AC 2010-1010: RESULTS FROM AN INTERDISCIPLINARY SERVICE LEARNING PILOT PROJECT INCORPORATING UNIVERSAL DESIGN CONCEPTS FOR ADA COMPLIANCE

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Results from an Interdisciplinary Service Learning Pilot Project Incorporating Universal Design Concepts for ADA Compliance

Abstract

Engineering and engineering technology students need to become more socially aware and learn to think of the entire population that may use the products or equipment they design. One of the main objectives of this project was to demonstrate how products can be designed to be compliant with the Americans with Disabilities Act (ADA) and usable by all people. The concept of Universal Design has emerged as a key component of this effort. Universal Design involves the entire process from its initial conception to end use by thinking more inclusively of the entire population that will ultimately use the product, including those with disabilities. This paper describes the results of the first year's pilot project that was developed to teach students the Universal Design concepts within the confines of a senior design project for engineers and engineering technology undergraduate students. The students designed and developed a product that would be used by both the university's Disability Support Services (DSS) Office and the Center for Disability Studies and Universal (CDS) Access. This project included a service learning component while studying and incorporating the precepts of Universal Design. It also demonstrated how these types of projects could develop a whole new generation of engineers trained to better serve our entire population through the precepts of Universal Design. The outcomes and lessons learned from the first year of this pilot development project are also presented. Overall the project was a resounding success with a product designed that could be utilized by a wide variety of people with varying abilities and satisfied users of the product. Both the student's education and the public's awareness of how engineers can improve the lives of people were enhanced. Programs and projects of this type can be replicated and used as a model for other universities to incorporate in their degree programs.

Introduction

How to design product of every type is a fundamental skill acquired by all engineering and engineering technology students during their undergraduate years. During this learning experience considerable time and effort is expended on the inclusion of features, physical size and shape, and meeting the design requirements. Other considerations typically include cost, style, safety, ecological, and other issues. However, little time is devoted to the end user. Their needs are often neglected.

Most products are designed for the “average user,” a mythical person that may not even exist. As a result, the use of many products by the general population is difficult if not impossible. One way to overcome this difficulty is to involve the end user in the actual design of the product. In this way, they can have a voice in how the product is designed and built from the very start of the project. The end user is no longer an afterthought, but rather an important participant in the entire design, development, and construction process.

Even with the end user involved, creating products that are usable by all is a daunting task filled with potential pitfalls and unintended consequences. Regardless of how well a product is designed, it is unlikely that it will be usable by all people. In numerous cases, the physical or mental boundaries of the end user will limit, hamper, or restrict the use of the product by many people. This issue adds another level of difficulty into the design process.

It is important that future engineers understand these design challenges. Fortunately, there are methods available to assist engineers as they design and create products that overcome these dilemmas, at least to some extent. The most widely accepted approach to designing products, taking all of these factors into consideration, is a set of principles collectively known as universal design. A pilot senior design project utilizing universal design was previously proposed and developed by Richter and Loendorf[9] (2009) and the results are discussed below.

Universal Design

Universal design recognizes the importance of a person's self-image by searching for solutions advantageous to everyone. Many definitions for universal design exist, but they can all be summarized by the following two examples. First, "universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaption of specialized design.[7, 8, 10]" Second, "universal design is the process of creating products (devices, environments, systems, and processes) which are usable by people with the widest possible range of abilities, operating within the widest possible range of situation (environments, conditions, and circumstances)[11]."

Seven principles form the foundation for universal design. They are[1, 3, 8] equitable use, flexibility in use, simple and intuitive, perceptible information, tolerance for error, low physical effort, and size and space for approach and use. These principles reflect designs that are usable by a wide variety of people for a wide range of applications. Other common constraints are gender, cultural, environmental, aesthetics, and cost. Of course, for specific products other constraints, aspects, and design considerations will likely also have to be included.

Four or five guidelines accompany each of the seven principles. They list the fundamental elements that must be present in a design that meets the full intent of the principle. The guidelines extend beyond an explanation of the principle and include details that engineers can follow while designing new products. They also offer suggestions to facilitate the integration of features to fill the requirements for a wide variety of users. However, it is highly likely that some guidelines will be inappropriate for some products.

In the fields of science, technology, engineering, and mathematics[6] (STEM) universal design has been successfully used to remove barriers for diverse learners. This has incorporated "the design of instructional materials and activities that makes the learning goals achievable by individuals with wide differences in their abilities[3]." However, it is important to remember that applying the principles of universal design "does not eliminate the need for specific accommodations for students with disabilities[1]." The use of universal design principles can equally benefit students with and without disabilities while actually enhancing the overall learning process.

