REPAIRING THE SPECIALIZATION OF TECHNOLOGY

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By

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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.

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The thematic structure of the typical American educational system is to channel students down distinct specialized tracts. What was science class in middle school becomes biology, chemistry, and physics in highschool. These classes further delineate into more specific fields in college and graduate school if students choose that path. As the breadth of human knowledge expands, this educational structure seems efficient in producing people who can push its boundaries. The centering of specialization, however, does not come without its downsides. Scientists of a particular field are more concerned with the pursuit of knowledge than how it will be accepted and used by society. Politicians and judges, who may be skilled in rhetoric and law, will struggle to keep up in addressing social issues with roots in technological complications. While professionals might be able to advance the knowledge of their respective fields, the inability to communicate between each other leads to problems when the knowledge they have perfected is applied to society and weathered by its complex social and natural forces.

The specialization of the educational system leads to the partitioning of occupational domains and the poor communication between them. How can the educational system restrucutre itself to bridge the gaps between technical and social perspectives? The Technical and STS research papers suggest a change in focus for the standard educational system through the teaching methods and academic focus of CodeVA, a nonprofit organization based in Richmond. Its purpose is to educate young students about various technologies and how they can be used by people in the real world. Both of these topics will also discuss the importance of technological literacy, the understanding of the technical aspect of tools and technology, as well as how they were created and how it affects society (Bugliarello, 2000, p. 83). The technical research paper analyzes CodeVA's specific teaching practices, and how it is able to inspire an intrinsic drive to create and innovate in students through technological literacy and project based learning. The

STS research paper examines the effects of an educational system centered around specialization using the Diffusion of Innovations STS framework (Rogers 1962). It also discusses how a technological literacy centered educational system can remedy the issues of the specialization model. These papers are tightly coupled as the technical paper considers precicely how to restructure the educational system in American public schooling, and the STS paper contrasts the existing educational system and how societal entities can benefit from a technological literacy centered education.

REPAIRING THE SPECIALIZATION OF TECHNOLOGY

THE PROBLEM WITH SPECIALIZATION

There is an inherent lack of connectivitiy between different types of occupations due to the structure of the educational system. Student's classes are compartmentalized, and this partitioning continues into higher education as students funnel into majors and graduate level courses. The educational system is centered around specialization which produces a narrow field of view for its graduates. Thus, there is a tendency to separate technical subjects from social ones with little communication between.

In engineering education, the separation of the technical from the social provides a large disconnect from what is taught in school and what is required in real world engineering jobs. Naude Malan writes that the identifying and resolving issues within a country cannot be managed soley within a technical or social domain. However, students are being taught along these stark divides in the education of engineering. The social systems intertwined with technology,labor groups, legislation, the global market, are entirely left out of the discussion (Malan, 2018, p. 11). As a group that is responsible for producing and overseeing various

technologies, it is crucial that engineers have a firm grasp on the relationship between technology and society.

Technology does not exist in a vacuum. An artifact or piece of technology is created in a specific state of society in an attempt to service groups within it. Additionally, throughout the lifetime of that technology, it will have intended and unintended consequences that can shape the culture and behavior of individuals within a society. This relationship between technology and society is categorized as the Social Construction of Technology (Bijker et al., 1987). To properly produce, maintain, or identify problems with a technology, it is vital to understand the social and political needs that surround its production and lifetime. At a very basic level, the current educational system's focus on specialization aims to sort out students based on their interests and proficiencies. However, the compartmentalization of people into subjects leads to a lack of cross-disciplanary perspectives that are necessary to understand real world issues and technology's role in it.

WHO IS RESPONSIBLE FOR UNDERSTANDING TECHNOLOGICAL PROGRESS

This STS paper centers around two specific groups who have significant control over societies priorities, norms, and values: engineers, and legislators. Because technology both shapes and is shaped by society, having a firm understanding of the Social Construction of Technology is crucial to effectively addressing social issues. Technology today looks drastically different than it did a few decades ago, and because of the interconnectedness and speed of the internet, it is able to propagate to individuals much more quickly. Therefore, not only is it important to understand the relationship between technology and society, it is also important to be able to keep up with the rapid changes and usages of technology. The Diffusion of

Innovations popularized by E.M. Rogers (1962) as an STS framework can be used to analyze how engineers and legislators react to technological diffusion and progress.

