The Role of Diversity of Knowledge in the Growth of Universal Design

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

James Cloetingh Easter

Spring 2022

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Kathryn A. Neeley, Associate Professor of STS, Department of Engineering and Society

Research Into Universal Design and What Fosters Its Growth

Introduction

The idea of universal design has been around since the early 20th century and is one of the key ways of implementing the strengths of diverse perspectives into a project. The scope in which universal design affects all people is much broader than what one may expect. The skill to conduct the engineering design process properly is wielded only by a few, yet it is important to consider how this design process may be improved. Universal design is the engineering practice of designing products for everyone to be able to use them; therefore, universal design should be the ultimate goal for engineers working to best practice a code of ethics and better understanding of how their product or design may affect the world. The idea of universal design is so infinite that it can be found in products and designs that affect the quality of everyday life of every individual (Izzo, n.d., 2). For example, a very common and mundane concept such as the design of an automatic door opener is one that people interact with daily in their lives. The design of the automatic door opener implements some of the key values in universal design because it is used by all, yet it also provides access to all. The design itself heavily takes into consideration that the door may be used for people who are unable to physically open the door by themselves. This key value to universal design is shown by the inclusivity included in how the product is used (Al-Azawei et al., 2016, 1). This product makes life easier for people with disabilities, and it has no discriminatory features in which a person would not be able to use it. This is the idea of Universal Design, the concept that thought went into designing a product so that it can be used by everyone.

Unfortunately, many other products and designs have far more complex concepts and constraints to take into consideration during the engineering design process; as a result, often

projects are not constructed with the idea of universal design. Walking into a store is a great example of the lack of universal design. There are so few products that are universally designed on the shelves. Main universally designed products include electric razors and toothbrushes, keyboards, and audio books (Brill, n.d., 1). There are thousands of products in a store but only a handful are recognizable as being universally designed. It is important to note the variance and complexity in products and designs. At first glance, there seems to be no correlation between what products are designed universally and which ones are not. Though simplistic designs may be inherently universal, it is vital to integrate the concept of universal design into all engineering projects.

Society is just beginning to face more complex problems which will inevitably lead to advances in which the solution will be more complex technology. These more advanced designs and products come with the responsibility of facing much larger consequences for humankind. Though small, simplistic projects like the automatic door can affect the everyday life of people, there will be a continuation of much larger problems that make it into the design process. For example, human bias has created vast amounts of inequality in the world; moreover, that bias can make its way into products such as AI designed to predict certain emotions or pain for individuals receiving treatment at a medical facility. This historical data pulled from human bias, where people of color may be represented as having a different pain tolerance should not make its way into the technological product to continue inequality. From a marketing perspective, products are becoming more complex as companies try to develop new user features to attract customers. This phenomenon is resulting in new products that increase the number of products that need to be universally designed. However, the number of products that are being designed

universally is not increasing to match the rate at which these complex products are being released.

The complexity of solutions resulting in more complex products and designs creates a gap for those solutions in which universal design is being considered and where it is not. As a result, this issue furthers the inequality gap for those who are unable to use these new technologies for their own advancement. Specifically, as this gap increases, it creates hardships for those who cannot use the products who are often already in historically marginalized groups. This is seen through legislation requiring universal design in certain products such as The Rehabilitation Act of 1973 and The Civil Rights Act of 1964 (Maisel & Ranahan, 2017, 1). When products aren't universally designed inherently there are certain groups of people who can't use the products. Examples of those affected most by this are the deaf & hard-of-hearing, wheelchair users, amputees, people with learning difficulties or learning disability, people with limited mobility, and the blind & low-vision (Sparke, n.d., 1). Those who can't use the products probably already experience difficulties in using products in their lives and it adds one more product that they can't use. This continues to widen the gap between groups of people who can and cannot use the product.