Melber and Brown[5] (2008) conducted a study to investigate science education for students with disabilities. They discovered by engaging and empowering students in an informal setting that they more likely to be motivated and in tune with the learning process. Providing the proper accommodations[5] for the student along with flexibility were other important considerations. Collectively these concepts and procedures were integrated into a senior design project utilizing universal design to improve the learning process and environment for students with disabilities.

Interdisciplinary Collaboration

Ronald Mace, recognized as one of the founders of Universal Design (UD), challenged the accepted practice of design for end users that conformed to the average human build and physical ability. He advocated an approach to design assuring accessibility to the broadest spectrum of human characteristics and traits present in society (Burgstahler & Cory[2], 2008). This concept is foundational for the inclusion of people with disabilities to become an integrated part of the community.

If this shift in design paradigm is to be successful it must incorporate an interdisciplinary collaborative approach. Engineering and engineering technology facility and students have over a century of experience designing for the average end user. They are now being asked to change an accepted design standard. This new concept incorporates a myriad of new elements such as, reduced user strength, flexibility, adjustable height needs, and environment of use. No one person or department would be expected to have all the needed information, thereby requiring an interdisciplinary collaborative approach.

This project involved a collaborative effort from three University departments, Engineering & Design (E&D), Disability Support Services (DSS), and the Center for Disability Studies and Universal (CDS) Access. The CDS was created under the United States Department of Education grant entitled "Improving Education Success for Students with Disabilities in Higher Education" (Education[4], 2008). The goals of CDS include:

1. To enhance the educational experiences of students with disabilities at Eastern Washington University.
2. To foster an environment in which students, faculty and staff with disabilities are identified as part of the tapestry of diversity at Eastern Washington University.
3. To provide support for persons with disabilities, in collaboration with Disability Support Services.
4. To promote a universally accessible campus environment for people from all backgrounds.
5. To collaborate and consult with the University community to enhance resources for people with disabilities and other diverse characteristics.
6. To develop and administer the Interdisciplinary Studies Certificate program and other Disability Studies classes at the graduate and undergraduate levels.

Under the (DOE) grant, the CDS initiated a service learning project as part of a senior project for two engineering technology students. Representatives from all three departments agreed that a good pilot project would be to design a portable adjustable desk for classroom use by students with disabilities. Even though this was a joint effort between three departments, two key entities took the lead. Working together the CDS along with the two senior engineering students were the key personnel involved in the project. Collectively, under faculty supervision, they determined the project's scope, design, development, and construction of the universal classroom desk.

During the first meeting, it became clear there was one essential question that needed to be resolved before the group could move forward. How do we structure the discussion? The engineering students were taking a technical design approach while the CDS wanted to take an approach of inclusive design. In an effort to promote an understanding of inclusive design, the students were offered the opportunity to take part in the CDS Universal Design in Education online course.

This course is designed to improve the educational environment for students with disabilities by promoting an environment of Universal Education Access (UEA). This is a concept that accounts for the learning styles of all students regardless of background or characteristics. To illustrate this concept of UEA, consider that this paper was created using a keyboard, the 'offspring' of the typewriter. The first successful typewriter was developed more than 150 years ago as a communication device for blind people; yet the typewriter and now the keyboard has universal application. In recent years, 'universal instruction design' for the classroom has become increasingly popular in educational settings. This course introduces universal design for instruction as well as universal education access that embraces the tapestry of diversity both in and out of the classroom.

After several meetings, a Requirements Document outlining the specifications and functionality for the project was agreed upon, finalized, and approved. The key components of this document were as follows. Foremost, to design and build a portable desk accessible by the greatest number of individuals, including but not limited to people in wheelchairs and students with other special needs. It was further determined that the design should be cost effective. That is, equal to in cost or less than alternatives presently available on the market. Further, the project was to follow the seven principles of universal design. It was also decided that the design would contain the following features:

- It would be portable to the best extent possible,
- It would contain a portable power supply,
- It would contain a power strip,
- It would have a number of USB ports,
- It would contain a bracket or basket to hold a CPU tower,
- It would be lightweight, and
- It would have an adjustable tilt keyboard platform.

Upon completion of the Requirements Document, an initial cost estimate was drafted. After presentation of the estimate cost it became clear that the CDS had grossly underestimated the cost of the project. The CDS discovered that it had limited knowledge in this area. It also became clear that not all of the desired features could be included and still be cost effective. A restructuring of the budget and reduction in desired features followed. This resulted in a desk design with reduced functionality and a slight delay in the estimated completion date. However, when delivered the desk was of professional quality and even with the reduction in features it was still found to be very functional for its intended use.

Project Description and Framework

The senior design project course spans two consecutive quarters during the students senior year. The first quarter is devoted to the design and planning of the project. The second quarter is dedicated to refining the design and building a prototype. Some senior design projects were determined to be a perfect fit for applying the concepts of universal design and these were concentrated on for this pilot project.

