were rated +1 for “easy” and “acceptable” answers, -1 for “difficult” and “unacceptable” answers, and 0 for “somewhere in between” answers.

"Functional Performance" as Indicators of the Case Study Building’s Observed Usability

The videotaped record of each subject's guided tour was sent to an off-site research team for data retrieval and analysis. After retrieval of each subject’s answers to the tour guide’s “environmental perceptions” and “general attitudes” questions, two off-site research team members independently examined each subject’s observable behaviors.

Each of the fourteen scripted person-environment transactions in the case study building was scored on the subject's “effort expended” and “assistance received” as indicators of the case study building’s experienced usability employing simplified derivatives of a previously developed Functional Performance Measure. That measure, also developed through previous funding provided by the U.S. Department of Education's National Institute on Disability and Rehabilitation Research, includes two uni-polar eight-point scales called the Level of Effort Scale and the Level of Assistance Scale (Danford & Steinfeld, 1999)(Steinfeld & Danford, 2000). For this study, only five/six of the original eight points on the Level of Effort Scale and Level of Assistance Scale, respectively, were applicable.

The Level of Effort Scale scores were determined by (1) whether the opportunity to perform the transaction was accepted and, if so, (2) the length of time taken to perform the transaction, (2) the frequency of any complaint (e.g., verbal or non-verbal expression of frustration, aggravation, inconvenience or anxiety), (3) the frequency of any interruption in continuity while performing the transaction (e.g., hesitation or starting over), and (4) whether the transaction was completed. The assigned Level of Effort scores ranged from *minimum = 1, moderate = 2, maximum = 3, impossible = 4, to declined = 5.*

The Level of Assistance scores were determined by (1) whether assistance performing the transaction was requested or received, (2) whether the opportunity to provide assistance was accepted and, if so, (3) whether the assistance received constituted direct performance of the transaction, facilitated performance of the transaction, or was merely incidental to performance of the transaction, and (4) whether the assisted transaction was completed. The assigned Level of Assistance scores ranged from *none = 0, minimum = 1, moderate = 2, maximum = 3, impossible = 4, to declined = 5.*

These two derivative scales made it possible to determine the level of usability actually experienced both for people with impairments and for people without impairments (e.g., the highest level of usability being defined by minimum effort expended and no assistance received).

Results for Hypothesis 1 - Compared to people without impairments, people with impairments will consider most other buildings they have experienced to be less usable

Hypothesis 1 was tested by the "general attitudes" data from the derivative Environmental Utility Measure's "typical difficulty" and "acceptability" ratings for "most other buildings."

Compared to the subjects without impairments, two of the three groups of subjects with impairments (i.e., subjects with vision impairments and subjects with mobility impairments) clearly rated most other buildings (i.e., non-universally designed buildings) as being more difficult and less acceptable for performing the fourteen transactions (see Figures 1 & 2). However, the differences in "general attitudes" between several of the groups of subjects were pronounced.

The subjects without impairments rated only three of the fourteen transactions in most other buildings as being difficult (operationally defined as mean < -.2) (i.e., "getting to a public restroom," "getting a drink of water" and "locating a public telephone" and none as being unacceptable (operationally defined as mean < -.2).

The subjects with hearing impairments rated only four of the fourteen transactions in most other buildings as being difficult (i.e., "getting a drink of water," "locating a public telephone," "identifying the top step of a staircase," and "using the public seating area") and, again, none as being unacceptable.