Diffusion of Innovations for Catching Technological Issues

Despite attempts at rigorous testing, and analysis, technological innovations produce unintended consequences when integrated into society. Technological issues will inevitably reveal themselves as an innovation is used by an increasing number of people. To map the timing of when an issue is recognized to when remedies are proposed and executed, the Diffusion of Innovations model will be used to consider the percentage of people a technology reaches as the issue develops.

Figure 1 on page 5 depicts the various groups involved in the diffusion of innovation with. It begins with the innovators on the left of the figure, a small group who develops a new innovation. If it is promising enough, it will then be adopted by early adopters, a slightly larger subset of the population. The early adopters are quickly made aware of the innovation, and are often social leaders or their opinions have influence over the greater public. Next, come the early majority, who take longer to become aware of and accept an innovation, but are easily influenced to accept and rationalize new ideas. The late majority take much longer to accept change and hold a more reserved view of the benefit of technologies. The main drive for the late majority accepting an innovation is peer pressure. The last group are the laggards who tend to be very skeptical, very traditional, and resist adopting a new technology as long as possible. The yellow "S" curve marks the percentage of a population that have adopted the innovation in total (Rogers 1962).

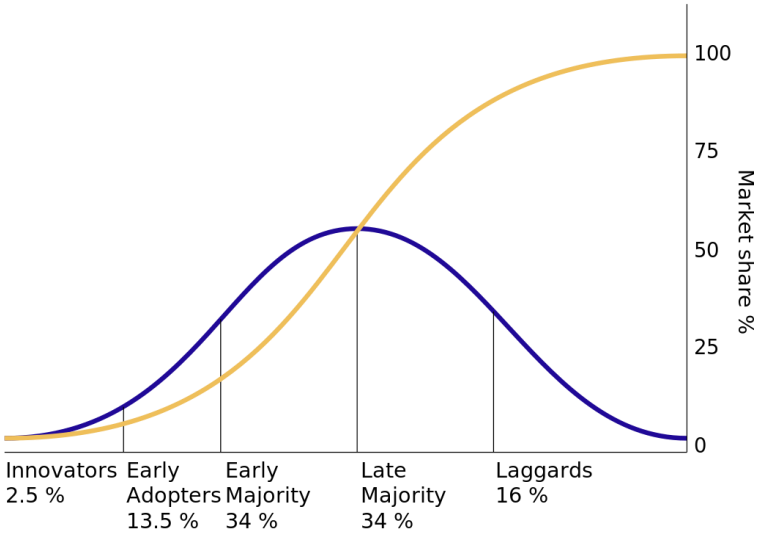

Figure 1: E.M. Rogers' diffusion of innovations model. This figure shows how various groups accept an innovation with varying propensity to adopt under the blue curve. As more groups accept a technology, the market share increases until it reaches a saturation point (Edward M. Rogers 1962).

Looking at socio-technological issues through the Diffusion of Innovations model can help prioritize the speed with which problems of a new innovation are addressed. As a technology affects a greater portion of a population, its potential influence over social behavior also increases. Any issues with that technology that go unnoticed not only affect a greater portion of people over time, but those issues are then ingrained into the way society functions and how individuals interact with eachother.

Engineers Have an Ethical Duty to Keep Track of Their Innovations

Engineers are not simply responsible for acomplishing the tasks set out by their managers and bosses. They are also responsible for the technology they produce, and how it is used. Under the Engineering as Social Experimentation Ethical Model, engineers are expected to ensure that their designs are safe to use once they are released to the public, and that their designs are used ethically (Martin & Schinzinger, 2009). Technology that is accepted and diffused to a large

portion of a given population can have strong effects on society. Given that Engineers are properly technically educated, they sit in an extremely advantageous position for identifying and resolving issues with their own innovations quickly after it is released to the public. As the innovators in the Diffusion of Innovations model, engineers are able to observe their innovation as it propagates through the early investors and the early adopters. While the initial groups of adopters might not have the perspective to understand possible underlying problems with an innovation, the engineer will be able to see if their innovation is being used properly and ethically. With a proper understanding of the relationship between technology and society, they will be able to identify any possible disconnects between the intent behind their design, and how it is being used in a real world context.

