Analysis of Frontend Software Design Efficiency and Completion Rate for Solar Tools
(Technical Topic)

Social Implications of Relevant Groups in Persuasive/Marketing Software Design
(STS Topic)

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Sebastian Borromeo

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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

William Davis, Assistant Professor of STS, Department of Engineering and Society

Rosanne Vrugtman, Lecturer, Department of Computer Science

Introduction

With the increasing urgency for energy sustainability, the world has seen a great shift in technological momentum in the past few years largely led by a rise in popularity for renewable energy sources. Of these, solar has proven itself to be one of the most sought-after resources for homeowners. The image of a self-sufficient, solar-powered residence free from the grid has captured much attention and replaced previous ideas of what an ideal home looks like. According to the Solar Energy Industries Association, "In the last decade, solar deployments have experienced an average annual growth rate of 25%" (*Solar Industry Research Data*, 2024). Moreover, the federal government has been passing regulations and offering incentives like tax credits, rebates, and net metering to homeowners to incentivize the switch (Church, 2024). With this growth, many new customers are left confused or overwhelmed by the large amounts of information or options available. This gap is where many companies have looked to the internet and software to bridge. With easy-to-understand breakdowns and tools such as ROI (return on investment) calculators, customers are more likely to give solar a shot, and thus the need for solar software is larger than ever.

Not all software is created equally, however. There is no guarantee that two programs capable of producing the same results but differ in design will be received equally. Small differences in layout, button placement, color schemes, or even the spacing of words can significantly impact how users perceive and interact with software. For instance, a well-designed interface may seamlessly guide users intuitively through steps and allow them to complete tasks more efficiently, while a poorly designed interface with the same functionality might lead to more errors or turn away a user completely. To many experts, the difference lies in how well something adheres to User-Centered Design (or UCD) which can be defined as, "a collection of processes which focus on putting users at the center of product design and development" (Novoseltseva, 2019). For solar software, we'll find that how well a design understands its users and how they operate is a crucial factor in effectiveness. Without user-specific consideration, a large portion of potential new customers could be lost.

At my internship this past summer, I worked at a company that specialized in building a site that could educate and connect new solar customers to devices that best fit their needs. My task was to develop a consumer-specific interface for my company's web application that could assist users in discovering their current energy usage and corresponding solar generators that best fit their requirements. Designing this tool, I researched and learned a lot about design from low-level as basic as what makes a button attractive to a high-level interaction of the specific components. I worked to learn as much as possible to ensure that the barriers between a users' goals and results were negligent and that their experience adopting solar was as smooth as possible. For my capstone, I've chosen to continue in this area of UCD and will be researching how design affects the speed and success rate of users interacting with solar info/marketing software. I hope that my results can inform other software developers of more efficient methods of empowering and informing new customers about solar energy.

Though optimized software for promoting education and the adoption of solar is necessary to further a more sustainable society, there is a delicate balance in persuasive software design consumers and designers must be aware of. A well-crafted design can make a user believe something or act in a certain way that could help them with no adverse effects but can just as easily convince one of an impartial truth that doesn't entirely benefit them like it'd led them to believe. That is why complementary to my technical research, I will also be investigating the influence marketing software plays on driving social change and overall human behavior. I've chosen to explore this using the theory of Social Construction of Technology, defining and examining the contexts and interactions between the relevant social groups. Through this, I hope to uncover how differing interpretations, values, and negotiations shape the design and ethical implications of solar marketing software, ultimately influencing who is adopting solar and in what way.

Technical Topic

The goal of any software designer is to create an interface that can guide a user towards achieving specific tasks efficiently with minimal friction. A key measure of this is usability which Tom Stewart defines as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (Stewart, 2009). Usability can be both visual and technical where a more usable technology is visually clear and obvious about its behavior and usage (e.g. colors using green for success, red for failure) as well as its functionality (e.g. informing a user of their options or when they've done something incorrect). Additionally, research on software design typically focuses on user interface (UI), the visual elements of the design, and user experience (UX) elements, the overall interaction and impression one has with the design (Turkyilmaz et al., 2015). All these concepts build into the larger design approach User-Centered Design and together determine a user's ability to navigate the software, complete tasks quickly, and make fewer errors during the process (Novoseltseva, 2019).