The subjects with mobility impairments, on the other hand, rated six of the fourteen transactions in most other buildings as being difficult (i.e., "finding the entrance," "entering the building," "getting to a public restroom," "getting a drink of water," "locating a public telephone," and "exiting the building") and six as being unacceptable (i.e., "entering the

Figure 1 - Groups' "general attitudes" mean difficulty ratings for "most other buildings"

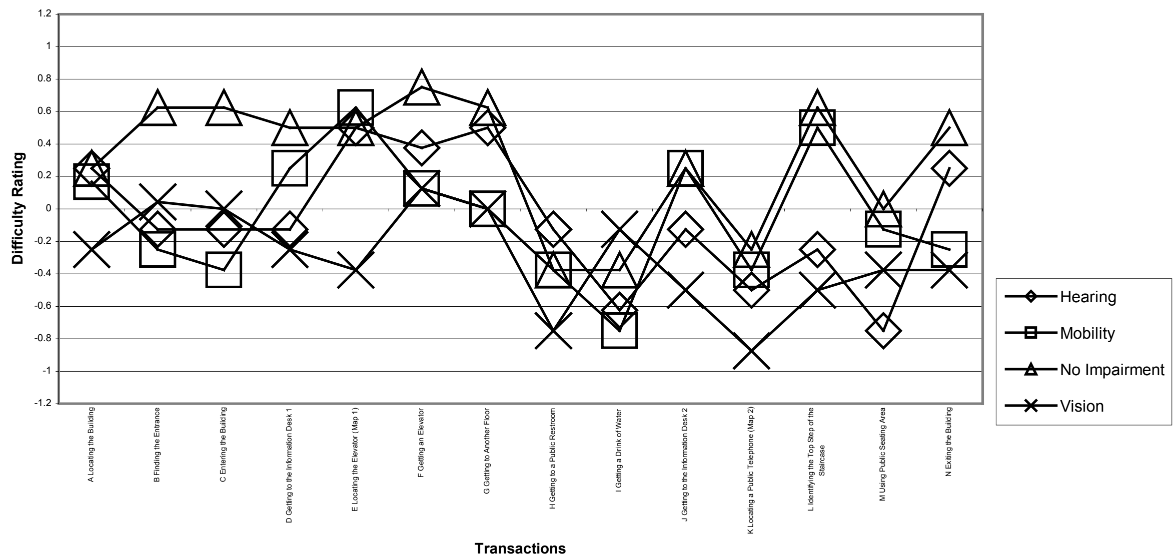
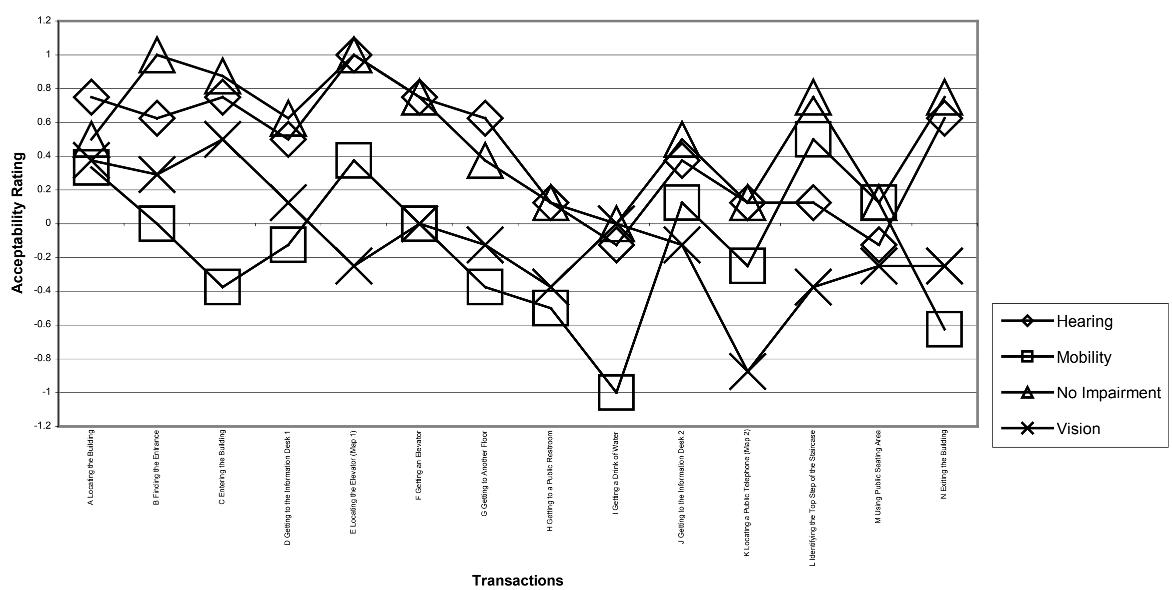


Figure 2 - Groups' "general attitude" mean acceptability ratings for "most other buildings"



building," "getting to another floor," "getting to a public restroom," "getting a drink of water," "locating a public telephone," and "exiting the building").