Some of the problems with meeting this ethical responsibility come from a lack of both ethical and socio-technical skills. As an engineer, one's responsibilities lie to more than just fulfilling the needs of their employer. Engineers also have responsibilities to fulfill with respect to their society through the technology they create. This can be viewed through duty ethics: the engineer's duty to protect society through sustainable and safe innovations, as well as rights ethics: protecting the rights of people in the public to make informed choices (Martin & Schinzinger, 2009, p. 81). The ethical model of viewing engineering through social experimentation brings to light that an innovation has an entire social lifecyle as it is diffused throughout a population. In line with the idea of experimentation, it is the duty of the engineer as a "guardian of the public interest" (Martin & Schinzinger, 2009, p. 86) to ensure that they are actively evaluating and assessing the impact of their innovations, and empowering the acceptors of an innovation with informed consent. A key way to provide informed consent and protect the public is to notify the public when a risk to the user's safety becomes apparent. A facet of

informed consent is knowing all of the relevant information including risks before choosing to use or participate in an experiment. Secondly, the engineer should ensure that fixes to the innovation will be remedied through the proper channels. The engineering as social experimentation model empowers engineers to think outside of the boundaries of responsibilities to their employer. As such, engineers should be expected to keep track of their innovations as they are used by the general public, and notifing relevant parties when an issue arises.

Legislators Should Be Expected to Keep Up With Technological Progress

Engineers cannot be the only line of defense for protecting the public from technological issues. Legislators are also responsible for maintaining the security and safety of individuals within a society. While engineers come from a technical background, legislators primarily come from a social and political perspective. However, seeing as many modern day issues stem from technology of some form from transportation to computers to energy production to social media, a firm understanding of technology is crucial to fully understand social issues. Therefore, legislators need to be aware of technological changes to properly approach technological problems. A failure to do so can result in a delayed response to an issue, such that a technology has diffused to a large portion of the population, and can also result in the inability of the legislator to properly engage in a conversation to actually address the issue.

The growth of Facebook provides an example of how the United States legislative body responds to societal concerns of emerging innovations like social media. At a Senate subcommittee hearing in the fall of 2021, Senator Blumenthal brought to Congress the issue of social media accounts on the health of young teenagers. The hearing was directed at Facebook in an ongoing effort to hold Big Tech companies liable for the health effects their

products have on their users. In the hearing Blumenthal asked “Will you commit to ending Finsta?” in reference to secondary Instagram accounts teenagers often make in an attempt to hide themselves online from their parents. In an NPR article, the author Alana Wise examines how Congress attempts to approach technological problems like this and how it’s perceived by the media. While Blumenthal seemed to understand what a “Finsta” account was and its effects on teenagers’ mental health, he was not familiar enough with it to properly communicate the issue (Wise, 2021, para. 5). His poorly worded question was quickly taken out of context and spread on the internet to show how out of touch Congress is with modern technology (Wise, 2021, para. 6). The media’s perception of the hearing was focused on making memes of how out of touch Congress seems to be. As a result, the original issue of trying to protect the health of teenagers was quickly overlooked by the greater public. Sarah Wise quotes Senator Josh Hawley, “These Big Tech monopolies know exactly how addictive and manipulative their products are but they're content to rake in billions by exploiting children” (Wise, 2021, para. 26). Though Congress did have the wherewithal to bring Facebook to a hearing on the issue of children’s mental health, it occurred after years of social media use by teenagers. When Congress finally attempted to reign in the tech giant, its genuine attempt to tackle a growing issue resulted in a circulation of jokes and memes on the internet due to the technological illiteracy of senators like Blumenthal.