Despite the importance of these elements, many software applications still overlook them and suffer from poor design, leading to frustration, inefficiency, and high rates of abandonment. When designers fail to observe and understand user behavior, the result can be convoluted interfaces, confusing navigation, or a lack of feedback. This issue is prevalent in both consumer-level applications, such as websites and mobile apps, and industry-level software such as hospital charts, and even on a developer-level with software used by other developers. Bad design is a problem shared by all people regardless of role, background, prior experience, or ability. Moreover, in a study on web performance optimization (WPO) techniques, it was found that after the techniques were performed on some sites, the conversion rate of customers increased from 6.35% to 14.30% within six months (Szalek et al., 2018). When designers fail to understand how poor usability and inefficient design directly affect a user's success rate in completing tasks, user frustration increases and can discourage engagement altogether. Prior to the WPO, the site missed out on potentially double the number of conversions had some design optimization been taken originally. If we instead considered a site that sold solar installment plans, a poorly designed interface like an overly complex navigation could result in fewer successful conversions, as users struggle to complete the necessary steps for adoption. In addition to conversion rate, efficiency in software can also be measured by the time it takes users to perform actions, the number of steps required to finish tasks, or surveys testing how well knowledge was absorbed. Poor design risks decreasing these metrics as well.

The costs of poor design become evident when considering the consequences of inefficient or incomplete user task completion. Users who experience frustration may abandon the software or, if considering a business, abandon the service entirely thus losing a customer. It's been shown that there exists a positive correlation between system usage and user satisfaction (Bokhari, 2005). Users will continue to use software they understand and enjoy and will stay away from those they don't. From this business perspective, the software is the product, and failing to match the needs of the intended customer will lead to dissatisfaction, negative reviews, poor brand perception, and impact revenue. On the other hand, in the case of critical industries like healthcare or infrastructure where poor UX could lead to reduced productivity of workers or even critical failure, the consequences of design aren't like losing a customer and are often much more severe. In 2013, the U.S. government launched HealthCare.gov as part of the Affordable Care Act which served as a platform for individuals to sign up for health insurance. Upon launch, however, the site was riddled with many problems like slow load times, crashing, and confusing navigation because of a rushed design process (Lee & Brumer, 2017). Millions of people experienced delays or errors in accessing healthcare as a result. Solar, however, stands at the crossroads of many types of industry where business, technology, infrastructure, government, and much more all play unique roles. There are many goals of solar technology that don't always align with one another. For instance, it is necessary that solar software succeed in increasing adoptions rates of solar as much as possible for its environmental benefits, but ultimately are trying to turn a profit at the end of the day. None of these goals could be accomplished, however, if design isn't prioritized. Addressing usability challenges improves user satisfaction, retention, and task completion rates, ultimately leading to better outcomes.

Existing research in UCD and the related field of human-computer interaction (HCI) already provides a foundation to address these issues in software design. Studies have shown that simplifying interfaces, improving cognitive load management, and ensuring clear feedback and navigation paths significantly enhance user efficiency. One study that focused on educational applications and UCD showed that designs using a UCD approach resulted in more effective and efficient systems (Al-Sa'di, 2021). One fundamental concept of UCD is performing user testing which is an iterative process where developers can directly observe where users struggle and refine the design accordingly. Existing literature has shown how essential a role testing plays in development and the difference the application of conducting user tests and gathering metrics can make on software quality (Firmenich, 2018).

My work will build on the principles of UCD, focusing specifically on how software design correlates with efficiency in solar adoption software. By conducting user testing and analyzing efficiency metrics, I hope to identify which design patterns lead to greater success and which hinder task completion. This could include studying the impact of intuitive navigation on efficiency or how varying levels of user feedback (e.g., progress indicators, error alerts) affect user persistence and task success. I expect to face challenges in my research trying to account for the variance in many variables of my experiments like the environments my users are testing in or preexisting knowledge they might have. Another form of controlling variance will have to be addressed in accounting for a diverse user base attempting to ensure that designs are universally applicable. Additionally, measuring efficiency and completion rates will require precise metrics that can be reliably interpreted and compared across different designs so narrowing down what tests will be ultimately used will require much thought. I expect the deliverables of my work will be design guidelines that offer design solutions, recommendations, and pitfalls for future software developers to improve user task completion rates in solar tools. By addressing these challenges, our research will demonstrate the importance of software design in optimizing user efficiency, task completion rates, and reducing turn around helping companies and developers create software that better serves new solar customers.

STS Topic

I've chosen to explore the social implications of persuasive software because I believe it's important to understand the degree to which software can influence our behavior, especially when concerning the products we place faith in and how we spend money. My research will focus on determining the different relevant social groups and the role each can play in shaping software and their implications. The Social Construction of Technology (SCOT) framework provides a valuable lens for analyzing these complexities, as it emphasizes the role of social groups in shaping the development, interpretation, and societal impact of technology (Klein & Kleinman, 2002). By examining the interactions and contexts of these groups, I can better understand the ethical implications of solar marketing software.