And the subjects with vision impairments rated nine of the fourteen transactions in most other buildings as being difficult (i.e., "locating the building," "getting to the information desk 1," "locating the elevator," "getting to a public restroom," "getting to the information desk 2," "locating a public telephone," "identifying the top step of the staircase," "using the public seating area," and "exiting the building") and six as being unacceptable (i.e., "locating the elevator," "getting to a public restroom," "locating a public telephone," "identifying the top step of the staircase," "using the public seating area," "exiting the building").

The fact that these "general attitudes" were obtained immediately after the subject had performed each transaction in the universally design building may have made the ratings for performing the same transaction in "most other buildings" more negative across all groups of subjects than otherwise would have been the case (i.e., the rated difficulty and acceptability of performing these transactions in most other buildings generally compared unfavorably to the case study building). This effect may have been even more pronounced for the subjects with mobility impairments and vision impairments since the case study building's design features was so conspicuously designed to be accessible to people with mobility impairments and inclusive of people with vision impairments.

That the "general attitudes" about "most other buildings" of the subjects with hearing impairments were nearly indistinguishable from the attitudes of the subjects without impairments is not really all that surprising. Even ADA-compliant buildings make relatively few accommodations for people with hearing impairments compared to those made for people with mobility impairments and for people with vision impairments, for example. And even the three or four transactions that the subjects without impairments and the subjects with vision impairments rated, respectively, as difficult might not have been rated that negatively had those subjects not just had such generally "easy" experiences with those same transactions in the case study building.

The more negative "general attitudes" about "most other buildings" of the subjects with mobility impairments and the subjects with vision impairments are also not particularly surprising. Even more than a decade after passage of the ADA, "most other buildings" today are still not fully accessible to people with mobility impairments and people with vision impairments. And, again, the fact that these subjects had just experienced those same transactions in the case study building that so obviously went well beyond the ADA's minimum requirements to promote their inclusion had to make "most other buildings" suffer by comparison – particularly for the subjects with vision impairments.

Results for Hypothesis 2 - Both people with impairments and people without impairments will perceive a universally designed building to be more usable than most other buildings they have experienced

Hypothesis 2 was tested by the "environmental perceptions" data from the derivative Environmental Utility Measure's "relative difficulty" and "acceptability" ratings for the case study building.

All four groups of subjects overwhelmingly perceived the case study building to be more usable than "most other buildings" for performing the fourteen transactions (see Figures 3 & 4).

Figure 3 - Groups' "environmental perception" mean difficulty ratings for the case study building

