Introducing Assistive Technology and Universal Design Theory, Applications in Design Education

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Abstract The aim of this study was to better understand student assumptions related to the challenges of developing a universally designed device compared to designing a dedicated assistive device. Two projects were conducted in a sophomore industrial design studio class. Data was collected from students via surveys. Results of the projects and suggestions for conducting similar projects are presented.

1 Introduction

The aim of this paper is to examine methods for introducing undergraduate design students to the concepts of Universal Design (UD) and to the design of Assistive Technology (AT) devices. UD here is defined as the design of environments and products to be usable by all people to the greatest extent possible so that adaptations without the need for adaptation or specialised design (CUD 1997). In practice, universal design helps to ensure that more people with varying abilities will have a better chance to be able to effectively use and benefit from a product. Design schools in the United States have been slow to adopt universal design, even as the number of individuals who will experience some level of limited ability is forecast to increase in the future (Fletcher et al. 2015). This makes it more important that designers are trained to consider a wider range of abilities when designing future products.

It is similarly important to introduce students to the design of assistive products. Assistive technology here is defined as any item, piece of equipment or product system, whether acquired commercially off the shelf, modified or customised, that is used to increase, maintain or improve the functional capabilities of people with disabilities. AT is distinct from UD in that the objective is to improve a specific functional ability rather than to achieve broad, general usability.

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A key element of this learning is enabling students to interface with potential users, particularly, those with disabilities (Burgstahler 2007). This is an important component to allow students to develop confidence in their ability to interface with people who may have very different needs and perspectives. Without it students may not have a way to solicit feedback on their designs (or may not take the initiative to seek feedback) and test/challenge their own assumptions.

It is arguably important to educate design students early about both Universal Design and Assistive Design and provide the opportunity to gain practical experience with both. With an early introduction to these concepts, students will have the opportunity to apply their experience to both future projects during the course of their training and into their professional careers (whether product design or other fields).

2 Method

This study was performed in a university industrial design class. All students were sophomores taking a foundational project-based studio course which is focused on teaching foundational product design skills and methodologies. Many user engagement techniques are introduced in the second semester. The aim of this study was to better understand student assumptions related to the challenges of developing a universally designed device compared to designing a dedicated assistive device.

The students completed two projects: the first (UD) focused on a universally designed device followed by a second (AT) to design an assistive focused device. Students were given surveys at two points during these projects. The first survey was given at the end of the UD project. It included questions asking students to provide their opinions about various aspects of the UD project and what they learned. It also included questions about their assumptions of assistive design. The second survey was given at the end of the AT project. It asked students to provide their opinion about various aspects of the AT project and what they learned. It also included several questions asking them about their general perceptions (after completing both projects) of universal design, assistive design and the differences between them.

A total of 34 students between two class sections completed the surveys. Participation was voluntary and the surveys were administered by a neutral party (not the instructor) and held until after grades were finalised for the semester. Since the project was conducted within a class, the process was outlined in the informed consent provided to the students to make clear that their participation, and any opinion provided about the projects, would have no impact on their course grade.

The primary feature of both of these projects was the recruitment of real, potential end users of products the students would be designing and scheduling their participation in the class. The projects were organised so that students prepared for user visits by formulating interview questions, preparing surveys or planning tests to gather data about their prototypes/designs. This allowed students the opportunity to realistically exercise their user engagement skills.

The universal design project was assigned first. It was a team project performed by students in teams of 3–4 students. The assigned goal of the project was to create a universally designed carry-on travel bag which included mobile-enabled features. This bag had to meet the needs of the general travelling public (business/leisure travellers, flight attendants, etc.) and also the needs of users with limited mobility. Some of the specific project requirements were as follows:

- The specific use environment for this exercise was air travel, with other types of travel (train, bus, car, etc.) being considered as secondary uses.
- The luggage had to be of a carry-on size (such as a carry-on roller bag). Bags of a size that require them to be checked were not to be considered).
- The luggage had to include mobile/wireless-enabled features intended specifically to meet the needs of users in the air travel environment.

Students were provided with the opportunity to interact with mobility limited users during class time at several points during the project. This was arranged to ensure that all students undertaking the project had equal opportunity to meet with this user group, since many students may not have the resources/connections to be able to connect with them on their own. It also provided a consistent and controlled environment.

