RESEARCH REPORT

QUANTIFYING UNIVERSAL DESIGN: A PROGRAM FOR IMPLEMENTATION

EXTERNAL RESEARCH PROGRAM

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Quantifying Universal Design:
A program for implementation

A report of a workshop
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Table of Contents

Executive Summary

Quantifying Universal Design was a research project to identify methods to acquire the pragmatic information needed to further the principles of Universal Design. These principles of flexibility, ease of use, etc. were again validated with some modifications. As seen in previous research, the concepts inherent in Universal Design are seen as critical, appropriate and useful to create more inclusive environments.

The literature review (Appendix C. Discussion Paper) found that most of the current dimensional information fails to meet criteria developed from a Universal Design perspective. In particular, people with disabilities, people 65 years and older, children, and pregnant women were under-represented in the samples and in the types of dimensional information available. As well, the information that was available was usually presented as separate from the 'general population' rather than integrated into inclusive databases.

The methodology for this project featured a literature search, the preparation of a Discussion Paper, and a meeting with people with diverse expertise discussing questions related to develop methods for collecting and organizing information to promote Universal Design (Appendix B. National Team). The Discussion Paper was used as background information for the meeting.

<u>The National Team Meeting</u>
The dialogue began by clarifying the need to have dimensional information framed as a sub-set to principles and inclusive outcomes. The definition of Universal Design should now read, 'an underlying principle to create responsive, sustainable, and useable environments for the widest possible range of the population throughout the life cycle.'

As a result of the discussion the characteristics of Universal Design or, what may be understood as good design, were modified to include:

- Flexible
  - Modifiable
  - Tasks can be completed in a number of ways
- Sensitive to social, cultural, and geographic environments
- Sustainable
  - Maintainable
  - Endurable
  - Resource sensitive
- Responsible
  - Valuable
  - Accountable
  - Ethical
  - Consultative
- Comfortable to access and to use
  - Uncomplicated
  - Understandable
  - Reasonable physical effort
  - Sufficient space
- Safe
- Marketable
  - Available
  - Affordable
  - Quality
  - Aesthetic

<u>Highlights of the agenda were:</u>

Question 1: Who is the Sample?

- Those most frequently missed or excluded should become the focus for any new information gathering. The Health and Activity Limitation Survey, 1991, should be used to determine the sample composition (updated when new statistical information is available).

Question 2: What do we measure?

- It is imperative to begin defining and measuring outcomes and characteristics of Universal Design, then identify the dimensional information needed to support those desired outcomes.

Question 3: How do we measure?

- Measurements should be both functional and situational and likewise both objective and subjective. Accuracy in method, equipment, and training is needed to develop standardized and credible information. Measurements and processes to collect information evaluating how effectively environments meet Universal Design characteristics must also be developed.

Question 4: How should the information be organized and disseminated?

- The information should describe a process demonstrating the relationship between goals, characteristics of Universal Design, human factors and functioning. This information should be organized in multi-media formats applicable to various target users.

Question 5: Resources

- While applicable to a number of fields and generating demonstrated enthusiasm there does not appear to be any one source for leadership or funding.

<u>Conclusion</u>

As a result of the information gathered, we conclude that a fruitful future direction would be to convene a **Consensus Conference**. The purpose of the Consensus Conference would be to identify the necessary leadership and resources to implement the results of this project.

RÉSUMÉ

L'étude intitulée ***Quantifying Universal Design*** visait à trouver des façons d'acquérir les données pragmatiques requises pour promouvoir les principes de la conception universelle. Ces principes de flexibilité, de facilité d'utilisation, etc. ont encore été validés moyennant quelques modifications. Comme l'ont montré des recherches précédentes, les concepts inhérents à la conception universelle sont considérés comme essentiels, appropriés et utiles pour créer des espaces inclusifs.

La recherche documentaire (annexe C, document de discussion) a permis de constater que la plupart des données dimensionnelles actuelles ne respectent pas les critères élaborés dans l'optique d'une conception universelle. Plus particulièrement, les personnes handicapées, les personnes âgées de 65 ans et plus, les enfants et les femmes enceintes étaient sous-représentés dans les échantillons et dans les types de données dimensionnelles disponibles. En outre, l'information dont on pouvait disposer était souvent présentée en dehors des données touchant la « population générale » plutôt que d'être intégrées à des bases de données complètes.

Cette étude comportait une recherche documentaire, la rédaction d'un document de discussion ainsi qu'une rencontre avec des personnes de divers champs de compétence dans le but d'élaborer des méthodes de collecte et d'organisation de l'information afin de promouvoir la conception universelle (annexe B - équipe nationale). Le document de discussion a servi de base à la rencontre.

<u>La réunion de l'équipe nationale</u>
On a amorcé le dialogue en clarifiant la nécessité de disposer de données dimensionnelles définies comme un sous-ensemble de principes et de résultats inclusifs. La définition de l'accessibilité universelle devrait maintenant se lire comme suit : principe sous-jacent visant à créer des milieux souples, durables et utilisables pour la plus grande diversité de gens possible tout au long du cycle de vie.

À la suite des discussions, on a modifié les caractéristiques de la conception universelle, ou ce qu'on pourrait appeler une bonne conception, afin d'inclure les éléments suivants :

- Souplesse
  - Modifiable
  - Les tâches peuvent être exécutées de diverses façons
- Sensibilité aux milieux sociaux, culturels et géographiques
- Durabilité
  - Soutenable
  - Supportable
  - Sensible aux ressources

Responsabilité
- Valable
- Redevable
- Éthique
- Consultatif

Facilité d'accès et d'utilisation
- Simple
- Compréhensible
- Exigeant un effort physique raisonnable
- Espace suffisant

Sûreté

Possibilité de commercialisation
- Disponible
- Abordable
- De qualité
- Esthétique

Points saillants de l'ordre du jour :

Question 1 : Qui compose l'échantillon?

- Les personnes qui sont le plus souvent oubliées ou exclues devraient obtenir toute l'attention lors de la collecte de toute nouvelle donnée. L'Enquête sur la santé et les limitations d'activités menée en 1991 devrait être utilisée pour déterminer la composition de l'échantillon (qui serait mis à jour dès que de nouvelles données statistiques seraient disponibles).

Question 2 : Que doit-on mesurer?

Il est impératif de commencer à définir et à mesurer les résultats et les caractéristiques de la conception universelle, puis de déterminer les données dimensionnelles requises pour appuyer les résultats escomptés.

Question 3 : Comment procède-t-on aux mesures?

Les mesures doivent être fonctionnelles et situationnelles ainsi qu'objectives et subjectives. La méthode, l'équipement et la formation devront être précis pour que les données recueillies soient normalisées et crédibles. Il faudra également élaborer les mesures et les processus qui serviront à obtenir l'information permettant d'évaluer si les milieux respectent efficacement les caractéristiques de la conception universelle.

Question 4 : Comment faudra-t-il organiser et diffuser l'information?

L'information devrait décrire un processus démontrant le lien existant entre les objectifs, les caractéristiques de la conception universelle, les facteurs humains et le fonctionnement. Cette information devrait être organisée dans des formats multimédias applicables aux différents utilisateurs cibles.

Question 5 : Ressources

Bien que pouvant s'appliquer à un certain nombre de secteurs et susciter un enthousiasme certain, il ne semble pas exister de source unique de leadership ou de financement.

Conclusion

L'information recueillie nous permet de conclure qu'il faudrait organiser une **conférence de concertation** pour bien orienter notre action. Cette conférence aurait pour but de trouver les leaders et les ressources nécessaires à la mise en œuvre des résultats de cette étude.

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Section One: Introduction

This project initially centered on the need for dimensional information, not currently available, for implementing Universal Design. As that question was being addressed, the National Team (see Appendix B) raised another over-riding issue. They felt Universal Design will not become more common by providing just dimensional information without a clear value base and without appropriate models. Data can be misleading and may even be harmful unless guided by principles of responsible design. The participants concurred with our original assumption that Universal Design, as a concept and as a process, provides such a safeguard.

