C.H.E.S.S.B.O.A.R.D.: An Interactive Chessboard Learning Aid

Electric Vehicle Supply Equipment (EVSE) as a Product – An Investigation into Intelligent Product Packaging

A Thesis Prospectus In STS 4500

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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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Introduction

Science, Technology, and Society (STS) promotes a perspective of products, devices, and technologies as integral, acting parts of the world we live in. The car is not just a mode of transportation, it is a way of living. The proliferation of cars and personal transport has cemented society into car-centric urban design. Cities are built for cars, not people. These spaces are not welcoming to those of lower income or those who have physical impairment and cannot operate traditional cars (Kay, 2013). This interaction between technological products and society shows that in many ways our choices to offer certain products and in what form have serious consequences. When we acknowledge and act upon the capacity of accommodating designs, we empower ourselves to produce a more sustainable future.

In both my Technical Project and STS Project, I am seeking to investigate how we can do better in building products that hold true to values of equity and sustainability. My Technical Project will be on the implementation of an assistive chessboard. The chessboard will leverage magnetic Hall-effect sensors to detect the color and type of piece on each tile. The chessboard will respond to inputs in piece movement by illuminating tiles with under-tile LEDs to communicate to the user about move legality and inform the user on potential moves. My STS topic will be on identifying the failings of Electric Vehicle Supply Equipment (EVSE), particularly how those failings are creating barriers to demographics and by consequence limiting the potential adoption of electric vehicles (EVs).

Technical Topic

Playing chess offers many benefits to physical and mental health (Nakao, 2019). Chess engages its players in social bonding, critical thinking, and motor activities. The team wants to create a variant of the chessboard that enhances the experience and makes chess as accessible as

possible. That is, we want to make a more intuitive way to learn the rules of chess and pick up on strategies without having to attend lessons, read a book, or connect to the internet. Our target clients are beginner-to-intermediate players, players who we expect are not familiar with the rules of chess and/or are not confident in their abilities. This is a diverse array of peoples but using children as the "lowest common denominator" was deemed satisfactory to ensuring accessibility to the largest audience. In terms of anticipating prior knowledge, if the system is usable to a child we believe it will be for an adult.

By embedding magnetic sensors into the tiles and corresponding magnets to the chess pieces, the system is theoretically capable of detecting and validating all possible moves. This is an important feature that sets this implementation apart from other similar "smart chessboards" created at UVA. Other implementations rely on digital configuration, which only knows if a piece is present or not (Chittari, 2023). A game limitation using a digital sensor network is the inability to promote a pawn. It is impossible to know what the piece is promoting too without asking the user. The move validation feature is imperative to the objective of being a learning aid. We want the user to adopt good habits and become competent enough to play alone and/or competitively.

The under-tile LED array will be the main method of communicating with the user. This method is both simple to implement, flexible, and language agnostic. The type of information that will be communicated are legality validation alerts, highlighting what pieces can move, highlighting where a piece can move to, highlighting a recommended move, and highlighting what piece to move to revert to a prior board state. The color of the illumination and frequency will help to further communicate ideas. Flashing red, for example, will communicate an illegal

move. It is both intuitive with red being a very common color for errors and flashing to catch the attention of the user.

The last major feature is automatic transcription. This is more geared toward our intermediate clients but can still be useful to beginners. The chessboard will automatically save the progression of board states and record them in standard chess notation. The transcription can be offloaded to a flash-drive for viewing on a personal device. If the person has access to online resources like Chess.com, the transcription is readily accepted by such programs and can be analyzed for the user. We hope by providing this option that a user be able to learn the standard notation so they can learn from other players' games.

The team has created a plan to finish the device in one semester. Liam, Lordes, and I are focused primarily on the hardware components of the product. This includes the part enclosures, printed circuit boards (PCBs), Hall-effect sensor array, LED array, clock display, and chess pieces. John and Paul will be the primary contact for software-related features. This includes integrating Stockfish (a publicly available chess engine), the input logic for the sensors and buttons, and the output logic for the LEDs and LCD display. Manufacturing is expected to finish in early November with product testing finishing in early December. The team will bring in external testers, like friends and the local chess club, to review the features of the product.

STS Topic

It takes just two minutes and thirty seconds to render a typical Electric Vehicle (EV) Direct Current Fast Charger (DCFC) site inoperable (Krisher, 2024). How? All it takes is a car and cable cutters. Cable theft has been a growing issue accompanying the growth in EV infrastructure. Without a charging cable, or even simply damage to a cable, EV chargers are unable to provide any meaningful service to EV drivers and can disrupt the day-to-day lives of

its dependents. A lack of security features is just one part of a larger failing of EVSE design that is contributing to the disparage in consumer experience, in this example to those of low-income communities. Very often we are caught up in the naïve perspective that in order to promote conversion from the internal combustion engine to electric drive we simply need more chargers. To some extent this is true, but we must remain cognizant that technology itself is a shaper of society. Langdon Winner in *Do Artifacts Have Politics?* Emphasizes that technologies have a capacity to impose upon society certain norms or experiences (Winner, 1980). I want to investigate what negative experiences people are having and what design aspects of the charger are responsible for these.