The first meeting, consisting of manual wheelchair users, was arranged during the second week of the project at the Shepherd Center, a spinal cord and brain injury rehabilitation centre. The goal of this meeting was to allow students to interview users and to learn about their travel related needs. Students spent the first week conducting research, preparing questions and engaging with other users on their own. After the class user meeting, students completed development of personas for mobility limited users as well as for other users met on their own. Students then developed and tested initial design concepts in order to fabricate a study model to use to conduct formative testing with users.

In the third week of the project, another meeting with mobility limited users was arranged. This meeting was used to test their study models with users and to obtain feedback on their chosen design direction and features. Students used the results of this testing, along with testing performed on their own with other users, to refine their design and fabricate a final mock-up for testing.

A final meeting with mobility limited users was provided in the fifth week of the project. This allowed students to perform summative testing of their design and obtain final feedback on what changes/additions worked well (or not) between the initial and final design concepts.

The assistive design project was assigned next. This project was not performed as a team, and each student developed his/her own design. Each student was responsible for researching/investigating an assigned task scenario to identify a potential design problem, success criteria for the design and then to design a solution to the identified problem.

Students were assigned to one of two possible scenarios focusing on users with low vision:

- Travelling from the studio building to a bookstore across campus via the campus shuttle, making a purchase and then returning to the studio via the shuttle.
- Travelling from the studio building to the student centre and ordering food at the cafeteria, selecting food, paying for it, eating the food and then returning to the studio.

Within these scenarios, each student was required to identify a problem/barrier and then to design and fabricate a working product prototype to reduce/overcome it. It is important to note that this was NOT a re-design project. One of the boundary conditions was that the new product had to work within the existing environment, not re-design the environment itself. For example, a student would not design a new tray for the cafeteria but could instead design a product that worked with the current trays in order to solve a problem/barrier. This was a necessary condition to limit the scope of the problem space to something more appropriate for a relatively short project and help the students focus on more manageable problems.

For this project, groups of low vision users were scheduled to visit class in order to provide input and feedback. Students spent the first week of the project researching and defining the problem they would design for. As they began developing design concepts, initial testing was performed via simulation. Students were provided with Zimmerman Low Vision Simulation Kits. These allowed simulation of visual acuity conditions (20/70, 20/200, 20/500 and 20/800), peripheral field of view loss conditions (3°, 7° and 10°) as well as conditions including macular degeneration (near and far), cataract, scotoma and hemianopsia.

The first meeting with users was arranged during the second week of the project. During this visit, students interacted with the users to discuss their solutions and to solicit feedback. Most importantly, each student personally walked through the scenario with three different users. This gave them the opportunity to both perform observation as well as to discuss issues with the users within the actual scenario environment. Students were challenged to think about how their simulation approach compared to the experience of users who actually have the disability and find out possible approaches directly from the users to allow them to more accurately recreate the user experience. Ultimately, students were encouraged to reflect on what insights they were able to discover about the user's experience in going through the task with them that they could not discover through simulation (Fig. 1).

The gathered input was used to update the designs and to fabricate a final, testable prototype. Low vision users again visited class at the end of the third week in order to test the design concepts and to engage the users in a participatory fashion to identify potential improvements. Students again worked with users to test their concepts within the actual scenario environment. Students then used this input to fabricate a final prototype. The final designs were evaluated by a panel of external reviewers, which included visually impaired academics and assistive technology design professionals.

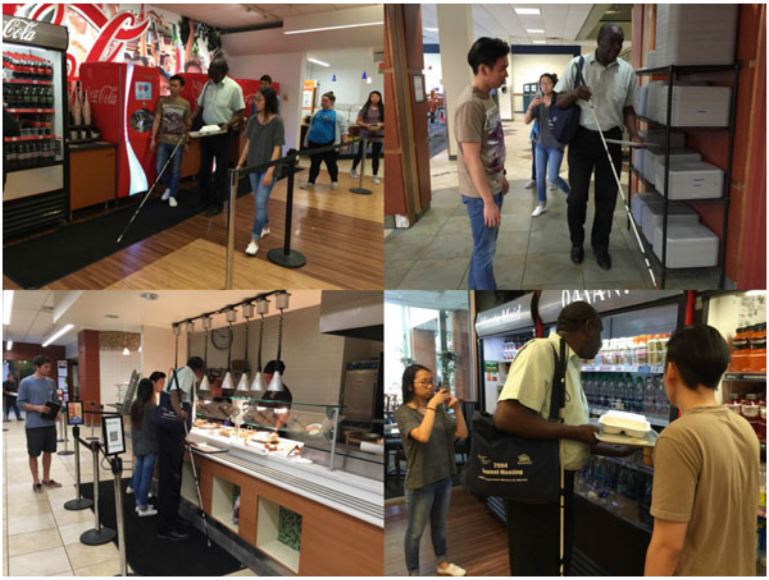

Fig. 1 Students shadowing a user through each step of performing a task in an assigned scenario