The methodology of this project was successful in creating a climate to maximize idea generation and analysis. The process of bringing expertise from diverse fields together resulted in lively debate and an exchange of ideas leading to inventive and practical conclusions. As a result, the original set of assumptions were challenged and altered as influenced by the data collected in the session.

This report includes a summary of the meeting discussions with a description of a proposed methodology, discussion of resources needed to implement such research projects, and the organization of a database. In the Appendices there are a glossary, the background discussion paper with a literature review synthesis, and the list of consultants.

Background

While Universal Design (and the other designations for a comprehensive approach to design) is gaining acceptance, it remains a term defined through concepts. It was assumed that to become more practical for designing and constructing environments, the concept must be clearly described and eventually detailed through actual dimensions.

A strength of Universal Design is that it is predicated on accommodating a population with a range of functioning or capabilities. This view of a population as a continuum of functioning can be cumbersome and complicated for practical application. Traditionally, we have designed for ‘averages’ or some random or specific percentiles of the population. As a result dimensional requirements have

been collected and presented to support that 'average' or some specific target group, but may misinform the process of implementing Universal Design. To rectify this problem it was proposed that separate, Universal Design dimensional requirements are needed.

"If you want designers to design for everyone, then it is incumbent to ensure that data on everyone are available in the same place and in the same way" (Connell & Sanford, 1999).

The extensive literature review (Appendix C. Discussion Paper) highlighted that some important basic dimensional information is missing, such as;

- Off the shelf information lacks accurate (and in some cases, any) comprehensive and inclusive information on the range of human variables in our population.
- Most guidelines are based on either dimensions from a barrier-free approach, which details a mythical person in a wheelchair, or dimensions that exclude any information on persons with disabilities.
- The people measured for the existing information represent a small and exclusive group.
- The tasks measured do not necessarily represent real life situations.
- The dimensional requirements for some marginalized groups are separated from those for 'normal' or 'healthy' groups making designing for the range of capabilities difficult to impossible

In addition, we noted that there was a lack of standardization of terms, measurement methods, and tools.

Research Assumptions

This project began with some basic research assumptions about the human condition and the environment that surrounds us:

It is given that:

- People at the extreme ends of society have inequitable treatment in the design of physical space, and in shaping social attitudes and public policies

- As a result of continuing inequities, we feel there are limits to the usefulness of disability specific solutions such as barrier-free design, a disability lens, or other group specific approaches
- Universal Design offers an effective response to inequities in designs and environments
- All human capabilities fit into a range of functioning
- The environment includes those spaces that surround us, built forms, programs (recreational, educational), social aspects (employment, citizenship) and attitudes
- This environmental context is an essential element in enabling/disabling participation and equity

Working Hypothesis

Current dimensional information is not compatible with Universal Design concepts and to facilitate the implementation of Universal Design this must be rectified. It was expected that just randomly collecting more numbers, extrapolating current data, or using a larger sample would not remedy the present problem of inadequate dimensional information.

A comprehensive and accurate database is needed by a broad array of professionals, consumers, and other stakeholders. To get such data we must first have a systematic methodology based on Universal Design principles. This methodology would be crucial to moving to the next steps of quantifying and implementing Universal Design.

Section Two: Process

The purpose of this project was to develop a method for collecting and organizing information to implement and promote Universal Design. The project used the word 'design' broadly to include a variety of applications beyond the built environment, such as landscapes, programs, and policies. As such it was important to gather information from consultants from a number of fields and perspectives. A thorough literature review was synthesized into a discussion paper (see Appendix C) for background on the issues to be addressed.

Consultants from across Canada formed the National Team. They met over a day and a half. After the meeting the organizers analyzed and synthesized the information collected. From this, a draft document was produced and sent to the National Team for feedback. Following that, the final document was completed.

The National Team

Experts from a number of fields were organized as a National Team (see Appendix B) and agreed to participate in this project. Funding was secured to bring this group together to discuss and exchange ideas. The meeting was held in October 2001 at Winnipeg, Manitoba.

The National Team represented a cross section of people from a wide variety of fields but with a mutual interest in Universal Design. Some of the fields include:

- Advocacy for people with disabilities
- Rehabilitation
- Professional design: Architecture, Interior Design
- Government: Health and Social Services
- Urban planning
- Gerontology

A month before the meeting the participants received the Discussion Paper (Appendix C) which outlined the agenda. The Discussion Paper provided the Team with background on the following questions, which were used as the agenda for the meeting:

- What defines the range of the population? What are the implications for selecting a sample group?
- What are the parameters for testing functionality?
- What methodology will produce an appropriate database?
- How should this database be organized?
- What resources would be required to implement such a project? Which of these resources are available?

Results of the National Team Meeting

Overview

The participants stated the strength and value of Universal Design is specifically that it is a concept and a process. There are defined principles that can be used as goals and as markers to evaluate the appropriateness of designs. These principles could then be used as standards to evaluate whether a design is a 'reasonable accommodation.'

There were some misgivings about the focus of this study, i.e. looking at collecting more dimensional information, whether reflecting Universal Design or not. Numbers or dimensions are available now, but environments continue to be barriers. The conclusion of the Team was that more numbers would not create change, rather change could come by promoting the principles and definition of Universal Design.

On the other hand, dimensional information is necessary to build environments. Numbers support the intent. The pragmatics of designing requires an understanding of anthropometrics to ensure there is a fit between persons and their environment. There was discussion on 'loose fit' that allows for differences. Therefore, the collection of numeric data must be described in such a way as to serve the intents and outcomes that Universal Design can offer. Dimensional information should be framed as a sub-set to principles and inclusive outcomes.

Language

Early in the meeting the issue of language arose. Universal Design focuses on functioning as a continuum and requires a new way to describe people and their

requirements. There is no longer a minority's need versus that of the majority, no longer people with disabilities versus the general population, or able bodied versus disabled.

A number of phrases came out of a discussion on how we describe our place in space, our fit in the environment, and how the environment can be adapted to the individual.

It became clear that it was important to establish a glossary of terms and descriptors of the concepts of Universal Design (see Appendix A).

Definition of Universal Design

The meeting began with a presentation that offered a definition of Universal Design.

> Universal Design is the underlying principle to create responsive and useable environments for the widest possible range of the population.

This definition is the result of previous work, which served as the foundation for this project. The following illustrates this evolution:

> Actualizing Universal Design (Finkel & Gold, 1999)
>
> > Universal Design creates design solutions that accommodate the range of the population to the greatest extent possible
>
> P^4 = People, Places, Participation and Process" Actualizing Universal Design (Finkel & Gold, 1999)
>
> > Universal Design is design solutions that respond to the widest range of the population possible. It is concerned with broad marketing by meeting requirements for children through to seniors, people with and without disabilities without identifiable or stigmatizing aesthetics.

Quantifying Universal Design Proposal (Finkel & Gold with Cooper & Havens, 2001):

> Universal Design (and its other designations for comprehensive design) is a concept that was developed for the design needs of the population at large.

In the definition the phrase 'widest possible' poses challenges. There is a struggle to operationalize it, since it can also be used as an excuse for maintaining the status quo.

The participants described Universal Design as accommodating changes through life stages. There was discussion on good design being responsible, aesthetic, and valued. Good design was equated with Universal Design. Sustainable design would allow for changing uses and users, as well as being sensitive to environmental resources and factors. Objects and environments would be aesthetically pleasing. There was some debate on whether all universally designed objects would or should be affordable.

Therefore, we propose a new definition of Universal Design.

> Universal Design is an underlying principle to create responsive, sustainable, and useable environments for the widest possible range of the population throughout the life cycle.