In this paper, I argue regulation or the implementation of engineering ethics and standards within a company urges the use of diversity or knowledge and perspectives within a design ultimately resulting in a more inclusive designed product. The environment and culture surrounding an engineering design process has a direct correlation in regarding how a company or country values diverse perspectives and the universal design process. This correlation is shown by the fact that more government regulated products such as public access products are more universally designed than products without any regulations. I will also provide the research

and evidence that is needed to answer the question of what causes universal design and what roles factors such as culture and diversity of knowledge plays in its growth. In more depth, this research will be conducted through an analysis of the definition of the problem stunting universal design followed by presenting the groundwork already laid through historical and cultural examples and how they relate to the factors encouraging universal design to become more widespread.

II. Problem Definition

Universal Design And Its Role In The Future And Consideration In The Engineering Design Process for Complex Problem-Solving

Universal design was first introduced in the United States by Ronald Mace in the 1970s and has since been gaining popularity as the primary term to describe this design process (Al-Azawei et al., 2016, 1). Universal design is a concept that has found its way into many different environments and final products. One of the main ways that universal design interacts with individuals and affects their quality of life daily is through infrastructure. Some examples in which universal design has manifested its forms within infrastructure includes stairs that are sloped to also be a ramp or automatic doors that employ motion sensors rather than manual handles. These designs consider both a minority group of people such as people with disabilities and a majority group such as individuals without disabilities who are both using this infrastructure for their everyday lives and commutes. These inclusive designs are constantly improving in order to consider both groups of individuals. Furthermore, there are other products that may not be as applicable to everyday life as infrastructure that affects mobility; however, often universal design can be inclusive while remaining targeted towards a certain audience.

For example, there are now efforts to include more universal design in teaching in schools. One product relating to this implementation is the Speakall! App. “(The) App offers a user-friendly, customizable program that helps students with autism improve their communication and classroom behavior skills. The Speakall! App was developed by the Engineering Project in Community Service (EPIC), a team of engineers and undergraduate students at Purdue University in Indiana. The app uses traditional communication aides such as low-tech picture exchange communication system in which children trade pictures for items desired and a mid-tech electronic device that speaks out constructed sentences” (Izzo, 2012, 4). This app is an important example in illustrating the way in which universal design relates to actor-network theory. Specifically, some of the actors include those involved in carrying out the universal design process resulting in the product. Furthermore, the product itself is a relevant factor in which actors such as those communicating through the app are using it to demonstrate the importance of the ideal and semiotic actor, universal design.

The importance of universal design can be best explained by looking at historical examples in which inclusivity in the design process was absent. In the early 1950s, a person with disabilities would face numerous barriers while trying to perform a task such as going to the grocery store. At that time, most homes built only had doors and hallways that were about 28 inches wide while wheelchairs at the time were between 25 and 29 inches. This exclusive design meant if a person with disabilities who would require a wheelchair wanted to move through a home, they would have little to no room to maneuver, if they could even fit (Williamson, 2012, 7). Even after a person made it out of their home, they would need a special ramp, which would need to be custom-built to get from the porch to the sidewalk as it was not an off-the-shelf product like it is today. Afterwards on the way to the supermarket, the person would encounter

many infrastructure barriers such as curbs without ramps. Those conditions are vastly different than what a person with disabilities would experience on a commute today; therefore, my research aims to find out the factors which encouraged the spread of universal design and in what ways this concept can be put to practice in more engineering products. Part of the spread of this ideology was due to the civil rights movement which helped show the world the hardships that people of color and people with disabilities struggle with. This movement also helped encourage new legislation to prevent discrimination and facilitate new ways of designing things such as universal design(ADL, 2000, 1).