The senior design projects are selected by the faculty and chosen to give the students an assignment that would be typical of a task they could receive as a young engineer in the industrial world. Great care is exercised during the selection process to insure the projects can be accomplished within the time, cost, and knowledge constraints imposed for senior design projects. The scope of the project is narrowed and defined prior to their assignment to the students. The project chosen for the first senior project using the concepts of universal design was an articulated desk.

The seven concepts of universal design were introduced during the design process. The students were shown how these concepts of designing for a larger/more inclusive group of users can apply to other projects they might encounter after graduation. The project also included a service learning component. Students were asked to work in an interdisciplinary environment as described in the "Interdisciplinary Collaboration" section ensuring that they did not disenfranchise members of our society by designing projects that present barriers for use. The students learned they could avoid these types of issues by implementing the principles of universal design from the initiation of the project.

This is comparable to training programs that prepare the future engineers to design with "green" intentions for the entire product lifecycle. The senior project design experiences are structured to provide as near as possible a "real world" experience for the young engineer. As a result, the students often work in teams on the project to help them with their group dynamics skills.

Formal project meetings are routinely scheduled with the instructor to simulate weekly update and status meetings similar to those held in industry. The students are required to submit written status reports including schedule updates for the entire project using Microsoft Project. Students are also required to meet with the stakeholders and end users of the project periodically. This is required to formulate scoping documents with deliverables and to guide the preliminary and final designs.

The project selected was to design and produce a prototype desk for use in a classroom environment that was accessible for motorized wheelchairs encompassing the seven principles of universal design. The challenge was to design a suitable desk that met the needs of individuals in motorized wheel chairs while being cost effective. This constraint would allow the desk to be purchased for use throughout the entire classroom rather than for just specific individuals. This goal for a more common desk would remove the barrier requiring students with special needs from being labeled as having to use the “special desk.” Often desks of this type are different and located in the front of the room. Even worse, they might require the instructor to ask for a “special desk” to be brought in.

It would be better for all the desks in the classroom to accommodate the needs of students with all ability levels. Even students without special needs may appreciate and use the added functionality. The projects objective was to show the students that, by using the concepts of universal design from the inception of the project, designs can be more inclusive to a greater segment of our society without having to make special accommodations. In many cases products designed for a wider audience often increases the functionality and usability for all users. A good example of this are the curb cuts used for wheel chair access; they have a far greater number of people using them for bikes, baby carriers, etc. The students also learned that the cost of including a greater audience is often cheaper in the long run than modifying or buying special items for users with specific needs.

The students outlined the work that needed to be done to complete the project from the Requirements Document and prepared a Statement of Work (SOW). The SOW is a description of the project that includes its objectives, scope, major deliverables, work tasks, impact, justification, and management (Wysocki, Beck, & Crane[12], 2000). The SOW was then reviewed and approved by the stakeholders that included Disability Support Services (DSS), the Center for Disability Studies and Universal (CDS) Access, the Disability Services Office (DSO), members of the Social Work Department, and a group of students that would actually use the desks.

The design incorporated both electrical and mechanical elements allowing for the proper adjustment and positioning of the desktop to meet the unique needs of the user. They examined in detail the various desks currently available on campus for motorized wheelchair use. The good features along with the deficiencies of each desk design were noted. Input from the people that would actually be using the new desks led to additional features that were incorporated. The students were acting in a true industrial environment with project status meetings and concrete deliverables. The seven principles of universal design were addressed throughout the design process.

The following figures show the final prototype produced by the students during this project.


Figure 1. The Desk at a Low Setting.


Figure 2. The Desk at a High Setting.


Figure 3. The Desk's Tilt Feature.

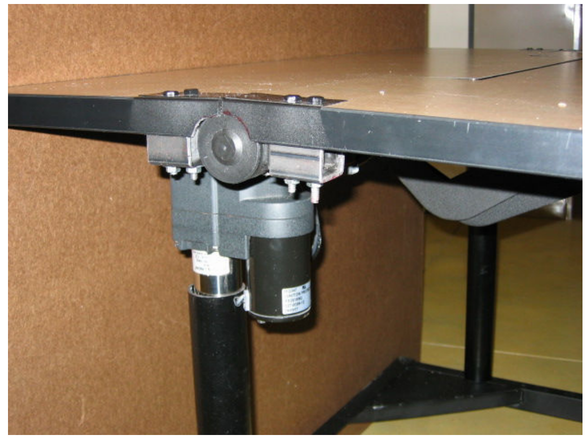
Figure 4. The Desk's Actuator.

Periodic meetings were held with the original stakeholders to make sure that the designs are indeed meeting their needs. Preliminary designs were presented to them and a joint decision made on which avenues to further develop. The final design also had this type of review process and buy in from all stakeholders.