Characteristics of Good Design (Universal Design)

The following statements of good design for places ('principles' of Universal Design) were presented:

- Marketable
- Flexible
- Uncomplicated and understandable
- Safe
- Requiring reasonable effort
- Easy to access and use
- Sustainable

The conversation about what makes a good design went in a number of directions. Mentioned was that the question should be framed around the outcome, that we need to look beyond the person to the environment. Is this product or process of value in the context of the lifestyle and society that we want to achieve?

Considering the point of whether designs need to be marketable, other characteristics were discussed such as aesthetics and affordability. When viewed from a social perspective, 'affordable' and 'marketable' are used as excuses for not providing accommodations. In any case, the Team stated that 'marketable' should not be listed as the first characteristic of good design.

The importance of design being sustainable was defined in terms of environmental resources, as well as being durable and maintainable through changing functions and over time. A good design would be sensitive to different cultures and climates.

Questions about the appropriateness of using terms such as 'responsibility' and 'usefulness' were raised. Universal Design should produce environments that are responsible in ecological and social terms. A good design would have quality and be of value to and by the community, as well as to the social environment. Because these concepts are applicable to a wider arena, it was suggested that the current term 'places' should no longer be used.

A new list of Characteristics of Good Design (Universal Design) flowed from the discussion.

- Flexible
    - Modifiable
    - Tasks can be completed in a number of ways
- Sensitive to social, cultural, and geographic environments
- Sustainable
    - Maintainable
    - Durable
    - Resource sensitive
- Responsible
    - Valuable
    - Accountable

Ethical
Consultative
- Comfortable to access and to use
Uncomplicated
Understandable
Requiring reasonable physical effort
Sufficient space
- Safe
- Marketable
Available
Affordable
Quality
Aesthetic

Human Condition within the Environment

In order to conceptualize design for the range of the population, a useable list of descriptors about design requirements is needed. To begin the conversation the following list was presented considering people, inclusive of devices, as having a range of capabilities in:

- Vision
- Audition
- Stature
- Balance
- Cognition
- Lower body strength and mobility
- Upper body strength and mobility
- Communication
- Dexterity
- Life Span

A multiplicity of lists with differing levels of detail exists. In discussion on what was needed, it became clear that different lists suit different fields.

The approach deemed most useful is based on body 'functions.' Overall, it is important to accept people as they present themselves and their environments.

'Life span' should be moved from this list to the definition of Universal Design. Chemical sensitivity should be added to the list.

There was no consensus on a single approach.

Agenda Questions

Question 1: Who is the sample?

The background to this question documented a paucity of studies, which accounted for a truly representative collection of data. To begin the conversation it was agreed that a large enough sample to reflect Universal Design is impossible due to costs and logistics.

The participants felt that the sample must be focused on people with disabilities, those with the most need in terms of developing useful and useable environments or products. Other segments of the population have been considered and included. Marginalized groups have often been ignored and are unable to speak for themselves in academic and anthropometric studies. It is also important from a Human Rights perspective that data to define and evaluate environments be collected.

The participants agreed that the sample of people with disabilities should reflect that of the Health and Activity Limitation Survey (HALS), Canada Census, 1990. This survey found that 15% of the sampled population self-identified as having a disability. The participants discussed whether to use a random sample or restrict the sample to ensure a cross-disability perspective. The current census includes a post-censal survey to update HALS (PALS, Participation, Activity, and Limitation Survey). Since there is no way to influence the design of the current survey, the data that it generates will most likely fall short of what is needed for Universal Design purposes. In order to meet the needs of a comprehensive survey, additional content should be added.

Difficulties with using post-censal survey data are that the numbers are dated and there is some question about the accuracy of the proportion of persons with disabilities who self-identify in a survey. A caution was placed on focusing solely

on sample size, it is as important to reflect the values, concepts, and social outcomes of Universal Design.

Question 2: What do we measure?

There was some discussion of available studies with dimensional measurements. It is important to review their suitability. After that process is completed, the question of what needs to be measured could be addressed.

There is a fine line between enough and too much information. Body and function measurements should focus on capabilities, not limitations. Measurements should quantify the impact of the person interacting with the environment.

The focus should be on collecting data that captures those things that make a difference to people. Data are important to developing new products and environments. Information should cover both structures (static) and functions (dynamic). Body measurements should include aids and clothing, and any other variables that may influence such measurements. There should be a range of numbers.

Discussing which part of the anatomy or function to measure is not the issue. The question of measurements should be based on desired outcomes asking "what do you want to do/" and "what measurements will support this?". When focusing on functionality, we must be mindful that there are many ways to achieve the same end. Measurements should start with a focus on social fit, with the process working back to the functional and dimensional aspects.

Measures of the environment are necessary to accommodate this shift. These measurements create and identify model environments by defining and measuring the outcomes and characteristics of Universal Design. Dimensional information will support and explain the details and path to this outcome. This approach supports innovation and creativity.

Question 3: How do we measure?

Existing data should be analyzed to ensure that it is compatible with Universal Design. The review of data should include reliability and validity tests.

Consumers should determine what is a realistic setting, what tasks should be measured, and what are the desired outcomes. Consumers should also play a meaningful role in the act of measuring.

Information should be functional and situational. Body structure information (static anthropometrics) should use established and standardized methods and equipment with well trained personnel for credibility. Dynamic anthropometric information should be measured in realistic environments, while completing meaningful tasks. Tasks need to be subdivided into steps.

Subjective data collection includes market testing where consumers are surveyed individually or in focus groups. There are a number of ways to collect information, such as surveys, focus groups, reports, self-report, mock-ups, and journal writing. These approaches should be balanced with observational data.

Ethical guidelines are an imperative. Accuracy must be ensured through the right tools, precision, and the training of staff. Measuring methodology should be utilitarian and pragmatic and include both subjective and objective data. The variables need to be selected by examining a task's relative function in space and desired outcomes.

Caution: If you can quantify dimensional requirements, will that make designs any better? There needs to be a way to measure how well environments meet the characteristics of Universal Design. This method should be clear and objective. The process to evaluate environments needs to be inclusive.

Question 4: How should the information be organized and disseminated?

The goal of collecting information is to educate and promote universally designed environments through guidelines rather than standards. This information should be action and community oriented and not owned by academic institutions.

Cooperation and coordination are necessary. Consumer involvement should play a critical role in developing information databases.

The data should demonstrate the utility of Universal Design and be easily accessed and understood. Credibility will come from presentations that are accurate, measurable, and useful. The information should be presented in multi-media formats, in order to be applicable to various target users such as consumers, professionals, businesses, banks, and government.

The data should be placed into a database that is organized in such a way that the information can be used differently to meet different needs. To do so the information will need to be adaptable. Enough information should be available to make it possible to extrapolate from specific examples to generalizable models.

Presently it is common to find the structural and functional information on people with disabilities and older persons in separate tables or in separate sections from descriptions of the 'general population'. This information should be integrated.

The information should be organized around case studies. The information should describe a process of what can be done by demonstrating the relationship between intents, characteristics of Universal Design and human factors and functioning. This should begin with a positive image describing desired outcomes or intents. Then, the characteristics of Universal Design that supported this outcome should be highlighted. The dimensional information on human factors and functioning that were used to achieve this goal would follow.

Examples of Universal Design should be changed regularly to keep the database fresh and interesting.

Question 5: Resources

The discussion demonstrated that currently some people are engaged in the process, see the potential of Universal Design, and are supportive about moving forward. Unfortunately there are not clear indications of appropriate leadership and resources needed to collect and disseminate the information. Both funds and expertise are required.

Networks and promotional activities need to be undertaken at the local, national, and international levels. To get national attention, someone with such networks and stature is required. There are connections among selected members of the National Team already established that might be strengthened, such as with:

- Ontario Design Exchange
- Farmers with Disabilities
- Canada Mortgage and Housing Corporation
- State University of New York- Buffalo

The dissemination of Universal Design requires an action-oriented approach. A number of advocacy directions were mentioned such as:

- Start with a small group
- Bilingual approach
- Aboriginal, northern and rural communities
- Developing a Declaration of Design Rights
- Go for a winnable project
- Use words other than 'Universal Design', such as 'good design'
- Tax benefits
- Reduced loan interest rates

Since universities or Centres of Excellence are not appropriate as major players, there are not readily available or designated programs to provide financial support.

