How Accessibility in Computer Interfaces Affect Society
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Joseph Moretto
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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.

ADVISORS

Bryn E. Seabrook, PhD, Department of Engineering and Society

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Introduction

Accessibility is allowing all to use or participate in a service, product, activity, or anything that can be made accessible, so that no one is excluded. Accessibility can both make a product easier to use or can allow for people that could not participate to partake. The benefits of accessibility can range from making products more accessible to a wider audience or making it so those with disabilities can use the product in the first place (Mortensen, n.d). Additionally, accessibility can benefit a larger audience than the original target. Though accessibility is typically a positive force, accessibility to powerful tools can have consequences. The research question is asks how accessibility with computer interfaces affects society and how does societal needs influence what accessibility features are developed? The frameworks of technological determinism and social construction are used to support the research question.

Methods:

The methodology involves the collecting keywords and sources, relating frameworks and concepts to the research question, and organizing the paper in a logical way to inform and answer the research question. Key words in the research process include accessibility, society, curb cut effect, tooling, and computer interfaces. Sources include the development of accessibility in computers, relevant STS frameworks examples, computer accessibility for disabilities, and accessibility of cybersecurity tools. The curb cut effects of certain innovations in computers is used to answer the STS question. For how the paper is organized, first, Information is presented to show early computers and how they became more accessible. Then the needs of the userbase driving development are shown through the further development of computer interfaces into the

mainstream and the creation of interfaces for those with disabilities. The societal changes and reliance on computers demonstrate how the technology shaped society. Lastly certain parts of the technology are shown to have consequences when made accessible.

Supportive Background Information:

Computers have not always been accessible. The first computers emerged in the 40s and were only available to few technical organizations because of their immense size, cost, and involved maintenance (Timeline of Computer History, n.d). Because of the barrier to entry, computers were rare. Since greater part of society did not have access to computers, accessible user interfaces were not too much of a priority as only trained users were using computers. Also, the concepts of design and technological capability to make computers accessible was not yet invented. As computers continued developed, they became easier to use, being able to take in keyboard input and having displays to show information. With keyboards emerging in the late 1950s and monitors not being fully implemented until the 1970s (Timeline of Computer History, n.d). Display and input advancements were originally not intended for accessibility, more so for efficiency because it took many times more user input to achieve the same results as a keyboard with older computer input methods. Increased accessibility allowed more people to access computers, which while comparatively more accessible, computers were lacking which sparked interest in making computers even more accessible. The needs of society then went to influence the development of computers, with better user interfaces being made to better accommodate newer users (What really makes software user friendly, n.d).

While not limited to, accessibility is widely used for people with disabilities. There are many technologies and techniques that are used for people with disabilities ranging from modified or alternate input devices to software assistance (Burgstahler, n.d). For those with lower levels of dexterity there are modified keyboards with different layouts and spacing between keys to allow for easier usage. Alternative input devices have been designed for people that are unable to use keyboards. One such device is the “sip and puff” which is a device and software that cycles through options on the display and the user can choose the specific option that is highlighted by puffing air into the device (Bird, 2021). Other interfacing options include face pointing, foot pedals, simple switches, and more. Eye tracking software can be used to select and click on parts of the interface. There are also text magnifications with those with poor eyesight. People with blindness utilize text to speech and speech to text among other software to interface with computers. Captions are used for people with auditory disabilities (Bird, 2021).

The creation and advancements of these technologies have primarily been for the purpose of helping those with disabilities, however some of these technologies and techniques are used by society as a whole. The curb cut effect is where actions taken to benefit those with disabilities end up benefiting a larger group of people (Mortensen, n.d). The term curb cut effect originated from adding depression into curbs at pedestrian crossing to allow for easier movement for people with mobility disabilities. The curb cuts ended up benefiting everyone as going over a curb is less comfortable for everyone, not just wheels. Captions were originally created for people with auditory impairments, but found wider usage for people in loud environments, learning to read, and watching videos in foreign languages (Mortensen n.d). Text to speech helps users learn to pronounce words and is an alternative to reading. Speech to text is used as a tool for easier

typing. The curb cut effect has applied to computer science, with many advancements being made for a group of people going on to benefit a wider audience of users (Bird, 2021).

For the most part, accessibility is a force for good, but if a product or service can be misused, accessibility widens the audience of potential bad actors. An example of misuse lies in cybersecurity with the increasing accessibility and access to tools. Tools in the field of cybersecurity allow for many tasks to be accomplished more efficiently, but also much more easily. Being able to take advantage of the vulnerability of a service and creating a payload would require a specific skill set that only those with a certain amount of experience could accomplish (Thomas, 2022).