3 Results

The following tables show the results of the two surveys. The questions in the first survey, and responses presented below and in Table 1, included

(1) Have you ever temporarily lost your vision (such as from an injury)?
(2) Have you ever temporarily lost the use of your arm (such as a broken arm or other injury)?
(3) Have you ever known a close friend or family member who has permanently lost their vision?

Table 1 Student answers to the first survey

Question	Yes	No	a.	b.	c.	d.
1	7	27				
2	7	27				
3	4	30				
4	7	26				
5	2	32				
6	2	32				
7	18	16				
8	10	9				
9	0	34				
10			0	1	20	12
11			0	7	24	2
12			0	28	6	

(4) Have you ever known a close friend or family member who has permanently lost the use of one or both of their arms?
(5) Have you ever had to provide care for someone who has permanently lost their vision?
(6) Have you ever had to provide care for someone who has permanently lost the use of one or both of their arms?
(7) Have you ever used a device to simulate a condition or situation?
(8) If yes, did you find that the simulation was an accurate representation of the condition or situation?
(9) Have you ever tried to design or build a device to simulate a condition or situation?
(10) How easy do you think it would be to build an accurate simulation tool?

a. Very easy,
b. Somewhat easy,
c. Somewhat difficult or
d. Very difficult.

(11) Do you think a simulation tool will be able to allow you to experience *everything* in *exactly* the same way as an end user?

a. Yes, I think it is possible to make a simulation tool that allows me to have the *same* experience as an end user.
b. I think it is possible to make a simulation tool that allows me to experience *mostly* the same experience as an end user.
c. I think it is possible to make a simulation tool that allows me to experience *some specific aspect* as an end user.
d. No, I don't think a simulation tool can provide me with the same experience as an end user.

(12) Do you think a simulation tool would provide you with the ability to test a product in the absence of an end user?

a. I think a simulation tool would provide a fully accurate way to test a product.
b. I think a simulation tool would provide an accurate way to test for specific scenarios.
c. I don't think a simulation tool would provide an accurate way to test a product.

The questions in the second survey and responses are presented below and in Table 2. The questions on the second survey included

(1) How easy was it to build an accurate simulation tool for the situation in this project?

Table 2 Student answers to the second survey

Question	Yes	No	a.	b.	c.	d.	e.
1			2	8	12	3	
2			0	9	9	7	1
3	11	10					
4			0	6	7	4	0
5	3	17					
6	12	8					
7			7	17	2		
8			21	2	2		
9	4	17					

a. Very easy,
b. Somewhat easy,
c. Somewhat difficult or
d. Very difficult.

(2) Was your simulation tool able to accurately replicate your problem condition?

a. Yes, it was the same as the problem condition in every way.
b. Yes, it was the same in most ways, but not perfect.
c. It was the same in some ways but not the same in others.
d. No, it was only the same in a few ways, but mostly different.
e. No, it was different from the problem condition in every way.

(3) Did you validate your simulation tool with actual users?
(4) If yes, how closely did the users say that the simulation tool was able to match their own experience?

a. It was the same as the problem condition in every way.
b. It was the same in most ways, but not perfect.
c. It was the same in some ways but not the same in others.
d. It was only the same in a few ways, but mostly different.
e. It was different from the problem condition in every way.

(5) If your simulation was not accurate in some way, were you able to correct it?
(6) Did product testing with your simulation tool give the same results as when you tested your product with end users?
(7) What did you learn about the design of your product based on the simulation tool?

a. A lot. I was able to find many design problems that I wouldn't have known without simulation.
b. Some. I was able to find some useful design problems that I wouldn't have known otherwise.
c. Nothing. The simulation tool did not help me identify any new design problems.

(8) What did you learn about the design of your product based on feedback from users?

a. A lot. I was able to find many design problems that I wouldn't have known otherwise.
b. Some. I was able to find some useful design problems that I wouldn't have known otherwise.
c. Nothing. I did not learn about any new design problems from the users.

(9) Based on your experience from this project (project 3) do you think that it is possible to design a universally designed product that will always work for all people with different abilities?