A similar parallel can be drawn to today and the ever-growing expansion of apps and technology. Technology is currently being implemented into every product known to man and this brings an entirely new set of barriers to people with disabilities and people of color. Most recently the addition of facial recognition added extra barriers as it would not recognize people of color as humans. This mistake in technology was quickly recognized as another lack of universal design and as just the creation of another racist program (Conger, 2017, 1). Most would not think twice about adjusting their thermostat but for people with disabilities, it can be quite hard once the technology was involved. With the addition of smart products in the home, all of the settings for the products are controlled through the owner's phone. This design is fine for the majority of people; however, it is not inclusive for those who are blind or deaf. Most in-home thermostat apps have no way to read the screen or listen for commands from the phone. Currently, there are accessibility features built into Apple products, but the features are not regulated or necessarily the same between manufacturers. Some examples of the accessibility features and who they cater to are useful but not comprehensive. “For consumers with vision loss, the iPad, iPhone, and iPod touch have VoiceOver technology which will audibly speak

what is on the screen and what the user is interacting with. For those with limited vision, the iPod touch has color inverting features to enable white text on a dark background. The contents of the screen can be enlarged or zoomed in. Numerous researchers are incorporating these devices and various apps to provide instruction or support for persons with disabilities" (Izzo, 2012, 2). This example is important in illustrating the way Apple's corporate culture is placing value on incorporating universal design elements into its product. Specifically, the effect of this action is instilling the value of inclusivity in its engineers which is an important takeaway. Apple is taking an ethical stance as a business through its engineering design process by providing an insight as to why it is including universal design in its products: inclusivity and respect for others. Businesses and companies should be held accountable for the culture they create in which they have the ability to shape the context in which a product is made through universal design. The diversity of perspectives and knowledge should be respected as key values in the design process.

III. Methods

Historical Context Of Universal Design And Its Role In Society

The most important tactic in implementing universal design in a project is to teach it. Creating a corporate culture that values respect and inclusivity will make way for the universal design process in its projects. Furthermore, universities who want to create better engineers should teach ethics behind problem-solving and creating real life solutions that directly affect society and the quality of life of people. Specifically, this research created a foundation from two studies that looked into how universal design in the teaching environment affects learning. One of these studies was conducted by Ohio State University and looked at how universal design is implemented in STEM courses. They found that "Professors are attuned to the need for greater

flexibility in instructional design while maintaining high standards to teach STEM students with and without disabilities. Universal design offers a promising approach to meeting the learning needs of all students. The UDL framework challenges educators to rethink the nature of their curriculum and empowers them with the flexibility to serve a diverse population of learners" (Izzo, 2012, 1). This is a great step in the right direction for universal design. It shows that those in positions of power such as professors are seeing the need for universal design and are trying to implement it for the next generation of designers. Once these designers enter the workforce their ideas and thought process can help sway others to designing universally. In addition, the second study relates to universal design in learning by synthesizing a study conducted on the materials used in the classroom and how well they incorporated universal design into teaching as well as how that affected the students. The study concluded that the materials which used universal design techniques instead of a one-size-fits-all approach helped students learn the best and helped all students master the material (Al-Azawei et al., 2016, 2). This can be related directly back to products and how one-size definitely does not fit all in a lot of current products on the market. With the widespread usage of universal design hopefully society can at least get to products working for everyone but it starts at the core with designers implementing this process.

Beyond the educational environment, this research explores how the lack of universal design in community planning has created destabilized conditions for minority groups. Specifically, this lack of inclusion is widening the inequality gap that is relevant all over the world. The University of Virginia has a wide diversity of students including individuals with disabilities. However, even a progressive school such as the University of Virginia, has room to grow as it still has not incorporated universal design into its infrastructure. For example, any student at UVA who had a class in one of its historic buildings on Grounds can see how big of a