Activities identified for the promotion of Universal Design will require particular expertise. Those activities include:

- Seminars
- Booklets
- Newspaper articles or columns In The Home Section
- Awards, such as a Gold Seal Of Approval
- Web site
- Home and Garden Show display
- Model homes
- Video/Film
- CD/ROM
- Presentation speakers

Section Three: Outcomes

The discussion with the National Team required some changes in the original concept for this project. Our assumptions for a numerical one-track research methodology have now become a multi-track process. There is still a numerical component, but it is tempered and strengthened by these concepts.

A. Proposed Research Approaches

Administration

After identifying those persons most affected by the research question or hypothesis, they should be approached and included in a meaningful way into the design and implementation of the research. Universal Design projects should be adapted to both an action and participatory orientation. It is important to focus the research problem around issues that are of concern and need addressing. Those affected by the issues are most knowledgeable about them.

In the case of Universal Design, people with disabilities and older persons should be owners or partners in investigations of this sort. There should be some input in determine what information is needed, the best methods to collect that information, implementing the research, and after analysis determine the conclusions.

Review the Literature

- Static and dynamic anthropometric tables

  Criteria for suitability

  - People with disabilities, older persons, children and pregnant women included as part of the sample
  - Diversity, such as ethnicity, addressed
  - Adequate sample size
  - Sufficient reliability
  - Adequate validity

- Examples demonstrating Universal Design

Search print and electronic media for examples

- Describing the characteristics of Universal Design (as per list on page 8)
- Responding to the range of design requirements (as per list on page 9)

- Identify information that is not available and remains to be collected to promote and implement Universal Design

Collect Missing Data

- Sample

The samples will need to include those persons who are most often omitted and/or adversely affected by outcomes of design:

- People with disabilities
- People over 65 years of age with and without disabilities
- Children (those under 18 years of age with and without disabilities

To determine numbers of persons with a certain disability initially use the Health Activity Limitation survey (1990) descriptions of the15% of the population who self-identify as limited in their daily activities. When the 2001 PALS data become available, this may prove to be a better source of the disability-specific information.

- Measures

Anthropometric (static and dynamic)

- Functional measures taken in environments and under realistic situations
- Standardized
- Appropriate tools and training
- As per the Discussion Paper, Question 2: What do we measure? (Appendix C)

Dimensional

- Characteristics of Universal Design (on page 8)
- Human condition (on page 9)

- Case studies

Examples of Universal Design identified in the literature review should include:

- Possible social outcome
- Demonstrated characteristics of Universal Design
- Human functioning that is accommodated
- Dimensional information needed to support the above

Organization and Dissemination of Information

- Organization

Dimensional information

- Integrate dimensions for all people (i.e. eye level both when seated and when standing)

Easily accessible

- Arrange both top down (starting with wanted social outcomes, then characteristics of Universal Design, human functioning, then dimensional information) and bottom up (dimensional information that can lead to social outcomes)
- Fully indexed
- Identified through case study

- Dissemination

Develop network

- Link with others interested in Universal Design

Multi-dimensional

- Presentation determined by target user
- Target consumers, design and building professionals, banks, government

B. Model

P^4=People, Places, Participation, and Process: Actualizing Universal Design (Gail Finkel and Yhetta Gold 1990) has some of the features described in this project. The lists of characteristics of Universal Design (called Places) and the

human condition factors (called People) were developed in that research and can now be updated to reflect the information from this project.

A feature of the *P*^{4} document was a four-step process to implement Universal Design. The process begins with the participation of the stakeholders. A group process is explained. Terms are defined in order that all the stakeholders are using words in the same way, that there is an understanding of what is Universal Design.

There is an evaluation form that allows the group to work through each aspect of Universal Design. The design is measured against each characteristic of Universal Design. Questions of how well the design meets that goal generate a discussion of what may be done to create a better fit. This process is repeated looking at the different aspects of human functioning. In this way, a design may be evaluated and adjusted to more suitably accommodate increasing aspects of Universal Design. The process ends with the development of an action plan.

This project, Quantifying Universal Design, highlighted the importance of using the values or characteristics of Universal Design to evaluate and motivate design. The new information validated the direction of *P*^{4}. The definition, the list of human factors, and the characteristics of Universal Design have all been improved. This new information further enhances the earlier project.

Section Four: Conclusion and Future Actions

Conclusions

This project, first and foremost, validated the concepts of Universal Design as an important tool useful in a variety of fields. Universal Design is a potentially powerful tool in the continuing drive for a more inclusive society.

The meeting generated many ideas. The original literature review and discussion paper with background information on each question of the agenda served as catalysts in the discussion. Participants had read the pre-workshop material and were therefore prepared; this saved time in introducing the subject.

The process of bringing together experts from different disciplines had many tangible benefits. Each participant was carefully selected in order to bring different viewpoints and experiences to questions about the application of Universal Design. The breadth and level of the discussions exceeded our expectations.

While some new technologies are used to eliminate face to face meetings, this event demonstrated the value of such meetings. Ideas were played off one another creating dynamic and informative discussions. Having a tight agenda that barely fit into the day and a half kept the interchange fast paced. The tenor for the meeting remained interested, positive, respectful, energetic and focused.

We allowed the discussion to flow in unanticipated directions. It was important to let go of a prepared agenda, not always an easy thing to do. As long as the discussion was on topic, we had to follow the path the group was taking. This allowed the group to be creative and not restrained by preconceived notions.

From the meeting it was evident that:

- Great interest in the potential of Universal Design exists
- Positive energy was generated
- Interrelationships of diverse areas of expertise occurred
- Old fashioned face to face meetings lead to creative idea generation
- Still much work remains to be done

The challenge to moving Universal Design forward rests on the lack of sponsorship. While those around the table felt it was critical to take the next steps, there was no one offering to take the lead. Strengths of Universal Design are that it is a concept or philosophy and that it is applicable to many fields, but these factors are also liabilities. Without any tangible handles, it is difficult for any department, faculty, or organization to provide leadership or funding.

Future Directions

Universal Design is important for a more inclusive society. As such there are a number of steps that need to be completed to promote and implement Universal Design.

1. Quantitative measurements

Existing databases need to be reviewed with strict criteria to ensure that people with disabilities and older people are included and have appropriate static and dynamic measurements. Areas not already covered need to be undertaken using strict standards.

This information needs to be collated in such a way that the information for people with disabilities and older people is integrated with the rest of the population. There must be links between the quantitative data and the qualitative information of Universal Design.

2. Qualitative measurements

The concepts of Universal Design need to be defined and explained in useable and useful terms. Processes for using Universal Design and for evaluating existing designs need to be detailed. This information needs to be completed in a number of ways in order to be targeted to different situations.

3. Models

A positive approach to disseminate and promote Universal Design is through models. There should be award programs that target designs at the macro-, meso-, and micro- environments, i.e. community designed parks, homes, and kitchen utensils. There should also be models developed to demonstrate universally designed policies, programs, and services.

4. Leadership

There should be a national organization responsible for promoting Universal Design through education, research, and displays of best practices and policies. It should provide links to the different organizations, consumers, research, programs, models, databases, and researchers and designers.

It should be based on inclusion, be community based and consumer driven. This organization should not be housed within government or academia, which would limit the application from a broad base.

Since no one owns Universal Design, no department is designated to fund universally designed projects. To resolve the problem of funding this organization needs to show how each field gains from the application of Universal Design and that it is in their economic interest to do so and therefore to support these activities.