Using tools however, the barrier to entry is much lower. Using a cybersecurity tool such as Metasploit allows for a user to look up and select a payload for existing vulnerabilities then automatically applies the exploit. The accessibility of tools is a wicked problem as while the tools are used by those in cybersecurity, they are also used by bad actors. While accessibility increases the overall audience, which means an increase in bad actors, accessibility also increases the number of good actors within the cybersecurity world. There is not a clear-cut solution to the problem as actions to access to bad actors may curb beneficial accessibility to good actors (McDowell, 2021).

STS Discussion:

Technological determinism is the idea that technology drives changes in society (Smith, 1994). Social determinism is the opposite in which society determines the development of technologies. A critique of technological determinism and social determinism is the existence of each other as opposites, such that one of these frameworks is more prominent than the other.

Technological advancement changes society and in turn society then changes the technology to better suit the needs of the current culture (Smith, 1994). These frameworks define the relationship between society and technology with opposite viewpoints on the matter.

The research question is relevant to these STS frameworks because the question asks how a component of a technology effects society. The social deterministic side of accessibility shows that the needs of the userbase drove accessibility measures. Accessibility options for those with disabilities and the development of friendly user interfaces support the social deterministic argument. The technology deterministic side shows that advancements in the accessibility of computers shaped society. The technological deterministic argument is supported by the advancements of computers allowing for computers to be accessible to the masses and the prevalence of computers in every facet of life. The critiques of technological determinism and social construction relate to them being opposites which do not consider each other, so they can be considered critiques of each other. Technological determinism is oversimplified in that it does not take into account social factors and that technology is not always a force for change, but sometimes for maintain the status quo (Green, 2023). Similarly social construction does not account for emergent technologies with minimal societal influence and how society can stagnate technological advancement.

Research Question Reiterated:

How does accessibility with computers affects society and how does societal needs influence what accessibility features are developed?

Results and Discussion:

Accessibility in computers has allowed for a much broader audience of people to use computers which as computers became ingrained in society, societal needs drove parts of the

technology's development. Both frameworks of technological determinism and social construction occur in the continued development of computers and computer interfaces. (Fuller 2017). An example of Technological determinism is with how computer usage became a cornerstone of society, with many people's jobs and hobbies revolving around computers (Smith 1994). Accessibility to computers in size, price, and interface in tandem with their benefits allowed computers to become an integral part of society. Social construction was responsible for increased accessibility to the general population. Social construction also influenced the development for more niche accessibility features in computers for the disabled and other groups. Accessibility features had a wider application than originally intended, allowing more people to benefit. Accessibility is not the only barrier to using computers, how accessibly computers are perceived and the perceived benefits also determine usage. While accessibility is an overwhelmingly positive force for good, but is does have some possible drawbacks. A possible drawback of accessibility is that some users may be less invested in computers, because they did not need to invest into it. Another possible drawback is the accessibility that tooling provides to fields such as cybersecurity and machine learning being used maliciously.

The Broad Scope of Computer Usage:

The way that computers interact with society is multi-faceted due to how widespread and versatile the technology is. There is embedded computing systems inside cars, homes, and many appliances. Personal computers are used by the average person for work, entertainment, communication, and more. Computers are also used as a tool to develop technology and solve problems, with simulations and calculations. Relevant to the discussion is the differing usages of a technology in terms of scale and accessibility. Early computers were used by only organizations. Due to computers being used to develop and assist in greater projects such as the

moon landing, computers had an effect on society by being an advancement enabling technology. The use of computers to for advancement supports technological determinism because is shaped other technologies and any resulting changes in society (Timeline of Computer History).

Technology Acceptance Model:

Technology Acceptance Model (TAM) is a model that supports the conclusion that social construction in connection with accessibility were present in the development of computers and the society that used them. TAM is based off another model, The Theory of Reasoned Action, which explains behavioral decision making. TAM shows that a technology's perceived ease of use and perceived usefulness are strongest indicators of its usage. The idea that perceived ease of use and perceived usefulness supports social construction in that societal perceptions of a technology influence its usage and therefore technological development. Most technology is made purposely and so if societal perceptions affect usage, it would also affect the development (Li, nd).

What TAM means for computers is that the usage was dictated by the perceived accessibility and the perceived usefulness. Throughout the history of computers, perceived usefulness of early computers made up for the low accessibility as certain events such as the moon landing may have not been possible without computers. For the average user accessibility was the main limiting factor for usage in cost, logistics, and interface. In addition, the perceived benefits for a computer were much lower for the average person. Many jobs did not use computers in any way. The internet was not created until the 90s so users could not do internet related entertainment, productivity, and communication (Li, nd).

TAM does not make claims on how technology is driven, but rather how technology comes to be more prevalent and accepted, unlike technological determinism and social construction (Li, nd). Both frameworks have a similar flaw, they do not account for each other. It's critiqued that it makes the models oversimplified and shortsighted (Green, 2023). Technological determinism does account for stagnation from technology, with technology being used to keep status quo, rather than driving change. Also ignoring cultural influences and desires is another flaw of technological determinism. Social construction does not account for emergent technologies, technologies that rapidly evolve and grow. Construction does not explain rapid changes in certain technologies when society has not changed to such degree (Green, 2023).