Taking a step back, and looking at the greater timeline of Facebook’s growth reveals the inability of Legislators to seek out and recognize technological issues. The company was able to develop its social media platforms for about a decade since its start in 2004. It was not until 2018, when Mark Zuckerberg, CEO of Facebook, was called to a Congressional hearing, that the company was first faced with significant legislative opposition. Figure 2 on page

9shows an approximate timeline of Facebook's diffusion into the American population as it grew as a company over time. It depicts the time it took for Congress to begin responding to privacy and mental health concerns over the company's lifespan. Since it began, the company itself is the first to see the results of its data from users, and are able to use it to make their platform more profitable. In 2018, around 85% of American teenagers said they used Facebook and 72% said they used Instagram according to data compiled by the Pew Research Center (Gramlich, 2021). A deeper breakdown in age demographics can be seen in Figure 3 indicating significantly higher percentages of young populations using social media platforms as of 2021. For each social media application, young users most consistently use these applications as shown with the dark blue dots indicating the percentage of eighteen to twenty-four year-olds who use each social media platform. The high percentage of young Americans using social media has a strong effect on how the platforms are designed and marketed. The platforms will continue to shape their content around these young reliable groups.

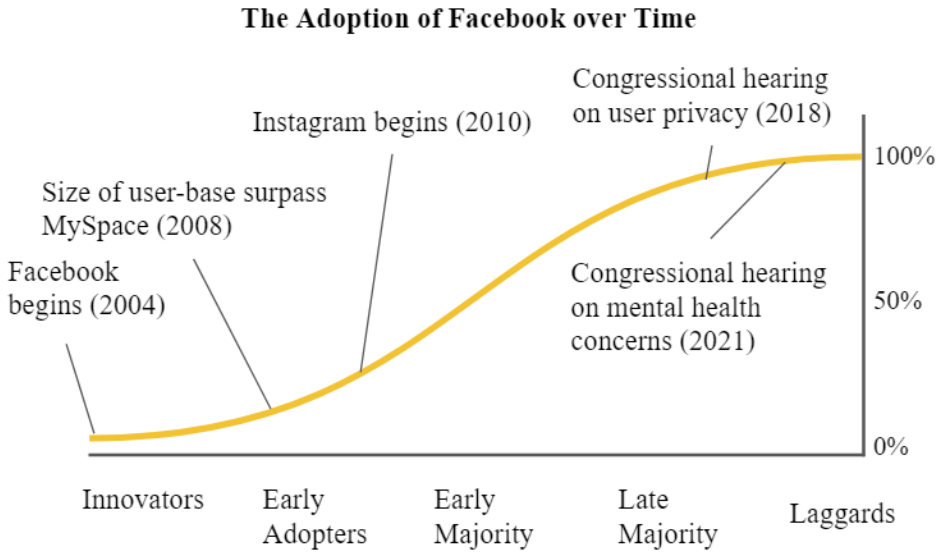

Figure 2: Approximation of the diffusion of Facebook through the U.S. Population. Several important moments in Facebook's history are also recorded. (Alcaine, 2022).