5. Next Steps

As a result of the information gathered, we conclude that a fruitful future direction is to convene a Consensus Conference. The organizers and sponsor of this research project along with the National Team should organize and secure funding for this meeting. The pre-meeting work should outline the appropriate resources and relevant participants to generate an action plan based on these findings. The Action Plan will confirm commitments to the enterprise and to implementing and developing models.

Appendix A. Glossary

Accessibility: the property that allows an object or space to be readily reached, entered or used[1].

Actualize: to make real or actual: materialize, realize, bring to pass, carry into effect[2].

Anthropometry: the scientific study of the measurements of the human body[1].

Barrier-free design: disability specific solutions to inaccessible environments

Capabilities: ability, power[1].

Capacity: the power of containing, receiving, experiencing or producing[1].

Concept: an idea, theme or design, especially- as the basis for development or execution[1].

Ergonomics: is the application of scientific information about human beings (and scientific methods of acquiring such information) to the problems of design; is the scientific foundation, both in terms of data and methodology, for a user-centred approach to design[3].

Functional: able to work; designed or intended to be practical rather than attractive; utilitarian[1].

Functioning: mode of action or activity by which a purpose is fulfilled[1]

Goal: the object of an effort; an aim[1].

Human factors: the science dealing with the application of information on physical and psychological characteristics to the design of devices and systems for human use[4].

Hypothesis: a supposition made as a starting point for further investigation from known facts[1].

Model: a simplified description of a system, process, etc. put forward as a basis for theoretical or empirical understanding[1].

Objectives: things that are sought or aimed for; targets, goals or aims[1].

Outcomes: results, visible effects[1].

Principles: fundamental truths or laws as the basis for reasoning or action[1].

Quantifying: the act of determining the quantity of; measuring or expressing as a quantity[1].

Responsibility: authority; the ability to act independently and make decisions[1].

Universal Design: is an underlying principle to create responsive, sustainable, and useable environments for the widest possible range of the population throughout the life cycle.[5]

Values: the principles or moral standards of a person or social group; the generally accepted or personally held judgment of what is valuable or important in life[1].

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Appendix C. Discussion Paper

Study to Quantify Universal Design

Discussion Paper

Prepared for the National Team

October 13, 2001
8:30 - 5:00

October 14, 2001
9:00 - 12:30

Norwood Hotel
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Table of Contents

Quantifying Universal Design

Welcome

We have invited you to Winnipeg to join us in developing a methodology for collecting, organizing and presenting universal design dimensional information. The diverse expertise of the National Team is essential to attack the issue of *Quantifying Universal Design*. This project is funded by Canada Mortgage and Housing Corporation.

The first section of this document explains the research problem and the scope of this project. This is followed by an overview of our research assumptions and values and previous works related to this project. The remaining sections present the questions that form our agenda for this meeting with relevant background information.

The Problem

While universal design (and the other designations for a comprehensive approach to design) is becoming more widely known and accepted, it remains a term defined through concepts. To become more practical for those using, designing, and constructing environments, the concept must be quantified through actual dimensions.

One of these concepts relies on accommodating a population with a range of functioning or capabilities. This view of population as a continuum of functioning sounds clear enough, but it is far more complicated for practical application. Traditionally, we have designed for ‘averages’ or some random percentiles of the population. As a result dimensional requirements have been collected and presented to support that 'average,' but misinforms designers implementing universal design. Rectifying this problem by providing universal design dimensional requirements will be no easy task. As a first step to tackle this problem, this project brings together experts to discuss and develop a program (methodology) for collecting information that supports and quantifies universal design.

"If you want designers to design for everyone, then it is incumbent to ensure that data on everyone are available in the same place and in the same way" (Connell & Sanford, 1999).

As we try to put universal design into practice, it has become clear that we are missing some important tools, such as;

- Off the shelf information lacks accurate (or even any) comprehensive and inclusive information on the range of human factors in our population.
- Most guidelines are based on dimensions from a barrier-free approach, which details a mythical person in a wheelchair, or dimensions that exclude any information on persons with disabilities.
- The people measured for the existing information represent a small and exclusive group.
- The tasks measured do not necessarily represent real life situations.
- The dimensional requirements for some marginalized groups are separated from those for 'normal' or 'healthy' making designing for the range of capabilities difficult to impossible.

Scope of this project

Just randomly collecting more numbers, extrapolating current data or using a larger sample will not remedy the present problem of inadequate dimensional information. We believe that to get a comprehensive and accurate database we must start with a systematic methodology based on universal design principles. This methodology is crucial to moving to the next step within universal design.

It was decided that the most viable way to get such a methodology was to consult with a team of experts from various fields related to universal design. We decided that the most productive approach was bringing this group together to develop a clear and useable methodology.

The following questions form the agenda for this meeting;

- What defines the range' of the population? What are the implications for selecting a sample group?
- What are the parameters for testing functionality?
- What methodology will produce an appropriate database?
- How should this database be organized?
- What resources would be required to implement such a project? Which of these resources are available?

The questions are presented in detail later in this document.

<u>Deliverables</u>

The discussions at this meeting will form the basis for the final report, *Quantifying Universal Design*. The report will include a summary of the meeting and a description of a methodology for collecting dimensional requirements. Also covered will be the resources needed to implement such research projects and the organization of a database with findings of the research (universal design dimensional information).

After the October meeting the researchers will analyze and synthesize the information collected. From this, a draft document will be produced. At that time (estimated at one month after the October meeting), members of the National Team will be given the draft document for feedback. Following that, the final document will be produced and sent to CMHC for publication and dissemination. Each member of the National Team will get a copy.

Future Proposals

It is hoped that the report, Quantifying Universal Design, will be used to implement the methodology to collect dimensional information for universal design. That information can then lead to appropriate guides for actualizing universal design.

Research assumptions

This document begins with established assumptions and values, which were the basis for past projects. The assumptions continue to influence this work.

Values

- People at the extreme ends of society have inequitable treatment in the design of physical space, and in shaping social attitudes and public policies
- As a result of continuing inequities, we feel there are limits to the usefulness of disability specific solutions such as barrier-free design, a disability lens, or other group specific approaches
- Universal Design offers an effective response to inequities in designs and environments
- All human capabilities fit into a range of functioning
- The environment includes those spaces that surround us, built forms, programs (recreational, educational), social aspects (employment, citizenship) and attitudes
- This environmental context is an essential element in enabling/disabling participation and equity

Working Hypothesis

It is possible to design more appropriate and satisfactory environments, by bringing together the individual, the range of human functioning and universal design principles.

Past Research Projects

Working from actualizing to quantifying universal design

1. *Actualizing Universal Design: P^4=People, Places, Participation and Process Parts 1 and 2*

Goals: To develop a working definition and concept of universal design
Process: Focus groups across Canada
Results:

- People -Clarified the range of function through a list of human factors
- Places - Developed a conceptual framework for good design practice
- Participation- Translate designs into usable environments or objects
- Process - Developed a process to evaluate designs by the stakeholders incorporating the range of functioning and the principles of good design.

2. Universal Design within the Home Building Industry

Goal: To find out what home builders know about universal design and what they would want to know and how the information should be delivered.
Process: Survey home builders in Manitoba
Results: They had knowledge of barrier free design and thought it had some use for seniors, but they would not use it to sell homes (the term has a negative stereotype). There was some knowledge of universal design. The builders clearly wanted more information on the range of functioning and the statements of good design. The information needs to be written directly for their requirements, be practical and delivered through their organization or CMHC.

The participants clearly endorsed the notion that language is the key. This new universal design language must be inclusive and marketable.