problem the lack of universal design is. Moreover, Michelle recalls that in order for her to enter the building she had to open two doors in opposite directions all while trying to operate her wheelchair. She requested an automatic door opener, but because of the historic building, she was asked to withdraw the request since pieces of the historic building would have to be replaced to install the automatic door (Dhyne, 2018, 1). Another example that highlights the room for growth even at UVA includes the story of Evan Dunks. Evan is a paraplegic student at UVA and brought up the point that most people with disabilities cannot streak the lawn because there was no handicapable ramp connecting the different tiers of the lawn (Heuser, 2019, 1). He required several friends in order to help him streak the lawn which students at UVA often consider a central part of their experience on Grounds. These students are just a sample of the stories that occur every day due to the lack of universal design and also illustrate the consequences of not fixing the problem. Moreover, the University of Virginia is a very small community in comparison to the entire world; therefore, these negative consequences of not including universal design, even in a progressive culture, do not scratch the surface of the inequalities and hardships faced by minority groups globally. After reviewing just a few instances of the lack of universal design it is quite clear that there is a distinct need for more universal design. To ensure an increase in universal design it is important to evaluate factors that lead to its growth.

Finally, after reviewing a collection of unique examples of how people with disabilities incorporated universal design into their lives by modifying consumer products, this research analyzes the core of universal design and how it helps individuals. From the collection of designs, it seems as though almost all areas of engineering completely disregarded universal design well into the late 1980s. This lack of inclusion parallels historically biased attitudes at the time which have been highlighted by the need for the Civil Rights Movement in the 1960s and

Human Rights Movements that continued well into the 1980s and onward. The movements affected the lives of people of color, people with disabilities, and other minority groups like women. One major, historical example includes the design of cockpits in reference to the gender of pilots during World War II. This design later affected the use of devices during flying and the ability for individuals to become a pilot. Specifically, these designs had to change for the safety of all pilots and to increase inclusivity in the profession. Furthermore, at these periods of time the only consumer products that included most people with disabilities were specifically designed for those users, which does not meet the requirements for universal design. Designs made for a specific minority group can help with inequality; however, it should still be encouraged to incorporate universal design to help specific users and have similar benefits for all users overall.

IV. Methods

Defining Universal Design At Its Core

The factors that contribute to universal design tie back into the values of any corporation, business, country, or individual. Universal design goes hand-in-hand with the ethical code an engineer should strive to follow and maintain within their life. At its core, universal design means understanding and empathizing with the perspective of other individuals when designing a product. As humans are socially dependent creatures, it is important to consider what we owe to each other when carrying out our professional duties ethically. Moreover, the University of Virginia has highlighted the importance of an ethical code for engineering professionals and this emphasis should be included in corporate engineering cultures to continue to value perspectives of others and practice respect in regards to diversity of thought. Engineers are problem-solvers; therefore, as research shows, problems are best solved through a team of diverse perspectives in

order to use all actors' perspective strengths and define the problem to the best ability of a collective team rather than one exclusive individual. Making an engineering design choice without the consideration of universal design can be detrimental to marginalized groups who are already facing inequality. Engineers must hold themselves accountable in the design process in the same way they would apply safety constraints to help individuals. However, because of the limitations to universal design being taught to all engineers and the lack of emphasis on it within corporate culture, the engineering world must make strides in facing the lack of knowledge surrounding the importance of universal design. This lack of knowledge can be inferred from all the products that are designed each and every day without the use of universal design. All the examples highlighted in the paper about products designed for people with disabilities were not designed to be used by everyone, they were designed to be used solely by people with disabilities. That is inherently the opposite of universal design. Though products that help marginalized individuals help more towards equity, it is important to consider the opposing side such as products made only for the majority. Furthermore, the latter happens far more and results in negative consequences such as the widening of the inequality gap.

Finally, this research will dive into the ways in which corporate engineering and businesses could be incentivized to include universal design in their culture. This solution poses the question: could profit make people care about universal design? After viewing all of the evidence, it seems plausible profit does have an effect on whether it would increase businesses' consideration regarding universal design. Furthermore, products that are often built with universal design in mind seem to become a more profitable product. Specifically, when considering how companies chose target markets, it would make sense that the market that incorporates the lives of more individuals would be more profitable as it provides a solution for

more people. However, in the current business world, there is a sad, but true correlation regarding how universally designed products are created. It appears that all the evidence points towards the fact that products are only universally designed if there is a law requiring the inclusivity within the design process. For example, the reason that universal design is seen most prominently in infrastructure today is because the 1990 Americans with Disabilities Act told engineers to do so. Moreover, the need for legislation directly juxtaposes the importance education highlights about universal design. By definition, the need for legislation to tell engineers to design the products a certain way illustrates the way in which there is a lack of ethical code emphasized within the corporate engineering world at this point.