- Yes, I think a universally designed product is always possible.
- No, I think a specifically designed product that works best for particular people is sometimes needed.

The second survey included several free-form questions. These are presented below along with some select responses.

(10) What was the biggest challenge related to assistive design that you encountered during project 3? Were you able to solve it?

- Some users found the device unuseful because they didn't think their vision was as bad as others and therefore did not need the device.
- The biggest challenge was finding unique ways to relay information to the users with limited vision. I solved it by finding creative ways that use the other senses (hearing, though, etc.).
- Not over thinking the design. I kept trying to do too much when the solution was very simple.
- The sheer variety of different users and different impairments.
- Because my initial exposure and preconceived ideas about 'visually impairment' was very little to none. I thought that it would be very difficult adapting to a brand new perspective, possibly even changing them as well. But I found that research into specific diagnosis helped. The user interviews and simulations helped the most.

(11) Was there anything that you expected would be a big challenge before starting project 3 but turned out to be easier than you thought?

- No, I expected that everything would be hard and they were.
- No, everything was challenging.
- I thought making a product for a limited vision users functional would be the most difficult. This required me to think outside the box for building and simulation tools.

(12) Comparing project 2 (universal design) and project 3 (assistive design), what do you feel is the biggest difference between them?

- Project 2 included so many other considerations because it included a wide range of target users. But project 3 was easier because it focused on a specific group.
- You have a smaller audience and can focus on working to solve some of their problems and not focusing on trying to accommodate the majority.
- Specifically making a product for a target demographic, or users, is something I prefer. Project 3 allowed me to focus all efforts onto solving a single issue rather than project 3.
- The bigger challenge of project 3 was the open-ended scenario.
- Project 3 was probably more difficult because simulating (and testing) it was more challenging and visual impairment is even more difficult to understand if you don't live with it.

4 Discussion

One of the main aims of both projects is to get students to think outside of the box and learn to identify design opportunities. For many students, this aspect (identifying design opportunities) was one of the most difficult tasks. To this point, most students' experiences are that assignments/projects generally give a very specified problem with particular boundaries, and consequently a limited number of solutions. That was not the case with either project as students were simply given a defined scenario/environment and were tasked with identifying a design problem along with the performance and success requirements for a viable solution. This is a difficult skill to learn and requires practice (and room to fail) but it is critical for a designer as it relates directly to innovation.

The vast majority of the students in the class were non-disabled. A small percentage of them reported personal experience with temporary disability or have known/cared for a close friend or family member with a disability. Most students began the AT project with mixed expectations on the effectiveness of simulation. Most did not expect that it would be perfectly representative or completely useless. Most had moderate expectations that it would be somewhat to very useful. At the end of the project, their experiences seemed to match initial expectations. They found simulation provided some insight, but that it was not perfect. By walking through the assigned scenarios and directly discussing their simulated experiences to users' own experience with the scenario, students found that their product testing results through simulation and testing results with actual users were almost always different. Students reported that they were able to improve their simulations in some ways after comparing their experiences with users, but that it was not a substitute.

Simulation under any circumstance is not perfect. There are advantages and limitations. Students were able to experience and learn from this first hand through the assignment. The best way to begin to know this is through experience, but students need to have some real understanding that there actually are limitations that could lead them to bad assumptions and poor design decisions. Many students often assume that their first ideas of a simulation are perfect without realising that they have not considered many factors. Through this project, they were able to experience this first hand and become aware of the possible issues to consider in their future design work.

The broader lessons in both projects, beyond the actual design solutions, were the most important: practice engaging actual users and directly tackling unexpected issues; building empathy through direct interaction; learning about the advantages, disadvantages and appropriate use of simulation; challenging assumptions of personal views of the designed world; and understanding the differences between universal and assistive design. The engagement of actual users, while logistically difficult to coordinate in a class/project setting, is critical for allowing these to be learned, and are a powerful experience for most students.

5 Future Suggestions

The short time frames of both projects presented challenges to addressing user's problems in a meaningful manner. This limited the level of finish achievable in testable prototypes and left little time to refine designs based on feedback or results from usability testing.

Working with users unfamiliar with the design process was sometimes problematic as end user participants in both projects were often enamoured with what the students accomplished and tended not to be particularly objective or critical of the solutions offered by the students. The subjective nature of their feedback was not universally helpful. It is suggested that users, as a group, be briefed on the design process before interaction with students in order to set their expectations and help them to provide more relevant feedback.

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