Our Definition of Universal Design

Universal Design is an approach by which to design for the widest possible range of the population.
This definition needs to be clarified:
1. "Design" encompasses a very wide berth. We design the built environment, houses, interiors with furniture, clothing and kitchenware and the exterior with sidewalks and roadways, as well as transportation systems, parks, programs, services and policies.
2. The term " range of the population" excludes values or levels or judgements on abilities. The group specific definitions such as ‘people with disabilities’ or

‘seniors’ have no place here. Everyone is a part of the general population and has a place in the range of the population.
3. "Widest possible" refers to the vast range of functioning in our population and implies the difficulty to meet everyone’s needs. Therefore, it is essential to have a process that establishes who is included and who is excluded.

Question 1: Who is the sample?

To collect data, we need a sample that is representative of the range of the population. Who is included when we say the range of the population? What are the criteria to select the sample group -age, abilities, ethnicity, etc? How many subsets of criteria do we need? How many people do we need? How would we find these people?

Background Information
If we agree that a truly representative sample is important to reach universal design principles, there are a number of factors to consider. Complicating gathering information is that our personal anthropometric data varies in a number of ways: through intra-individual variations, inter-individual variations, and secular variations. These differences create challenges in developing appropriate criteria. This challenge is made more difficult by examples of past projects. Through incomplete information and selection criteria of the samples used, building on previous work must be carefully considered (Campbell, 1996).

a. No description of the characteristics of the sample
The initial issue with existing dimensional databases (static anthropometric and dynamic anthropometric (biomechanical)) is that they rarely describe the sample group. A survey of a number of these sources provided no information concerning who was measured.

Most databases cite other databases in their bibliographies. Trailing the databases back through their references still provided little information. Those references also rarely gave information on who was measured for their databases.

b. Vague descriptions
When a reference did describe the sample criteria, the typical description was either vague (providing only gender and numbers), or clearly excluded people with disabilities, people over 65, and children. An example is research to validate design assumptions relative to these databases. They used 140 subjects, 70 male and 70 female. "Only healthy individuals participated in the study," (Vasu & Mital, 2000). The term ‘healthy’ is not defined.

"Although the anthropometry, biomechanics, physiology, and psychology of adults in Europe and North America are fairly well known, large subgroups of this population - pregnant women, children, the aging and the disabled - have not been studied extensively enough for complete ergonomic design" (Kroemer, 1997). As in this quote the term ‘adult’ in many references most probably does not describe men or women with disabilities. This validates the importance of entrenching universal design into the vocabulary, so the definitions of 'men' and ‘women’ include persons with disabilities.

In this context for people over 60, little information has been gathered or is not useful. Most tables do not offer any information on people over 65 years. There is even less information on people in their 80's and 90's. Second, there is the question of how valid is the information when using age as the sole criteria, and importantly, using one specific age as a marker for 'old age' (Stoudt, 1981). Third, the age ranges in the databases become less useful at approximately age 65. "Habitually, anthropometric and most demographic and capability-related information is collected in five-year intervals until the age 65, and then just lumped together for the remaining years, with only occasionally a time marker set at 75 years of age"(Kroemer, 1997).

"To date, characteristics of the older population have been largely ignored in engineering design, and thus the elderly often have difficulty manipulating the designed environment. For this reason many older adults currently need some type of assistance to complete living activities" (Czaja, 1990). From the search results on people over 65, the most obvious conclusion is that this is a group not important to designers or others. Again, this would not be if universal design principles were followed.

For people with disabilities, a similar situation exists. Most studies do not include people with disabilities of whatever age. In a few examples of research that included people with disabilities, the numbers were skewed to people using wheelchairs and people over 45 years old (Hunter, 1987; Steinfeld, Schroeder, & Bishop, 1979; Waters, Torbum, & Mulroy, 1992). As to the representation of people with disabilities in the population, The American Institute of Architects: Architectural Graphic Standards illustrates how vague information can be. "Disabilities are to be reckoned as follows: 3.5% of men and 0.2% of women are color blind; 4.5% of adults are hard of hearing; over 30% wear glasses; 15 to 20% are handicapped, and 1% are illiterate. Left-handed people have increased in number to more than 10%" (Ramsey & Sleeper, 1989).

c. Ethnicity

Canada's demographics have changed to become a more multi-cultural country. It seems that most of the data collected have not been representative of ethnicity. When completed, most data have focused on North America and Europe. 'North American' most probably does not include aboriginal people. Including considerations of ethnicity could change results in a number of areas such as height, weight and type of clothes worn (which must be accounted for in dimensions). Again universal design should be truly representative of the population, so ethnicity is an important factor and will affect results.

The most comprehensive databases were created by the US military and NASA. These samples represent a very particular profile. Generalizations to the civilian population should be questioned. There may be many differences due to genetics, environment (altitude or temperature), nutrition, effects of aging, race, gender, and transient diurnal differences

"How can research data on human performance be applied most appropriately across cultures? Within a country, who decides on the degree to which standards accommodate the needs of the population as a whole? How can the findings from research with small samples be generalized to the population as a whole? How can the validity of standards as a prescription for fit be evaluated?" (Steinfeld & Danford, 1999)

d. Small sample sizes

Creating a large sample would require great resources and access to many people. (Czaja, 1990; Tilley & Henry Dreyfuss Associates, 1993). Most of the studies reviewed for this project had samples numbers from 15 to ±150 people. These numbers could not have examined enough people from different criteria such as a range of abilities or ethnicity to provide generalizable results.

"Given the limitation, in fact paucity, of these data from the United States, one anticipates even poorer and less complete data from other regions of the earth" (Kantowitz & Sorkin, 1983). An example of such problems is Australia's first documented study to provide anthropometric data on seniors. They measured 133 people (33 males and 100 females) with a mean age of 76 and the age range was 62-92 years (Kothiyal & Tettey, 2000).

Sampling would be beyond reproach if it includes everyone. Given that this is impossible, random selection should be used, where everyone in Canada has an opportunity to participate. Given that that is not possible, we must stratify sampling. By placing the population into a number of segmented criteria, we reduce the sampling numbers. Usually the first segment is based on one or more distinctive characteristics such as gender or age. The more segments we use, the more important the demographics describing that criteria be reliable. Unfortunately, there will be error, because that demographic information is based on a sample as well. This weakens the data by the number of times that the original information has been transposed (Kantowitz & Sorkin, 1983).

Summary

In universal design one would expect the sample would be a true reflection of the range of functioning in our total population. What constitutes a representative sample?

Question 2: What do we measure?

Which human factors do we need to measure? How do we establish whether data presently available is accurate and therefore useable? What is missing? Are there other factors to measure?

Background Information

a. Definitions

- Ergonomics attempts to ensure that human users are at the centre of all design activities. It is the science that allows us to design environments, processes and products that humans can use efficiently, easily, and safely. "The human centered approach considers information on human physical, physiological and mental capabilities and limitations for designing things for human use. It also takes into account the behavioral, social and cultural characteristics of the users. Ergonomics is, in fact, the fundamental design science." (Kothiyal, 1996).

Ergonomists and human factor engineers take the anthropometric data to ensure a fit between man and machine or product. As well, rehabilitation practitioners and designers in a number of fields (architecture, landscape architecture, product designers, interior designers, mechanical and lighting engineers) use this information to create a comfortable fit between people and their design.

"Ergonomic knowledge and ergonomic procedures can be of aid from infancy through adulthood into old age. The ergonomic principles and techniques for architectural and interior layout, for design of workplace, equipment and tools are the same for anybody: they are just more critical and important for persons different from the "normal adult" model" (Kroemer, 1997).