Furthermore, this apparent need for legislation stresses how important it is for universities like UVA to teach future engineers this inclusive engineering design process and its benefits. This conclusion also lines up with the overarching idea that comes from Thomas Jefferson, himself. Instilling the importance of values such as respect and inclusion should tie into the morality people should carry into the engineering profession (Hall & Charlottesville, 2017, 1). Unfortunately, as Haidt explains in his book *The Righteous Mind "*Behind every act of altruism, heroism, and human decency you'll find either selfishness or stupidity". This is a fact that I think has been taken to the extreme. After discussions with peers, I believe that every decent act does have a motive behind it but I also think that that motive can be as simple as making yourself proud. This would usually come in the form of sticking to one's morals which usually focus around Haidt's five pillars. Hopefully through the teachings of ethics in engineering new engineers can focus on the rewards of sticking to their beliefs rather than the rewards most commonly seen in design such as money and promotions. Most engineers try to design ethical products; however, no training or emphasis is applied to the idea that designing a

product universally is ethical and to neglect that idea is unethical. On the same level as that idea, a new approach can be drawn in order to train future engineers to be aware of this area of ethics and how it affects people. As the whole purpose of the STS department is to teach future engineers about ethics and what to think about while designing a product, part of it should be the idea of universal design. Hopefully, once this shift is enacted through the addition of teaching methods and seminars within the engineering corporate world, the answer to this research will be that universal design is solely implemented because the law required it, but because an engineer decided it would be the ethical thing to do.

Conclusion

One major cause of universal design as determined in my research is government regulation. However, it is important to consider the minority of engineers who have worked towards making inclusive products even in small strides. The improvement of face recognition software to include people of color is an important example. There is also the improvement of voice recognition software for different dialects and translation apps that include sign language symbols for communication for all. This research moved through the different uses and contexts of universal design and looked at all the destabilizing factors that are barriers to the use of universal design. These barriers are clearly evident after reviewing the research on the history of universal design and how there was no real concept of universal design until laws were passed that required it to be incorporated into public architecture. Furthermore, those laws were only passed after massive cultural movements that worked hard for the inclusion of more human rights for more people.

There are however newer ways in which universal design is emerging through learning environment techniques and cultures such as through engineering classes at UVA. This emphasis on the importance of respect and inclusion causes better training for future engineers to take a deeper look at social issues in more recent times and how their products and designs can affect that. This research will prove invaluable to further designers of curricula who would want to incorporate universal design into their ethics teaching. The addition of these new teaching methods would lead to a new generation of engineers that would design things universally without the need for laws to govern them. This result would be a much better outcome than the government forcing engineers to design this way and would be a much quicker process so that products could become more universal as they become more complex. The only drawback of this research would be that the government portion could be explored more in-depth to determine the extent of work that is required for the government to pass such a law in the event that a better ethics curriculum is not created. Finally, the continuation of this research through the University of Virginia's School of Engineering can maintain its mission to create the highest quality engineers here and provide a mold for education and culture everywhere shaping engineers.

References

ADL. (2000). *A Brief History of the Disability Rights Movement*. Anti-Defamation League. https://www.adl.org/education/resources/backgrounders/disability-rights-movement

Al-Azawei, Ahmed, et al. "Universal Design for Learning (UDL): A Content Analysis of Peer Reviewed Journals from 2012 to 2015." *Journal of the Scholarship of Teaching and Learning*, vol. 16, no. 3, 17 June 2016, pp. 39–56, 10.14434/josotl.v16i3.19295.