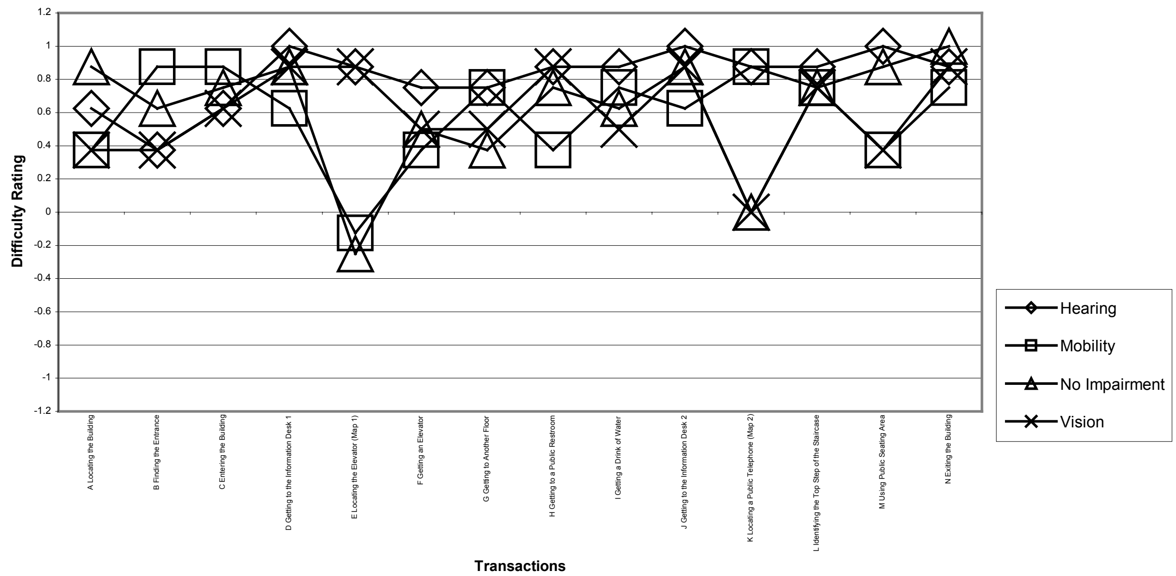
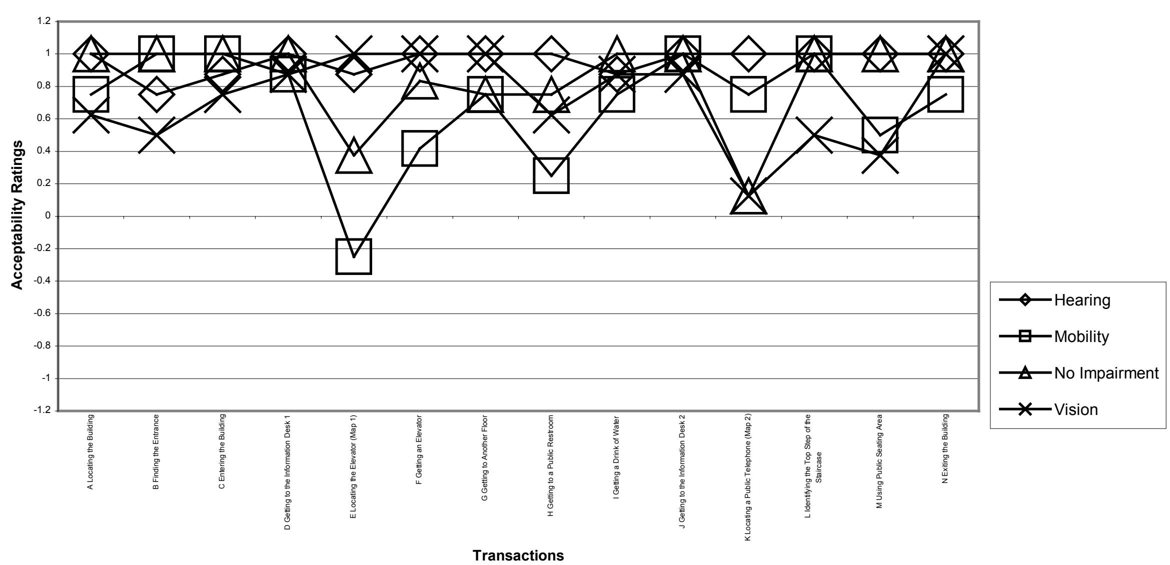


Figure 4 - Groups' "environmental perception" mean acceptability ratings for the case study building



The subjects with hearing impairments rated all fourteen of the transactions as being both easier (operationally defined as mean > +.2) and acceptable (operationally defined as mean > +.2) in the case study building.