Being absolutes for determining whether technology drives society or society drives technology is very restrictive for compatibility of technological determinism and social construction. It may be better for the frameworks to not be considered frameworks, but rather phenomena. This means that rather being antithetical frameworks, they could instead be seen as recognizable phenomena that happens in a mutualistic relationship between technology and society.

Societal Perceptions Influence Usage and Developments:

The perceived benefits are the indicator of usage, not benefits themselves. There may have been certain application a person would have found useful, but the lack of knowledge of computers would prevent it from becoming a perceived benefit. So even if computers were accessible the barriers of their perceived usefulness at the time from the state of society's needs for and knowledge of computers would still keep computer usage limited. As more jobs started to use computers as well as their personal benefits becoming more attractive due to advancements, computer usage increased.

Perceived ease of use, or perceived accessibility is also the indicator of usage, not the actual accessibility. Much like benefits the difference between perceived accessibility versus actual accessibility is partly knowledge. What it means to for a computer to be accessible to a person is personalized to the individual, as while not accessible to most people the early computers were accessible to those trained to use them (Mortensan). In that way it can be hard to quantify accessibility as most people have the capability to learn more difficult computer interfaces, but the time and effort to do so made it inaccessible to them. People with disabilities sometimes do not fall under that. Computer interfaces can be harder or even impossible to use with disabilities. (Bird 2022)

Another facet of perceived accessibility is bias and perception of computers. How computers are perceived is usually based on a person's personal experience with computers. Everyone has a "comfort zone" with computers with experiences outside of that seem daunting. An example, is the average user without technical knowledge seeing someone else us or explain less user-friendly interfaces such as a command prompt without other interfaces. Another example is a person claiming to be clueless with computers and either not trying or wanting to understand them better, sometimes seemingly intimidated by computers. Perception of one's own ability to use computers may hinder being able to learn something they otherwise have the capacity.

Computer usage at a societal scale needed to not only be accessible, but also have a certain number of perceived benefits and presence within the culture. Comparing the usage statistics of computers between societies across countries provides insight on how perceived accessibility, perceived benefits, and societal perception effects usage. For example, the United States of America has 762.15 computers per 1000 people, while Mexico has 138.81 computers

per 1000 people (NationMaster). There are several reasons for population differences, one most prominent is accessibility via economy. There are more people in the United States of America that can afford computers compared to Mexico. Another possible factor is that there are more computers being made and imported to the United States of America.

Besides accessibility with finances and logistics, there may be societal reasons that influence the usage. Mexico has less jobs that require the usage of computers. The infrastructure for internet and content on computers in Spanish may be less than that of the United States of America which makes the perceived benefit less. Because of being used less the perceived accessibility of computers may be less because people in the United States of America are more involved with computers on average (NationMaster).

The Possible Downsides of Accessibility:

Accessibility in computer interfaces is usually seen as a net positive, which accessibility usually is, however there are some cases in which is can be some concerns. An example is the negatives associated of the increased usage of a technology that has become more accessible. Computers are an accessible form entertainment to the point that it may be considered by some to be too accessible as addiction to the various features computers can offer is becoming more prevalent as time goes on. Accessibly interfaces into powerful tools also raises ethical concerns.

An example of powerful accessible interfaces in computers is tooling in cyber security. Performing advanced cyber-attacks is becoming increasingly accessible due to tools (McDowell 2021). Before a lot of knowledge, skill, and sometimes effort was required to perform various cyber activities, but tools allow people with minimal investment to perform certain actions. The

accessibility also allows more people to get into cyber security, but not enough to counter the consequences of easily accessible cyber-attacks (Thomas 2022).

Another powerful technology that is becoming accessible is AI generative programs. Image, sound, and other types of AI generation was only accessible to a few people due to it being highly technical, requiring high computer specification, and the code being closed source. The reason why accessibility to AI generation is an ethical concern is the potential for misinformation generation. It takes can take time and technical skills to generate a convincing fake image. With AI image generation it can just take a prompt and a couple moments using open-source image generation stable diffusion. Once powerful models are developed and convincing images can be made consistently, anyone could make anything with a few keystrokes (Burgstahler).

Future Work and Limitations:

The limitations of this project are covering the sheer scope of the prevalence of computers and how they interact with society. In modern times computers are interconnected with so many systems and ingrained into the culture that it is difficult to draw a complete picture within a paper of this size and scope. Instead of becoming more general, future work should narrow down and focus more on specific parts of this project. An entire project could be made individually from several topics presented in this project, this project is too broad and this acts a limitation.

