AC 2009-1092: DEVELOPMENT OF AN INTERDISCIPLINARY SERVICE-LEARNING PILOT PROJECT INCORPORATING UNIVERSAL DESIGN CONCEPTS FOR ADA COMPLIANCE

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Development of 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 is 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 conception to end use, thinking more inclusively of the entire population including those with disabilities. This paper describes a pilot project being developed to teach these new Universal Design concepts within the confines of a senior design project for Engineers and Engineering Technology undergraduate students. The students would participate in undergraduate research that has a service learning component while studying the principles of Universal Design. This paper describes how through the use of these types of projects a whole new generation of engineers could be trained to better serve our entire population by applying the components of Universal Design. This paper further discusses how this pilot development project could be a model for other universities to incorporate in their degree programs to enhance both the education of the student and the public awareness of how engineers can enhance the lives of people.

Introduction

Engineering and Engineering Technology students spend years studying how to design products of all sizes, shapes, and descriptions. They learn that during the design process many factors are considered including economic, features, style, standards, safety, ecological, and other issues. However, the unique needs of the ultimate user of the product are often neglected. Products are merely designed for the "average user." This makes use of the product awkward, difficult, or even impossible for many members of the general population.

The over used expression "ease of use" may best describe the problem. This phrase implies that the product is easy for everyone to use. Nevertheless, almost everyone has discovered that it is a relative term based on a person's knowledge, skill, and ability. What is easy for some people to accomplish may be hard or not even possible for others. It is all too common for users to get frustrated while trying to make a product work as advertised and simply quit using it or return it to the store. Frequently the user has no alternative and must continue to struggle with it no matter how difficult, cumbersome, or unwieldy it may be.

In reality, designing a product that can be used by all people is not a simple task. The solution to this dilemma is to design products that can be used by people with a wide range of abilities. It is important to remember that regardless of how well a product is designed, some people will never be able to use it. Physical or mental restrictions will come into play and limit its use. However, it

is important for future engineers to understand this design challenge and create products that conquer it in one way or another. One accepted approach to designing products with this in mind is a set of principles collectively called universal design.

Universal Design

The concept of universal design was derived from the earlier movements toward "accessible design," "barrier-free," and "assistive technologies." Collectively these programs promoted accessibility for people with disabilities. However, the solutions were often isolated in location and out of the mainstream of activity. Use of these solutions separated people and singled out those with disabilities, often hurting them emotionally. In contrast, universal design seeks solutions beneficial to everyone by recognizing the importance of a person's self-image. Functionality is significant along with how things look to others.

Universal design has been defined in many ways, but two definitions stand out above the rest. 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.[5, 6, 7]" 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[8]." Together these definitions clearly show the intent and focus of the universal design process.

A group of seven principles form the foundation for universal design. They are[1, 2, 6] 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. These aspects are on top of the other considerations that must also be included into the design process. Among these constraints are gender, cultural, environmental, aesthetics, and cost.

A set of 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.

Universal design has been successfully used to remove barriers for diverse learners in the fields of science, technology, engineering, and mathematics (STEM)[4]. This may include "the design of instructional materials and activities that makes the learning goals achievable by individuals with wide differences in their abilities[2]." However, employing the principles of universal design "does not eliminate the need for specific accommodations for students with disabilities[1]." In addition, universal design benefits both students with and without disabilities and can enhance the learning process. A study was conducted by Melber and Brown[3] (2008) to investigate science education for students with disabilities. They discovered that an informal setting was more likely to motivate a student to the learning process by engaging and empowering them. Flexibility was another important aspect along with providing the proper accommodations[3]. These concepts

were incorporated into a senior design project utilizing universal design to improve the learning process for students with disabilities.

Project Description and Framework

The senior design projects run for two consecutive quarters during the student's senior year. The first quarter is mainly spent in the design and planning while the second quarter is dedicated to refining the design and building a prototype. Senior design projects are a perfect fit to apply the concepts of universal design.

The senior design projects are selected by the faculty and are chosen to give the students an assignment that would be typical of a task they could receive in the industrial world. Great care is exercised during the selection process to insure the projects are doable within the time, cost, and knowledge constraints imposed for senior design projects. The scope of the projects are narrowed and defined prior to the assignment of them to the students. All projects utilizing the universal design concepts must also include a human element and cannot be exclusively a mechanical, electrical or automation system.

The seven concepts of universal design can be introduced during the design process and shown how they can apply to other projects the student might do after graduation. Service learning is also a component in making sure that we do not disenfranchise members of our society by designing projects that present barriers for use by all society members. These types of issues can be avoided by the proper design of the project from its inception.

This is similar to training the young engineers of the future 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 team dynamics skills.