Project Results and Assessment

In keeping with the concept of universal design, the students had to design a desk that could be used by all students including those with disabilities. The final design was also required to be cost effective. This would allow the desk to be purchased and used as a standard desk and not just a few for the special needs individuals. The final design was built as a prototype and tested by both students requiring special needs and those who do not need any special accommodations.

The student's awareness of universal access was appraised by a thorough examination of the design looking specifically for incorporation of the basic principles. The final prototype was judged to incorporate the seven principles of universal design. The student's ability to create designs that are usable by people with varied abilities was assessed through design reviews with the likely end users and other stakeholders. The results in this area have been encouraging. The final prototype desk did reflect that the needs of both special need students and traditional students. The final design was required to be approved by representatives of both groups.

The flexibility of the design for modification to meet individual preferences and abilities was also evaluated by determining the adaptability of the design to meet the needs of its end users. The evaluation of this was judged to be met within the confines of the budget requirements of the design. The design was first critiqued on paper and then through use of the prototype product. The desk design was reviewed by potential users along with staff members from the Disability Services Office and received their approval. However, the real test occurred only after the prototype desk was actually used by the students, faculty, and staff. Their feedback determined exactly how flexible the desk design was.

The amount of physical effort required to use the design was obtained by feedback from actual users. The prototype desk was judged by all that used it to be acceptable. It had adjustable controls within easy reach and required little effort from the user. It was discovered that the placement of the controls must also allow for improper transport of the desk. The final prototype had a switch damaged by trucking services while transporting the desk to the Social Work building for use in one of their classrooms. The control switch was located for ease of use by the student only and therefore was easily damaged by inattentive movers. As a result, the switch location has been modified to correct this defect.

Overall the final prototype desk either met or exceeded all of the project's objectives. It looked like a standard desk but included increased functionality suitable for individuals in motorized wheelchairs. The students were exposed to a "real world" engineering project that included specific specifications, functionality, cost constraints, and stakeholders. By becoming familiar with and incorporating the principles of universal design, the students are better prepared for the challenges that lie ahead for them during their engineering careers.

Lessons Learned

All of the interdisciplinary departments that collaborated on this universal design project have learned some valuable lessons. Theory is very important, but just as important was the ability to bring relevance to the curriculum through real life design projects. In this way, theories from different academic disciplines were combined and applied to solve a real world problem. This collaborative approach to problem solving and product design offered an opportunity for everyone involved to participate in the design process for the final product.

The cost involved with any project is always an issue. In this case, it was the cost to build the universally accessible student desk. Initial cost estimates exceeded the expectations of the university departments that would utilize them. In order to contain the cost, features were reduced without limiting its overall functionality. In the end, it was simplicity of design that brought the project within budget.

Time is always an issue with every project. Allocating enough time to adequately complete a project is difficult, especially in an academic environment. This is especially constrained in a quarter system with only 10 weeks in each term. The need to start early and maintain a steady schedule cannot be over emphasized. An often-overlooked time consuming issue is reaching agreement between all parties, or in this case departments, involved in the products design. It always takes far longer than anyone anticipates.

Another important issue to address early on in the project is communication. Channels need to be established allowing for an open and frequent exchange of information. Primary contacts need to be recognized and regular status meetings scheduled. The need for frequent, open, and honest communication between all parties involved in the design project must be stressed from the very beginning. Many projects have encountered difficulties and delays caused by poor communication.

Conclusions, Reflections, and the Future

Eliminating the exclusion of persons with disabilities by design changes presents a method of correcting hidden social oppression. This often-overlooked problem is experienced by up to one-fifth of the general population. However, by providing this population with social justices, it in itself can have limitations without a proper collaborative design. Inclusion through design must be conducted on multiple levels. These include user need, social need, product purpose, facility capabilities, economic limitations, and design restrictions.

Within the environment of higher education, inclusion by design starts with the individual students need. It is a concept of meeting the need of students with all levels of capabilities. From the very beginning of a project, design must focus on more than the needs of the average user. Rather, it should concentrate on a much broader spectrum, meeting the needs and capabilities of the widest range of students, staff, and faculty.

This began by educating all design team members involved about the important goal of inclusive design. The first step was education addressing the social and cultural aspects and needs of the disability community, and the concept of inclusion by design. This goal was achieved through this senior design project for two engineering technology students and their faculty advisors. This goal will also be achieved on a broader level as future students are trained in the concepts of universal design and incorporate in designs during their engineering careers.

This project was an interdisciplinary exploration into the design of products for common or widespread use. The concept of universal design is widely accepted and the idea of inclusion by design is clear. However, the dissemination of information between departments, organizations, and stakeholders was challenge at times. After merging all of the accumulated information gathered from multiple sources into a design specification, the construction and testing phases proceeded as scheduled. During this project many other products were identified that require design modifications to make them more usable by people with the widest possible range of abilities. Redesigning these products using the concepts of universal design will become the next step for this project.

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