-Anthropometry is of Greek derivation for the measurement of man (Kroemer, 1987). Anthropometrics can be static measurements or dynamic measurements. Static anthropometric measurements provide important information about body size and shape. Static anthropometrics describe the physical measurements of the human body such as the length of the forearm, circumferences such as the circumference of the waist, linear measurements such as height. Dynamic anthropometry (biomechanical) measures body motions. These measurements include range of movement envelopes, reach heights, angles, force and velocity. Both of these are essential tools to provide a fit between people and man made objects (McCormick, 1964), (Connell & Sanford, 1999).

b. Value of collecting data

Having information that is more inclusive and representative of the actual population is a key principle for universal design. “The universal design approach is based on the view that it is within the power of designers to decide how much of the total population they wish to address" (Ward, Rogers, Brown, Jeffries, & Wright, 1996). We need a systems perspective to consider human characteristics for physical and psychological environments to improve fit and

comfort (Dainoff, Mark, & Gardner, 1999). We need this information to reduce the disabling effects of the environment (Patrick, 1997). We should not design for people without information about their design requirements. Besides fit, this information is important to provide safer environments to prevent injuries in the home and workplace.

c. Required measurements

To build objects and environments that are universally useful, it is important to see and measure the interaction between the person and the environment. Person measurements provide geometric constraints. The biomechanical or dynamic anthropometric measurements provide the range of movement, strength as a function of the person's body. The environment and the task are important to examine in both dimensional and performance levels. The importance of the task will determine if the person will use only a comfortable amount of energy or stretch and exceed the comfortable range of motions. The environment in which the person and task exist is a pivotal point that enables or disables the activity.

"By considering only the geometry of the user and workplace, we neglect meaningful constraints on the way in which people perform goal-directed activities" (Patrick, Richardson, Starks, Rose, & Kinne, 1997). There are no tables readily available with this information.

There may be some dimensions that have been collected for the general population that do not need to be repeated for marginalized groups. Unfortunately with the lack of information on criteria for these samples, there is no way to ensure diversity, range, validity and credibility. We do know that a number of usual measurements such as height, eye level and range of motion are affected by age, posture, gender, ethnicity and the use of assistive technology. "National populations cannot therefore be regarded as homogenous" (Patrick et al., 1997).

The following typical measurements are from *Bodyspace* (Pheasant, 1986).

-Static Anthropometry

Standing erect, sitting erect and slumped: height, eye height, shoulder height, elbow height, hip height, knuckle height, fingertip height, sitting height, sitting eye height, sitting shoulder height, sitting elbow height, thigh thickness, buttock-knee length, buttock-popliteal (bend behind knee) length, knee height, popliteal height, shoulder breadth - bideltoid, shoulder breadth –biacromial, hip breadth, bust depth, abdominal depth, shoulder-elbow length, elbow-fingertip length, upper limb length, shoulder-grip length, shoulder-grip length, head length, head breadth hand length, hand breath, foot length, foot breadth, span, elbow span, grip reaches, body weight

-Dynamic Anthropometry
Clearance: maximum body breadth, maximum body depth, walking erect (height), walking stooped (height), kneeling height and width, kneeling leg length, crawling height and width, crawling length, buttock-heel length (with light and bulky clothing)
Reach: forward grip reach, with trunk twisted, zones of comfortable reach
Joint ranges: Angular movement of upper and lower arms, shoulder (flexion, extension, abduction, adduction, medial rotation, lateral rotation), elbow flexion, pronation, supination, wrist (flexion, extension, abduction, adduction), hip (flexion, abduction, adduction), knee flexion, ankle (flexion, extension)

Limited measurements are taken for people over 65 and less for people over 80. For people with disabilities the predominance of information is collected from a person using a manual wheelchair who has upper body strength and dexterity. Only in rare occasions are dimensions available on other types of wheelchairs and scooters.

Typical data for people who use a wheelchair:
Floor to vertex, floor to eye, floor to shoulder, floor to elbow, floor to knuckle, floor to top of thigh, floor to top of foot, floor to vertical grip reach, knee from front of chair, toes from front of chair, forward grip reach from abdomen, forward grip reach from front of chair, sideways grip reach from front of chair (shoulder –grip length), shoulder breadth (bideltoid), overall length of wheelchair, overall breadth of wheelchair, height of armrests.

For people with other disabilities there may be dimensions for the width of a person using a white cane, crutches, a guide dog and a walker.

A relatively new category has developed for pregnant women for measurements of abdominal depth, forward grip reach from front of abdomen.

d. Available information
The difficulties of using existing data include:

- Much information has been collected using small sample size
- Limited or no information on selection criteria, which may lead to biased information
- No details explaining how the data were collected
- Older studies may have used older technology that could result in less precise measurements
- Data may not be the information required today (Campbell, 1996)
- Language including value judgements and bias
- There will be measurement error
- Inter-rater measurement variation

Most of the data sources referenced the following in bibliographies, but did not detail what data were used from which source.

-*Humanscale* series (Diffrient, Tilley, & Bardagjy, 1974),(N. Diffrient, A. R. Tilley, & D. Harman, 1981; N. Diffrient, A. R. Tilley, & D Harman, 1981)
-NASA's *Anthropometric Source Book* refers to military populations. A number of sources have combined this information with civilian surveys to provide a larger sample base (Kroemer, 1987).
-*The American Institute of Architects: Architectural Graphic Standards* (Ramsey & Sleeper, 1989)has been listed as an important resource. They reference *Humanscale* by Niels Diffrient, Alvin R. Tilley, Henry Dreyfuss and Associates.
-*The Measure of man and woman: human factors in design* (Tilley & Henry Dreyfuss Associates, 1993)
-Military –*MIL-STD1472C Human Engineering Design Criteria for Military Systems, Equipment, and Facilities*
-*The Society of Automotive Engineers Inc. Anthropometry of Infants, Children and Youths to Age 18 for Product Safety Design* (1977)

Bodyspace (Pheasant, 1986) was clear as to which data came from what source, but there still remains questions as these quotes point out.

> "British adults: We have considerable confidence in the validity and reliability of these data. Reference sources for E1 and E2 were: US civilians (Stoudt et al. 1965,1970) for dimensions 8,11,13,14,15,16,17,18 and 19; French drivers (Rebiffe et al. 1983) for dimensions 22,23,24,25 and 36; British drivers (Haslegrave, 1979) for dimensions 12, 20 and 21. The remaining dimensions were calculated from a variety of US military surveys published in NASA (1978). Separate E coefficients were established for the different age bands." (p62)

and

> "The over-65-year- olds presented a problem. The OPCS stature data only extend to 65 years. An alternative source would be the survey by the Institute of Consumer Ergonomics (1983) of the inmates of geriatric institutions…" (p83)

Previous work appears biased as reflected in the language used. Historically, the results were used to define the "regular" adult, who is presumed to have:

> -"'Normal' anthropometry; that is, with body dimensions such as stature, hand reach, or body weight within an "average" range and with no severe limitations regarding posture or mobility.
> -'Normal' biomechanic[sic] functions, regarding muscular, metabolic, circulatory, and respiratory capacities and nervous control, with fully functional sensory capabilities and intelligence are fully functional." (Kroemer, 1997)

There are a number of software programs that incorporate environmental designs with human figures that reinforce 'normal' based thinking. The programs are meant to test the efficiency, comfort and safety of an environment by a modeled person moving through the design. The import commands allow the user to select gender and anthropometric data. The problem is that the

dimensions are based on averages from existing dimensional databases (Sengupta & Das, 1997). In some cases specific workers' anthropometrics are inputted related to a particular workstation (Gilad & Karni, 1999; Waly & Sistler, 1999). This process uses the worksite to define the dimensions of the 'normal' person that can do that work or use that equipment. In cases that have been developed to demonstrate the needs of people with disabilities, barrier free information is provided based on stereotypes, a 'regular' person using a wheelchair.

Typically the descriptions of people at the extremes of the range of functioning are seen as anomalies as represented in the following quote. "The remaining 5% include some who learn to adapt and others, not adequately represented, are excluded to keep designs for the majority from becoming too complex and too expensive…" (Ramsey & Sleeper, 1989)

Summary

To quantify universal design, we need comprehensive and accurate measurements. What can we use from data that exists? The more existing data we use the easier it will be to collect the missing pieces, but what do we give up in terms of accuracy? Is it worth it?

Question 3: How do we collect information?

What should the methodology be? How do we ensure that the results will be useful? Can the methodology be standardized? What types of analysis are required?