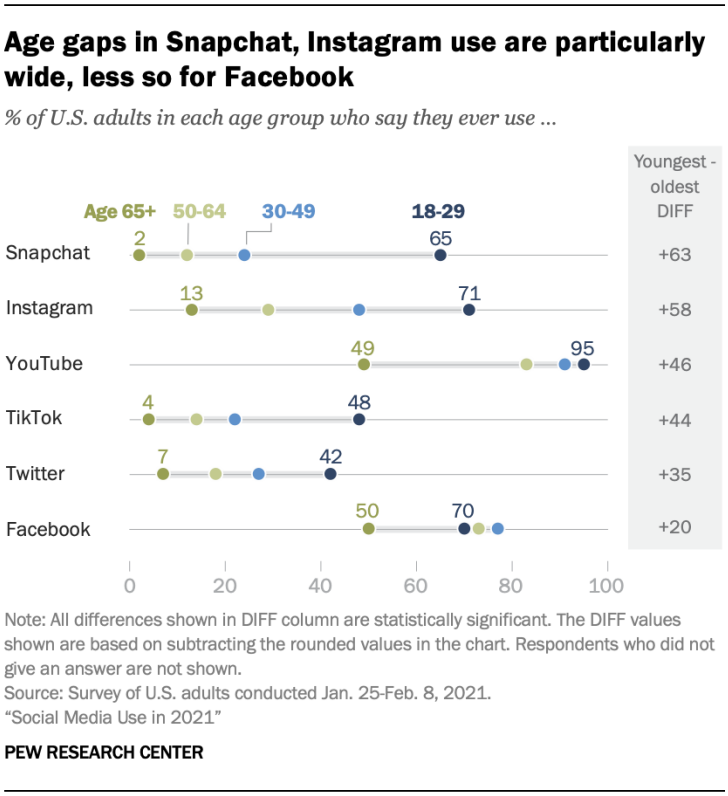

Figure 3: Age breakdown of users for several social media platforms. This diagram is primarily meant to show the age gaps between different user groups on different platforms. (Pew Research Center, 2021).

It was not until 2020 that a bill was introduced with the Kids Internet Design and Safety Act to try and make social media platforms safe for teenagers (116th Congress, 2020). The Diffusion of Innovations model applied to technologies like Facebook shows at what point legislators become aware of issues they cause in society and when they try to propose legislation to regulate those technologies. It points out how these legislative bodies tend to be reactionary: controlling damage after it has occurred to a significant portion of the population, and the technology has become integrated into society. Problems must be resolved early if technology is to be used effectively and safely such that it benefits society more than it harms.

TECHNOLOGICAL LITERACY AS A SOLUTION

Technology today is more accessible than ever. Most families in America have smart-phones or computers such that young Millennials and Gen-Z kids are growing up using these devices daily. This basic understanding of how to use these tools can be seen as technological literacy, however, George Bugliarello argues that technological literacy should extend to knowing how the tools and technologies were created, and how they affect society. George Bugliarello was a multidisciplinary engineer who became president of the Polytechnic Institute of New York University, and was awarded the Huber Civil Engineering Research Prize of the American Society of Civil Engineers in 1967 (Juran & Falcocchio, 2011). Bugliarello argues that the broader dimension of technological literacy in citizens is crucial to the health of our democracy. Otherwise, people have "unrealistic expectations about technology, excessive fear of technology, and inability to participate intelligently in the discussion" (Bugliarello, 2000, p. 83).

The role of technology in public schooling today is left to the wayside in favor of traditional sciences and liberal arts classes like social studies. The two are in separate spheres, and while science and math lends itself to more technical studies, it does not make an effort to relate to society. The study of technology inherently lends itself to relating how artifacts affect people in terms of risk, safety, and trade-offs (Bugliarello, 2000, p. 84). Schools need to shift their focus toward technology. Restructuring the educational system around technological literacy will enable students to bridge the gap between social and technical issues. Technology cannot be entirely divorced from its social contexts and its social effects. Centering technological literacy in all levels of the educational system will prevent the fracturing of occupational domains that comes with centering specialization, and, as Bugliarello stresses, will help cultivate

healthy and intelligent growth of technology that involves input from people of all cultural and economic backgrounds (2000, p. 89).

Existing Models for Centering Technological Literacy

CodeVA provides valuable insight as to what centering technological literacy can look like. The material that is taught to students covers both the technological and the societal aspects of the topics covered from week to week. As students work on projects, they are asked to consider why the technology in their projects is needed or used, and how their projects would interact with real world situations.

In a course centered around the integration of technology with clothing and fabrics called E-Textiles, students are shown recent advancements in the field like 3-D printed dresses or hidden touch sensors in clothing that interact with smart devices. Students are also asked to think of their own ideas of how to integrate technology into clothing. The main goal of the class is to explore simple circuitry, and how conductive thread can be used to sew lights into fabric. These students are given important life skills like sewing, as well as given foundational knowledge of a fairly complicated field in technology. Later in life, this student will have direct introductory experience with the various topics CodeVA has taught them, and will feel less daunted by the technological fields when they inevitably encounter them in the future. More importantly they will be equipped with basic skills to explore deeper into the topics if they so choose.

The Effects of Teaching Technological Literacy

Widening Engineers' Perspectives. If Engineers are properly taught technological literacy, they will be in the practice of considering the greater context of their designs in society.

The social effects will have been considered in the design, and Engineers will have the tools to analyze their innovations after they are put in effect. Additionally, Engineers will be empowered to fullfill their ethical duties through the model of engineering as social experimentation.