The subjects with mobility impairments and the subjects with vision impairments both rated thirteen of the fourteen transactions as being both easier (i.e., "locating the elevator" excepted for subjects with mobility impairments; "locating a public telephone" excepted for subjects with vision impairments) and acceptable (i.e., "locating the elevator" excepted for subjects with mobility impairments; "locating a public telephone" excepted for subjects with vision impairments).

Even the subjects without impairments rated twelve of the fourteen transactions as being easier (i.e., "locating the elevator" and "locating the telephone" excepted) and thirteen as being acceptable (i.e., "locating a public telephone" excepted).

The considerable effort that had been made to design the case study building so that it would promote inclusion was not lost on these subjects. Even in the face of the few transactions that were not rated "easier," all four groups of subjects were effusive in their praise of this building.

The fact that a few transactions were singled out by three of the four groups of subjects for criticism (i.e., not rated "easier" and/or not rated "acceptable") actually provides reassurance that these incredibly positive ratings were not just reflective of some "halo effect" attributable to an overall appreciation for the building.

Overall, it is clear that performing these fourteen person-environment transactions was widely perceived to be both easier and acceptable in the case study building.

Results for Hypothesis 3 – People with impairments will experience the same usability as people without impairments in a universally designed building

Hypothesis 3 was tested by the "functional performance" data from the derivative Functional Performance Measure's "observed effort" and "observed assistance" scores for the case study building.

Had the case study building "perfectly" achieved the theoretical ideals of both "universal usability" and "equal usability," all the Level of Effort scores for all four groups of subjects would have been 1.0 (i.e., minimum effort expended) and all the Level of Assistance scores would have been 0.0 (i.e., no assistance received). Of course no building's design, universal or otherwise, is ever "perfect." Still, the mean Level of Effort and Level of Assistance scores for all four groups of subjects' fourteen transactions hovered near those ideal numbers with only a few notable exceptions (see Figures 5 & 6).

The subjects with no impairments who would normally rely more on traditional directional signage to locate features like the elevator and public telephones were frustrated by its conspicuous absence in the case study building and proved to be predictably inexperienced in the use of the multi-sensory map as an alternative way-finding device. Still, they managed to locate the elevator (that was not visible from the map location) with only a little more than minimum effort expended and to locate the public telephone (that was visible from the map location) with only minimum effort expended.

The subjects with the mobility impairments were affected similarly to the subjects with no impairments when forced to rely solely on the multi-sensory map to locate the elevator (i.e., only a little more than minimum effort expended) and also had no problem locating the public telephone (i.e., only minimum effort expended).

Figure 5 - Groups' "functional performance" mean level of effort scores for the case study building