To begin my investigation, I need to understand how many different types of people react and interact with EVSE. Demographics that are relevant pertain to divisions in race, age, and economic status. If EVs are to reach the popularity of their combustion engine counterparts, they need to accommodate everyone, not just early adopters or well-bodied individuals. I will emphasize those with traditionally less accommodations in technology like women, people of color, the elderly, and blue collared individuals.

I plan to make use of multiple types of sources to try to create a more complete understanding of the situation. Online forums are a good way to hear opinions directly from people. These will not be very professionally formatted, but this type of environment is where people who are most frustrated would likely vent their opinion out. Consumer reports would likely have similar content, but slightly more professionally conveyed. I expect some level of "filtering" to have occurred since these reviews are made by more experienced professionals. The same can be said of other journalist media. Another useful source is official studies/surveys. I expect that there are studies where volunteers are invited to charge an EV and their response is

recorded. Surveys will most likely tackle the minute details revealed by a study, especially if categorical concerns are given as options rather than a free response. *Reliability of Open Public Electric Vehicle Direct Current Fast Chargers* by David Rempel is an example of such a study that fathers customer reports of issues to better understand EVSE problems (Rempel, 2022). Overall, I think each source has their own virtues, which is why when put together I can create a better assessment as to where and how EVSE need to change. Some technical sources will be brought into the mix to also provide background about why certain directions were taken, like in the case of the cumbersome Combined Charging System (CCS) vs compact North American Charging Standard the bulkiness is for the safety of an independent DC and AC system (Paryani, 2023).

Key terms that I am looking for when searching for these sources are “EVSE User Experience”, “EV Charging Standards Survey”, “EV Charging Cable Theft”, “EVSE Security Concerns”, “EVSE Confusion”, etc. I anticipate having to be very specific for certain topics. I, having worked on EVSE design, am aware of some design flaws which I am sure users have had issues with but with which I have not heard any major news about. This is likely where forums will be necessary to get beyond the typical issues and covered by the media.

I will use the Actor Network Theory (ANT) framework to analyze my topic. For the eventual success of EVSE we must satisfy the demands of many different social groups as well as inanimate objects like EVs themselves. EVs, corporate parties, engineers, technicians, and consumers are all examples of broad stroke actors in the network. Even then, divisions in company and demographic background garner even more diverse needs toward a common goal of being able to successfully charge on public EVSE. Nissan, for example, is one of the only companies with continued interest in support of CHAdeMO equipment, since the Nissan Leaf

has yet to move to the more popular CCS and NACS standards. Gender, ethnicity, age, and gender, as my initial research has shown, amount to circumstances where contemporary design do not always allow the consumer to participate.

Key Texts

Like mentioned in the introduction, most sources focus heavily on the issue of charger location, speed, and reliability. These alone do not address the usability of the dispenser design itself. A good example of a source that did match what I was looking for was a study by Haopeng Wu and Wonseok Yang. They describe their study as follows, "The experimental setup featured a simulated EV charging station interface, where participants completed tasks mirroring real-life scenarios." (Wu, 2024, Page 1). This is directly investigating the barriers created by user interface design and found that education and language were major factors in poor experience as both acted as barrier to understanding how to use the dispenser (not able to make sense of the sparce instructions).

John Hekman's *Electric Vehicle charging infrastructure for people living with disabilities* explores the difficulties experienced by those with disabilities in using EVs (Hekman, 2020). This is a key source for my key demographic of elderly individuals.

There was also a J.D. Power evaluation of EVSE experience, and it found a major consumer interest was in "Plug & Pay" (Effler, 2024). This feature reduces the interaction between consumer and dispenser, streamlining the process. I expect the elderly to be a significant portion of the consumers who prefer the old payment method by card.

As mentioned at the beginning of the STS section, security of EVSE is a major concern for lower income individuals. This is explained in *Electric Vehicle Charging Analytics and*

Reporting Tool (EV-ChART) (DOE, 2024). This source connects socio-economic markers with regions of high EVSE downtime. I found a study evaluating the reliability of EVSE.

With these key texts already identified, there is not too much more that needs to be done in research. Research should conclude by November 22nd. This prospectus is due December 6th. A presentation about this prospectus will be given just prior to Thanksgiving break.

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