Background Information

a. Mechanics

There are a number of detailed approaches to collect anthropometric data (Lohman, Roche, & Martorell, 1991; McCormick, 1964; Pan et al., 1999). Historically human factors engineers, anthropometrists and ergonomists have collected this information. There is a growing trend for rehabilitation specialists including, sports science, physical therapy, occupational therapy, and orthopaedic medicine to add to the databases.

The method/process must be carefully and completely described. A standardized approach is essential for validity, reliability and credibility. An example of types of measurements and possible tools for static anthropometry are: length with tape measures and calipers, shape by stereogram or markers, movement by infrared motion analysis, strength by a dynamometer, skin pressure through pressure sensor arrays.

Other measurements must relate to dynamic anthropometry and should result from a task orientation. Beginning with a task, the steps to complete the task need to itemized. All movements then need to be studied, from a comfortable mode and from an imperative to complete (Boff & Lincoln, 1988).

Even with a clear methodology, interrater variability and body mechanics makes accurate measurement difficult. "The human body is difficult to measure reliably and repeatedly: its shape and the forces it generates vary significantly with posture, and absolute datum is not easy to identify without considerable expertise."(Ward et al., 1996)

Any methodology must consider the people in the sample. People considered marginalized, such as persons with disabilities, have had various tests and research studies done to them, many with disregard for their attitudes and needs. The system developed must not be intrusive and must protect privacy. "The designers of assessment studies and those who seek to develop such methods must ensure that the approaches adopted all extraction of the maximum amount of reliable, significant data with the minimum additional inconvenience to the subjects." (Ward et al., 1996)

b. Ensure usefulness

Static anthropometric measures are usually taken in a controlled environment. In more cases than not, dynamic anthropometry is also done in a controlled environment. This raises the issue of generalizability to real world experience.

Without the comparison, studies have only face validity with no guarantee that the results have any predictive value (Steinfeld & Danford, 1999)

According to Connell, et al., there are 3 issues to be resolved:

- The data that have been collected previously should be reviewed for reliability and validity and then integrated into a database for the general population
- Missing data should be noted and ranked in terms of relative importance and for those data that will most probably be different for people with disabilities and seniors
- As the new data are obtained it is most important to ensure they be reliably and meaningfully integrated into existing population data (Connell & Sanford, 1999)

c. Analysis

Anthropometric data are used to inform designers to ensure the fit between person and machine. Typically, human factors engineering mentions three principles to determine which data to use (McCormick, 1964).

1. Design for the average
2. Design for extreme individuals, where the minimum or maximum is the limiting factor
3. Design for a specific range, for people who fit the task

The survey information is analyzed and organized to provide data that are easily useful for those 3 principles. The typical statistical analysis for each dimension shows the average (50^{th} percentile), the standard deviation, and the 5^{th} and 95^{th} percentiles (in some rare cases the 1^{st} and 99^{th} percentile).

The first issue is with the tables that are based on a limited sample. Therefore 90% of the population is in fact only 90% of the sample, with suspect sample criteria. There seems to be a bias to make the results produce a normal curve for easier statistical analysis. “There is some evidence that not all body dimensions are normally distributed" (vanSchoor & Konz, 1996). Clearly this approach is not in keeping with universal design and skews all analysis and design theories.

In designing for the average, we are describing no one. "If we pursue the average in terms of more and more dimensional measurements taken we find that as the total number of dimensional measurements taken increases so the percentage of the 'average' person who can represent them also decreases" (Croney, 1981).

Studies have shown that a person with the average dimension in one category is probably not going be in the 50^{th}percentile in another (the population percentile invariant assumption). Therefore, constant proportions should not be used (Kroemer, 1987; Vasu & Mital, 2000).

When designing for a fixed range we get other problems. For example, when designing for 95% of the population and considering that in each category 5% of persons are excluded, and that in each category there could be a different 5% excluded, the amount of people included diminishes. "It is sobering to realize that if we rigorously follow a policy of accommodating the 95% of the population (i.e. excluding 5%) we actually end up excluding 25%" (Pheasant, 1986).

Designing for a specific range is explained as finding people who fit the profile for the job. Finding people who fit already designed systems or equipment. This approach has no place in universal design principles and will not be discussed further.

Summary

All these approaches are not in keeping with universal design. In universal design we need a descriptive statistical analysis. Perhaps, focusing on the range of results provides a starting point for further discussion. Is the collection of data standardized to ensure usefulness, credibility, and reliability.

Question 4: How is the information organized?

How should the data be organized in a database? How should the information be used? Who should own the information?

Background Information

a. Separate Tables

The first problem to tackle is all existing data on people with disabilities are placed in separate tables from the 'general population.' "Gold standards for dimensioning objects and spaces (i.e. Architectural Graphic Standards and Humanscale) do not integrate anthropometric and biomechanical information for people with disabilities with that for people without disabilities" (Connell & Sanford, 1999).

A universally designed list of anthropometric data would integrate the data to represent all people. In this way a user of this information gets a true picture of the range of functioning. To date, a user must go to separate tables, which implies intent to include people with disabilities. As well this implies approval for designs for 'normal' people and special designs for people with disabilities (usually separate from and less than).

b. Organization

If we can overcome the hurdle to integrate data, the information must be compiled and published in an organized, readable and concise way. The material should be direct and the language unambiguous, with a statement on how the material was gathered including both the methodology and sample group criteria (Campbell, 1996).

The format for reporting the material could include:

- Title
- Key Terms (could be the table of contents),
- General Description (general findings, conclusions, trends, definitions),
- Applications (task environments where this information may be useful),
- Methods (test conditions and experimental procedure),
- Sampling strategy
- Experimental results (more detailed information than the General Description, statistical information and graphs/tables),
- Empirical Validation (methods used),
- Constraints (limitations of data, subject characteristics, etc),
- Key References (full bibliographical information listed alphabetically or numbered), and
- Cross References (related topics) (Boff & Lincoln, 1988)

c. Computer Databases and Modeling Programs

Computer access could have a great impact on the dissemination and usability of dimensional requirements. Where the database is stored becomes a mute point

through the Internet. The way in which the database is organized could allow users to store and sort vast amounts of information. There is the option charging a fee to use the database or have it as open to anyone. These questions should be answered with users in mind. Potentially there are a number of target users for this information: academics, practitioners in design, physio- and occupational therapies, and community advocates.

As well as a database, there are a number of prototypes using a manikin to test design against the anthropometric data. Manikin drawings are available from Communications Complex Design, England demonstrating the characteristics of a number of different percentile ranking and ethnic groups. (Pheasant, 1986)

Computer generated manikins are incorporated into a number of ergonomic expert systems. ERGOEX can transform sets of worker data into design plans to test the efficiency of the design (Gilad & Karni, 1999). HUMAN integrates the manikin into AUTOCad, an architectural drawing program. The manikin can be programmed for different postures and percentiles from *Humanscale* 1974 (Sengupta & Das, 1997).

Summary

Can universal design principles be met through blending current 'average/normal' data with information on people with disabilities and other marginalized groups? If so, what materials will be chosen and how can this be done?

Question 5: Where are the necessary resources?

What resources are needed to be able to implement this methodology? Are they available in Canada? In North America or elsewhere?

Which of the following must support for a proposal for quantifying universal design to be accepted: designers, rehabilitation professionals, advocacy community, or government departments? Is it either or is it all?

Is there political will to do this?

Are there Centres of Excellence with a fit for this work? Where are appropriate laboratories? Where is the necessary equipment? Where is appropriate expertise (leadership, technical)?

Can Canada develop a prototype? Will it be applicable internationally? Do we need a larger population than is available in Canada?

What auspices are necessary? The resources necessary are possible only with political will? How much money?

Question 6: Your questions are?

Summary

"What is done in the name of disability today, will have meaning for all society's tomorrow." (Zola, 1989)

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