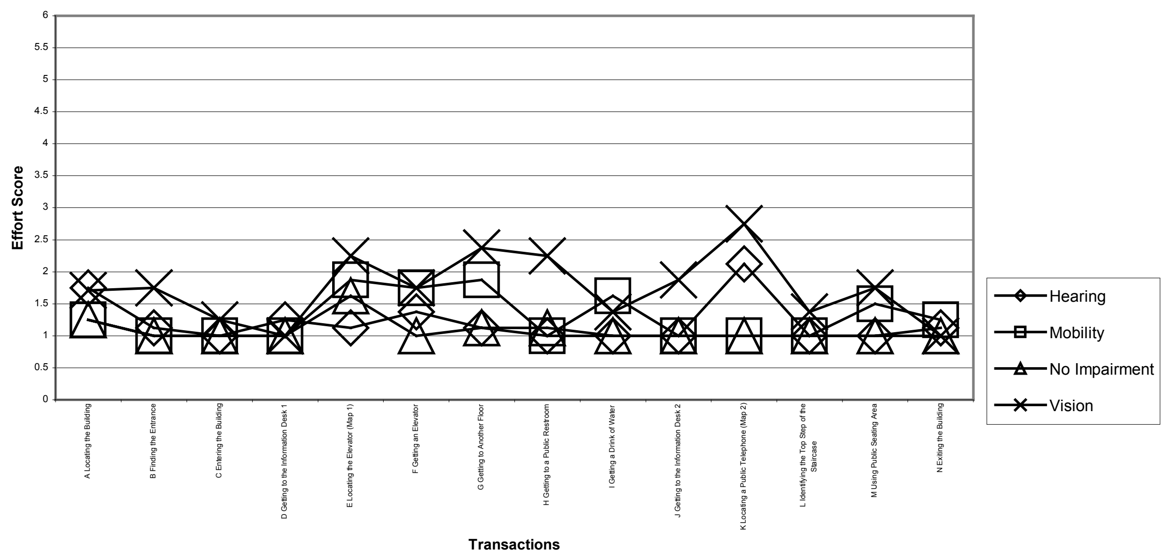
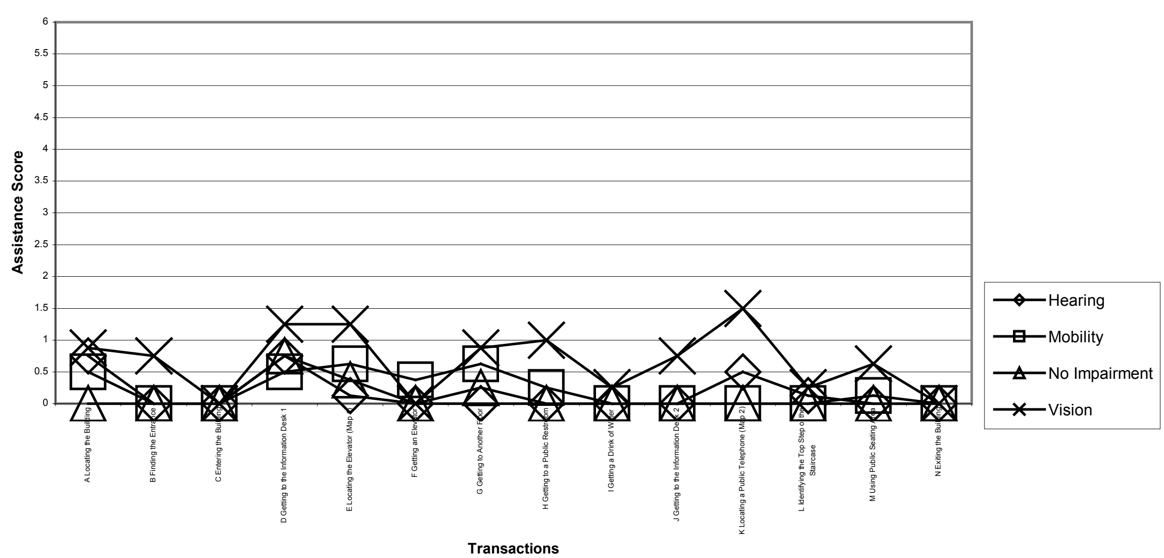


Figure 6 - Groups' "functional performance" mean level of assistance scores for the case study building



The subjects with vision impairments were understandably affected when they discovered that the multi-sensory map was inadvertently missing Braille to denote the public telephone that they were required to locate. That oversight translated into these subjects' highest mean "effort" and "assistance" scores for any of the fourteen transactions (i.e., effort expended being midway between "moderate" and "maximum"; assistance received being midway between "minimum" and "moderate"). They also expended more than minimum effort for several transactions where technical design execution problems with the talking signs system proved problematic (e.g., the variable positioning of the sensor that the hand-held receiver had to be pointed toward precisely affected their "finding the entrance," and "getting to a public restroom" transactions) and where the high contrast carpet runners misled them (e.g., the carpet runners' leading "past" rather than "to" the information desk affected both their "getting to the information desk" transactions).

Compared to the other groups of subjects, these subjects with vision impairments also tended to expend slightly higher than minimum levels of effort and/or receive slightly higher than no assistance across several of the remaining transactions. This appeared to be attributable to a combination of their inexperience with the novel designs of several of the universal design building features in the case study building (e.g., the oversized and unconventionally shaped elevator call buttons made them difficult to recognize as devices for "getting an elevator") combined with "oversights" in the designs of other building features (e.g., positioning a support column so it presented an obstruction in the middle of the public seating area).