Allowing Politicians to Enter the Discussion. Politicians who are technologically literate will be able to participate in technical discussions and hearings. They will also be able to recognize technological issues for themselves and know how to find credible resources and opinions for how to mitigate the issue.

Technological Literacy with Diffusion of Innovations. As an innovation is propagating throughout a population, a technologically literate society will be able to identify technological issues before it reaches the late majority. Figure 4 depicts what the diffusion of an innovation would look like as problems are discovered and arise. Engineers will be able to identify issues of their own designs very early on as the early adopters initially use and participate in the experiment of using the innovation as shown with the red dotted line. Notifying the public, and perhaps calling for studies to be done For example, the software designers within Facebook could have called for studies to be done to examine their social media platform's affect on the mental health of teenagers when they realized that the platform began to be widely used among young teenagers. Early studies will allow legislators to step in much earlier in the diffusion of an innovation to also address problems. This is shown with the shift from the solid blue line to the dotted blue line as legislators are able to catch issues before it enters the late majority and technological problems begin to affect more than half of a given population.

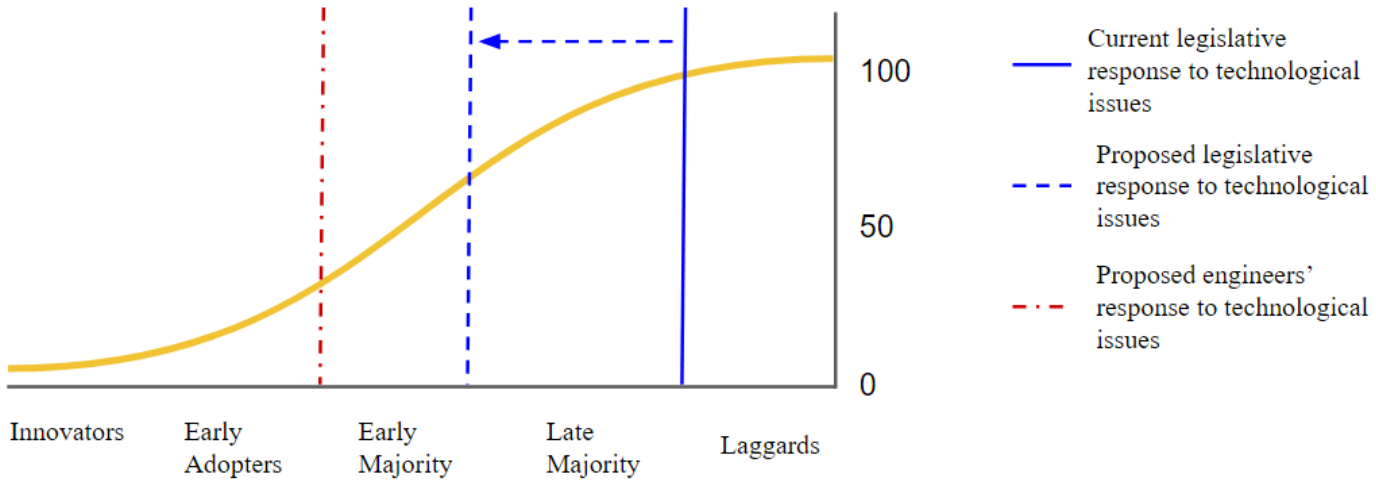

Figure 4: Proposed model of when engineers and legislators are able to address technological issues using Diffusion of Innovations. (Alcaine, 2022).

SHIFTING THE EDUCATIONAL FOCUS FROM SPECIALIZATION TO TECHNOLOGICAL LITERACY

The specialization of different technical and social fields leads to a disconnect between people of different occupations, and prevents productive communciation between them. Because the problems of specialization stems from the compartmentalizaiton of subjects in the educational institution, education must be restructured. By centering technological literacy within education, technical and social issues can be viewed under the same lens, and will allow people of varying occupations to have a more robust perspective of the work that they do.

Future work can be done on this subject by looking into more organizations like CodeVA as to how centering technological literacy affects students later in their careers. Additionally, steps should be taken to integrate the teaching principles laid out by CodeVA in more conventional educational systems.

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