Conclusion:

Does advancement in computer accessibility causes societal change or does society shape what computer features are developed? A combination of social determinism and social construction applies to the development of computers, with one being more prominent depending

on the sector. Accessibility is a major factor for computers for being able to integrate into society and many accessibility and general features were developed specifically for societal needs. Accessibility by itself is not only driving force for computers to affect society, societal perceptions and culture can facilitate or diminish a technologies ability to change society or be changed by society. Accessibility is mostly a net positive, but accessibility to powerful tools has risks.

Works Cited:

Bird, D. (2021, February 18). Assistive technology devices: How disabled people use the web. The Big Hack. Retrieved September 29, 2022, from https://bighack.org/assistivetechnology-devices-definitions-how-disabled-people-use-the-web/

Burgstahler, S. (n.d.). Working together: People with disabilities and Computer Technology. Working Together: People with Disabilities and Computer Technology | DO-IT. Retrieved November 4, 2022, from https://www.washington.edu/doit/working-together-peopledisabilities-and-computer-technology

Edwards , B. (2022, September 6). With stable diffusion, you may never believe what you see online again. Ars Technica. Retrieved November 4, 2022, from https://arstechnica.com/information-technology/2022/09/with-stable-diffusion-you-maynever-believe-what-you-see-online-again/

Fuller, J. (2017, December 8). *Does Society Influence Tech, or vice versa?* GlobalSpec. Retrieved March 21, 2023, from https://insights.globalspec.com/article/7343/does-society-influence-tech-or-vice-versa

Green, L. (2023, April 21). *Technological determinism is wrong: Lelia Green*. IAI TV - Changing how the world thinks. Retrieved April 23, 2023, from https://iai.tv/articles/technological-determinism-is-wrong-auid-2218

Hardesty , L. (n.d.). Explained: Neural networks. MIT News | Massachusetts Institute of Technology. Retrieved November 4, 2022, from https://news.mit.edu/2017/explainedneural-networks-deep-learning-0414

Li, L. (n.d.). *A critical review of technology acceptance literature - SWDSI*. Retrieved March 21, 2023, from http://www.swdsi.org/swdsi2010/SW2010_Preceedings/papers/PA104.pdf

McDowell, J. (2021, May 17). The Unforeseen Cost of Offensive Cyber Capabilities. Advancing Cybersecurity via development of tooling. Retrieved September 5, 2022, from https://libraetd.lib.virginia.edu/public_view/kh04dq580

Mortensen, D. H., & Spillers, F. (n.d.). 3 reasons why accessible design is good for all. The Interaction Design Foundation. Retrieved September 29, 2022, from https://www.interaction-design.org/literature/article/3-reasons-why-accessible-design-isgood-for-all

Mostaque, E. (2022, September 2). Stable diffusion public release. Stability.Ai. Retrieved November 4, 2022, from https://stability.ai/blog/stable-diffusion-public-release

NationMaster. (n.d.). *Countries compared by media > personal computers > per capita. international statistics*. NationMaster.com. Retrieved March 21, 2023, from https://www.nationmaster.com/country-info/stats/Media/Personal-computers/Per-capita

Niggl, Katja Accessible design - why it matters and what are the benefits. (n.d.). Retrieved September 29, 2022, from https://futurice.com/blog/a-guide-to-accessible-design-forconnected-products-and-services

Nishiyama, C. (2022, October 24). Inspiration vs. imitation: How to copy as an artist. Might Could Studios. Retrieved November 4, 2022, from https://mightcould.com/essays/inspiration-vs-imitation-how-to-copy-as-an-artist/

Plagiarism. University of Oxford. (n.d.). Retrieved November 4, 2022, from https://www.ox.ac.uk/students/academic/guidance/skills/plagiarism

Sandberg, A. (2022, September 19). Reflective Equilibrium in a Turbulent Lake: AI Generated Art and The Future of Artists. Practical ethics. Retrieved December 6, 2022, from https://blog.practicalethics.ox.ac.uk/2022/09/reflective-equilibrium-in-a-turbulent-lake-aigenerated-art-and-the-future-of-artists/

Seager, T., Selinger , E., & Wiek, A. (2011). Sustainable Engineering Science for Resolving Wicked Problems. Springer Science+Business Media B.V. 2011, 467–484.

Smith, M. R. (1994). Technological Determinism in American Culture. MII press.

Thomas, M. A. (2022.). Distinguishing cyberattacks by difficulty. Taylor & Francis. Retrieved November 4, 2022, from https://www.tandfonline.com/doi/full/10.1080/08850607.2021.2018565

Timeline of Computer History | Computer History Museum. (n.d.). Retrieved November 4, 2022, from https://www.computerhistory.org/timeline/computers/

What really makes software user friendly? KNDCODE. (n.d.). Retrieved September 29, 2022, from https://kndcode.com/nearshoreinsights/UX-UI-importance