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

This is the first year of the revised course that now includes universal design. The project selected for this year is to design and manufacturer a prototype desk for use in a classroom environment that is accessible for motorized wheelchairs encompassing the seven principles of universal design. The students are to produce a scoping document after talking with many of the stakeholders for the project. The design must incorporate both electrical and mechanical elements allowing for the proper adjustment and positioning of the desktop to meet the unique needs of the user.

To date, they have met directly with students with disabilities, staff of the Disability Services Office, and Social Work Department to help develop the scoping document. They have

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 have been noted. Input from the people that will actually be using the new desks has led to additional features that will be incorporated. The students are acting in a true industrial environment in that they will have project update meetings and concrete deliverables. The seven principles of universal design are to be addressed throughout the design process.

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

In keeping with the concept of universal design, the students will have to design a desk that can be used by all students including those with disabilities. The final design must also 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 will be built as a prototype and tested by both students requiring special needs and those who do not need any special accommodations.

The hope of the project is to show the students that by using the concepts of universal design from the inception of the project we can be more inclusive to a greater segment of our society without having to make special accommodations. Indeed, to date we have found that designing for a wider audience often increases the functionality and usability for all users. An example of this is the curb cuts used for wheel chair access have a far greater number of people using them for bikes, baby carriers etc. The students will also learn as part of the course that the cost of including a greater audience is cheaper in the long run than modifying or buying special items for special needs users.

Project Outcomes

The senior project is intended to be a real learning experience for the students. It offers an opportunity for them to apply in a very constructive manner all of the engineering knowledge they have acquired during their undergraduate education. It is their first real world engineering design experience.

To that end, five critical outcomes are expected from the students. First, increase the awareness of universal access in order to incorporate it into every design. Second, develop the ability to create designs that are usable by people with various abilities. Third, incorporate flexibility into designs that can be modified for individual abilities and preferences. Fourth, create designs that are easy to use for people with varied abilities. Fifth, generate designs that require minimal physical effort to use.

Good designs will meet all of these outcomes. The students are challenged to include all of them into their designs while exceeding the expectations of the stakeholders and end users. This senior project design experience lays a foundation that can be utilized throughout their industrial careers. They become better engineers producing better products for consumers with all levels of abilities.

Project Assessment

Even though the first project of this type is only nearing the midpoint, some measurement data relating to the outcomes is available. The methods used to determine the accomplishment of the outcomes will be reviewed and updated after completion of the first years project. However, the process that will be used to currently measure the attainment along with the initial information relating to each of the outcomes is presented below.

The students awareness of universal access will be appraised by a thorough examination of the design looking specifically for incorporation of the basic principles. The specific project being designed will have some influence on which of the universal design concepts are employed. The design prototypes for the classroom desk currently include aspects relating to all seven of the universal design principles satisfying this outcome.

The students ability to create designs that are usable by people with varied abilities will be assessed through design reviews with the likely end users and other stakeholders. The results from these meeting have been encouraging. They reflect that the needs of the users have been incorporated into the designs for the new desks.

The flexibility of designs for modification to meet individual preferences and abilities will be evaluated by determining the adaptability of the design to meet the needs of its end users. The designs will be critiqued first on paper and then through use of the prototype product. The desk designs have been reviewed by potential users along with staff members from the Disability Services Office and received their approval. However, the real test will occur only after the prototype desks are completed and actually used by the students, faculty, and staff. Their feedback will determine exactly how flexible the desk design is.

The designs ease of use by people with varied abilities will be reviewed through focus groups representing both students with and without disabilities. At this stage of the project, only the paper design has been evaluated for ease of use and it was received favorably. Since ease of use is a relative term, the real test will occur after the prototype has been completed and people with various abilities actually begin using the desk.

The amount of physical effort required to use the design will be measured by feedback from actual users of the design. The current designs have the desks adjustable controls within easy reach and require little effort from the user. Once the finished prototype desks have been completed, users of all abilities will be able to determine if the operating forces required are appropriate and reasonable. After all, the best judges of the effort required to adjust the desk to suit the individual's needs are the end users.

At this point in the initial project only some of the outcomes from this senior design project can be evaluated. However, the feedback from the likely users, Disabilities Services Office, the Social Work Department, and the engineering students involved has all been encouraging. More data will become available throughout the remaining phases of the project.

Conclusions and the Future

By applying the principles of Universal Design the engineers of the future can become better trained and prepared to serve the population as a whole with every product they design. Students encounter their first opportunity while completing their undergraduate engineering education with the senior design project. This is a threshold experience that applies all of the knowledge accumulated during their academic years into one project that must meet or exceed the expectations of the stakeholders and end users.

This pilot product development project is a model that can be replicated by other colleges and universities offering engineering or engineering technology programs. It enhances the students learning process as well as the public's perception of how engineers improve people's lives through the products they design.

The project will be expanded in the future to include all student designs. As a result, students will be exposed to the concepts of Universal Design throughout their engineering curriculum. The goal of this service learning focus is to train engineers that are better prepared to serve the entire population as a whole and not just one segment or another.

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