However even in the face of these obstacles, the subjects with vision impairments required, on average, only marginally higher levels of effort and assistance to perform most transactions and, it must be noted, still considered all but one of these transactions (i.e., "locating the public telephone" without benefit of Braille on the multi-sensory map) to be both "easier" than in most other buildings and "acceptable" (see Results of Hypothesis 2 above).

Discussion

This research study sought to verify the ability of universal design to produce a building that was usable for everyone ("everyone" operationally defined in this study to be the aforementioned four groups of subjects). Given that universal design's goal is, being realistic, the achievement of "unattainable" absolute ideals (i.e., "universal usability" and "equal usability"), this study's data provide remarkably strong support for its three hypotheses.

Compared to subjects without impairments, two of the three groups of subjects with impairments (i.e., subjects with vision impairments and subjects with mobility impairments) clearly considered most other buildings they had experienced (i.e., non-universally designed buildings) to be far less usable for performing these fourteen transactions. Obviously, non-universally designed buildings still present a significant "usability gap" and continue to discriminate differentially against people with certain impairments.

On the other hand, the subjects with impairments as well as the subjects without impairments all perceived the universally designed building to be far more usable than most other buildings they had experienced (i.e., non-universally designed buildings). As they address the three hypotheses, the study's data were the strongest on this point.

And while all three groups of subjects with impairments did not uniformly experience precisely the same (i.e., equal) usability in this universally designed building as did the subjects without impairments, the additional effort required and assistance received to enable selected subjects to perform certain of the fourteen transactions was remarkably small – certainly smaller that the differences in usability that could be inferred from the “general attitude” “typical difficulty” and “acceptability” ratings that at least the subjects with vision impairments and the subjects with mobility impairments assigned to “most other buildings.”

Finally, in some ways this study presented a particularly stringent test of the relative usability of the case study building. After all, these subjects all had to perform the fourteen transactions in a novel building with which they had no prior experience – heightening the necessity for this building’s design features to be simpler to use and more intuitively obvious than would normally be the case.

Conclusion

On balance, Lighthouse International’s New York City headquarters came surprisingly close to both “absolute” ideals of universal design – i.e., “universal usability” and “equal usability.” And with only minor corrections to a relatively few design features, this building would have come even closer to achieving those “unattainable” ideals.

Certainly there are obvious “oversights” and technical design execution problems in the design of this building that compromised its ability to come even closer to perfect “universal usability” and, especially, perfect “equal usability” for the subjects in this study. Although describing all the “best” or, more theoretically correctly, “better” universal design implications of this research study’s data is outside the scope of this paper, some implications are so transparent that they virtually speak for themselves.

The absence of directional signage in a building will differentially affect people without impairments who more typically rely on it for way-finding information. Multi-sensory maps that lack Braille for identifying all key building features will differentially affect people with vision impairments who often rely on it for location information. The absence of visual information displays on hand-held receivers for talking signs systems will still differentially affect people with hearing impairments even if the problems with the variable positioning of its sensors were resolved. This study’s data provide literally dozens of implications for the design of building features that will be more usable by everyone … far more than can even be mentioned here.

So, even though the case study building did not “perfectly” achieve the theoretical ideal of “equal usability,” it did come surprisingly close to being “universally usable” for this study’s four groups of subjects. Given universal design’s inherent nature as a continuous, iterative process that is always approaching those ideals asymptotically, these data are hardly discouraging.

A building that’s design predates the formal publication of the defining principles of universal design by half a decade (1) was overwhelmingly perceived by all four groups of subjects to be more usable for performing fourteen person-environment transactions than most other buildings and (2) required only marginally higher expended effort and/or received assistance to enable particular subjects to perform certain of the fourteen transactions. These data are not only very supportive of the claimed that universal design can produce designs that can be more usable for everyone but also enormously encouraging for universal design’s continued iterative development.

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