Beckman, M. (2019, October 1). The fluid transmission: Today's automatic transmission fluids are doing more than ever--with the challenge of EVs still ahead. Tribology & Lubrication Technology, 75(10), 40 - 44.

Brill, S. (n.d.). *Universal Design Products*. Thatz How I Roll. Retrieved May 4, 2022, from https://www.thatzhowiroll.com/home/2019/9/3/5-universal-design-products-we-use-every-day

conger, K. (2017). *How Apple Says It Prevented Face ID From Being Racist*. Gizmodo. Retrieved May 4, 2022, from https://gizmodo.com/how-apple-says-it-prevented-face-id-from-being-racist-1819557448

Dhyne, A. (2018, May 25). Lessons from Uva's "grounds". Retrieved October 14, 2021, from http://disability.virginia.edu/2018/05/25/lessons-from-uvas-grounds/

Hall, O. of the D. S. of E. T., & Charlottesville, R. A. 351 M. R. P. O. B. 400246. (2017, June 23). *Our Mission, Vision and Core Values*. University of Virginia School of Engineering and Applied Science. https://engineering.virginia.edu/about/mission-vision#:~:text=Our%20Core%20Values&text=Innovation%20%2D%20Determination%20to%20innovate%2C%20create

Heuser, A. (2019, October 03). Students are students, disabilities or not. Retrieved October 14, 2021, from https://disability.virginia.edu/2019/09/28/students-are-studentsdisabilities-or-not/

Izzo, Margaretha Vreeburg. "Universal Design for Learning: Enhancing Achievement of Students with Disabilities." *Procedia Computer Science*, vol. 14, 2012, pp. 343–350, 10.1016/j.procs.2012.10.039.

Lowenkron, Hadriana. "Creating More Accessible, Inclusive Buildings." Bloomberg.com, Bloomberg, https://www.bloomberg.com/news/features/2021-08-18/how-universaldesign-creates-inclusive-infrastructure.

Maisel, J., & Ranahan, M. (2017). *Beyond Accessibility to Universal Design | WBDG - Whole Building Design Guide*. Wbdg.org. https://www.wbdg.org/design-objectives/accessible/beyond-accessibility-universal-design

Rechtin, M., & Robinson, A. (2000, January 10). Sticks hit the skids. Automotive News, 74(5856), 34 - 36.

Roberto Ferris. (2020, April 15). Manual transmission cars are disappearing, but purists prefer to drive a stick shift. Retrieved October 14, 2021, from https://www.cnbc.com/2020/04/15/manualtransmission-cars-are-disappearing-butpurists - prefer-to-drive-a-stick-shift.html

Sparke, J. (n.d.). *What is Universal Design and who benefits?* Blog.ai-Media.tv. https://blog.ai-media.tv/blog/what-is-universal-design

Ulitskaya, Jane October 1, 2., Jane Ulitskaya October 8, 2., Jennifer Newman September 27, 2., Mike Hanley Senior Editor, Kelsey Mays Assistant Managing Editor-News, & Aaron Bragman Detroit Bureau Chief. (n.d.). Which new cars have manual transmissions?: News. Retrieved October 14, 2021, from https://www.cars.com/articles/which-new-carshave-manual-transmissions-437905/

Wheals, J. C., Crewe, C., Ramsbottom, M., Rook, S., & Westby, M. (2002). Automated Manual Transmissions - A European survey and proposed Quality Shift Metrics. SAE Technical Paper Series. doi:10.4271/2002-01-0929

Williamson, B. (2012). Electric moms and Quad Drivers: People with disabilities buying, making, and using technology in postwar America. American Studies, 52(1), 5-30. doi:10.1353/ams.2012.0030

Zhang, G., Marvel, Keeting, D., & Praveen, J. (n.d.). How a clutch works. Retrieved October 13, 2021, from https://x-engineer.org/automotiveengineering/drivetrain/couplingdevices/how-a-clutch-works/