Consumers are the primary social group interacting with solar marketing software, and their perspectives are central to its impact. For a consumer to buy into a product or service, they must first trust it. Schneiderman states that “Users are more likely to participate in Web transactions and relationships if they receive strong assurances that they are engaging in a trusting relationship” (Shneiderman, 2000). The average user will not simply trust every product or piece of info thrown at them with no questions asked; there is a level of trust that must be attained first. Moreover, in a study between the trust in a social networking site and purchase intentions, it was found that there was a strong positive relationship between the two and thus the stronger one’s trust in a site, the more likely they would purchase from it (Hajli et al., 2017).

Assuming there is a level of trust, users are attracted to use certain software like solar tools because they may offer insights into their own energy usage, information on the benefits of adopting solar solutions, or reduce the barriers between them and committing to purchasing some solar device. Such users often view the technology as empowering, providing them with the information needed to make well-informed decisions about renewable energy. However, this trust can be abused, and software’s persuasive elements may be intentionally or unintentionally misleading. Online fraud occurs frequently. In 2001, The Internet Fraud Complaint Center received over five thousand filings from both consumers and businesses that claimed to have been defrauded (NWCCC, 2001). Because the customer is the focal point of any E-commerce industry, they are unfortunately targeted often, and it can sometimes be impossible to tell when. In a study conducted by Grazioli, it was found that subjects were not able to discriminate between a clean and deceptive site where a deceptive site could contain misleading info, fake statistics, scam deals, or fabricated seals (Grazioli, 2004). There is an ethical responsibility for software to ensure transparency, foster trust, and empower users to make decisions rooted in accurate, balanced information rather than manipulation. Unfortunately design often seems to work to achieve trust then pushes its own agenda (typically monetary gain) only enough to the point where trust is not lost.

Building off trust, designers and developers are the engineers behind creating the space where information is to be believed, and products deemed legitimate. Their choices regarding software features, user interface, and persuasive elements directly influence how the technology is perceived and used. While designers may aim to create software that effectively promotes solar adoption, they also face ethical dilemmas regarding the extent to which persuasion should be employed. Persuasion is very powerful with a study finding that brand design is a significant factor on consumers' purchase decisions at the point of sale, where 73% of purchase decisions are made at that point (Connolly & Davison, 1996). Such intentional focus on tactics can easily blur the line between encouragement and coercion, however. Some designs choose to use personalized data to better inform the results given to users. Most personalization processes do this by relying on big data, including geolocation, buyer personas, and buyer statuses, to infer customers' preferences (Yan et al., 2009). This can lead to an additional imbalance in power dynamics if a customer isn’t given control over what and how their information is used. For a developer in solar, their main ethical challenge lies in balancing the urgency of promoting renewable energy with the need to respect users' autonomy and avoid deceptive practices.

Some developers are fully aware of the ease they can hide their manipulation and create a product with the sole purpose of deception. In a study analyzing over 18,000 E-Commerce sites across the internet, it was found that 32% of search results pointed to a site selling counterfeit goods (Wadleigh et al., 2015). Software design is thus of course shaped by the values of the designers themselves but also by market forces, societal standards, and other influences on the creators.

The broader societal context also plays a significant role in shaping the development and reception of solar marketing software. Increasing awareness of climate change and the urgency of transitioning to renewable energy sources create a favorable environment for persuasive software. In a poll of 600+ participants, Latkin found that 65% of them were either very worried or extremely worried about climate change and 25% were willing to take political action (Latkin et al., 2021). If this sentiment were to be taken advantage of or played into using certain rhetoric, software may have a stronger influence if targeted at the specific audience, even if it compromises consumers' trust.

Conclusion

User-centered design is a powerful tool that enables software to better connect with its intended audience. It births software that places its users first and fits the requirements around them. A user-friendly interface helps to bridge users and technology, empowering them to use the software and its results confidently. For growing movements like solar, good design is crucial to empowering new consumers and pushing against existing standards. Because of how powerful a role software design plays now in how information is communicated, we must also be cautious about the extent we allow software to govern our decisions.

I expect my technical work to yield results about specific designs and heuristics that best captivate, educate, and empower new solar customers. With these results, boundaries that separate users from investing in solar will hopefully be reduced. I also hope to discover what responsibilities different parties hold in the creation and use of software and the role that they play. This analysis should help inform all parties of how they influence and are influenced by all relevant groups. With this, consumers can become aware of the different types of influence at play and designers can understand the ramifications of their product. As society pushes forward into a solar-powered world, consumers must be protected and empowered so emerging software must be designed and examined with care.

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