Design and Construction of a Kinetic Art Weather Display

(Technical Report)

The Inclusivity of MakerSpaces

(STS Research Report)

A Thesis Prospectus Submitted to the

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Katherine Ellis
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Technical Project Team Members
Lisa Accolla
Jack Davis
Adam Lenox
Josh Rigby

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

Signature _____ Date _____
Katherine Ellis

Approved _____ Date _____
Gavin Garner, Department of Mechanical and Aerospace Engineering

Approved _____ Date _____
Sean Ferguson, Department of Engineering and Society

Introduction

The field of mechatronics is a synergistic view of engineering in an applied setting. It harnesses the skills developed in mechanical, electrical, and software engineering to create a complex and interactive system. This capstone focuses on showcasing how mechatronics can be applied to create artistic value in a space. This type of kinetic art piece will be a weather display that takes in inputs from a real-time weather application and move the weather indicator pieces in the display to mimic what the weather is outside. The purpose is to bring creativity and light to the Mechanical and Aerospace Building basement, a space where students and faculty spend significant time, but however lacks windows and natural time indicators. Upon brainstorming how to create this piece and with what materials, it was realized how unlimited the ideas could be due to the advanced lab, The Mechatronics Innovation and Learning Lab (The MILL), that students are able to work in. The MILL has any tool, machine, and part that would be needed in the design. Spaces such as this are called MakerSpaces and they are becoming increasingly more available to the everyday individual. There are currently MakerSpaces open to the public, which have to potential to include more groups in what is called the Maker Movement compared to before. The STS research portion explores how inclusive the MakerSpaces really are— diving into their accessibility both physically and financially, as well as analyzing their social impact in regard to expanding the STEM field beyond one group of individuals.

Technical Topic

The objective of the capstone project is to develop a functional piece of wall art that uses mechanical movements and electronics to display various outdoor/weather conditions. It will

further be referred to as a kinetic art weather display or weather display. This idea was inspired by the conditions that students and researchers are under when they are working in the labs of the University of Virginia's Mechanical and Aerospace Engineering department, which are located in the basement of the Mechanical Engineering (MEC) Building at UVA. These labs have no windows and one can easily lose track of time, especially when personal protective equipment is being worn, making it difficult to check one's phone. Thus, the weather display will serve the purpose of informing users of the current conditions outdoors (rain, snow, clear, daytime, nighttime, etc.) through pictorial means that are quick and easy to process with just a glance, while also being aesthetically pleasing. It will also demonstrate important engineering concepts such as the modern-day synthesis of electronics and mechanical devices, as well as advanced manufacturing techniques such as 3D-printing, CNC machining, and laser cutting that allow for the construction of complex products with relatively low monetary and time costs.

A literature review yielded one product that is of a similar concept to the one developed by the capstone group. The "Weather Clock" by Bramwell Brown is primarily an analog clock, but it has a small display in the bottom portion that depicts various weather conditions with moving parts and what weather condition is displayed is dependent upon the information from an internal barometric pressure sensor (Bramwell Brown, 2020). From the following description, it can be discerned that the capstone group's weather display will differ significantly.

The display will be a circular design fashioned from wood using a CNC Mill, where the top half is a visible window for weather and the bottom will be space to store the mechanics that operate the weather changing devices. It will feature two transparent, semicircular acrylic sheets that are engraved with rain and snow patterns. These sheets, when illuminated by strips of LED lights, provide an artistic simulation of the current weather pattern. The design will also involve

sun and moon figures that rotate around the display to indicate the day and night. Smaller features that will be included are a backlight that can vary brightness within the window, a UVA-themed background, an LED matrix display indicating time, date, and temperature, as well as interactive buttons that will allow manual control of the settings. The goal is for all these movements and displays to be dictated by a Parallax Propeller microcontroller chip that is connected to a Raspberry Pi single-board computer that will relay weather and time data from an open-source application programming interface (API). OpenWeather offers free API's for over 200,000 cities, processing data from various satellites, radars, and models that can that be programmed with the mechanical weather indicators to display an accurate depiction of the current weather (OpenWeather, n.d.).

The capstone group's general plan is to prototype the various mechanical movements to see if they are viable. Then, the entire project will be modeled in a computer-aided design (CAD) software to determine the placement of all the components and overall size of the project. Once the modeling is complete, the weather display will be constructed with traditional techniques as well as new, advanced manufacturing techniques such as 3D-printing, wood CNC milling, and laser cutting acrylic. The project is set to be completed in November 2020.

STS Topic

The emergence of Makerspaces in everyday society brings immense opportunity for inclusivity in the STEM field. MakerSpaces offer an array of machinery and materials for users to harness their creativity in a limitless environment. These spaces also attempt to promote inventions and further technological advancement. MakerSpaces have started becoming available to everyday people, no longer just the elite or those at prestigious universities. There now exists

spaces available to the public similar to a local business, where, theoretically, anyone can go and use the resources available for a price or using a nonexclusive membership. This growing availability allows for the potential for more groups to be involved in this Maker Movement, expanding the types of people who have access.

While humans have long had the drive to invent and build new things, the Maker Movement was officially started in 2006 with Dale Dougherty's first ever Maker Faire which brought together all types of inventors, hobbyists, educators, students, and the like to showcase things they've made or to teach something they've learned (Fernández, 2015). Dougherty describes the modern maker as having a greater advantage due to "a level of interconnectedness that has helped to build a movement out of what in the past would have been simply a series of micro communities defined by a particular hobby or activity" (Dougherty, 2012). The event was very popular and show cased how invention is no longer limited to a select few. Much of this is due to major developments in technology such as the 3D printer that made challenging design and creation tasks simpler. The 3D printer is considered a revolutionary technology as it brings ease to the creation of parts and objects that would normally have taken considerable amounts of time, money, and material. With the commercialized industry, everyday consumers can now purchase one as their own and use at their own discretion. This newfound access of society to such an elaborate technical machine is argued to have led to the development of civil society's intervention in shaping the technological and intellectual future (Savvides, 2019). As Christopher Schneider at Karlsruhe Institute of Technology describes it, not only do the new technologies foster this growing sector of influence, but also "novel processes that organize and distribute technological skills and creativity" (Schneider, 2020). There are many arguments being made that more of society is involved in technological advancement due to these spaces.

However, it will be interesting to look into whether all of society is included in this movement, or rather if some are more involved than others as normally seen in the STEM field. This way to looking at the movement ties heavily into the Actor Network Theory. Using this theory, the relationship between people and MakerSpaces as well as the technologies inside them can be connected to why people are drawn to the spaces and what gains they hope to receive from them. As described by Sismodo in *Actor Network Theory: An Introduction to Science and Technology*, the actors involved, people and MakerSpaces, have a purpose in this movement that is causing them to act and lead to societal change (Sismodo, 2010).

Not every MakerSpace is built the same or attracts the same type of person. To start, there are many variations of the space. One of the most common locations for a MakerSpace is a university. Universities have immense capital to invest in spaces such as these and stock them with materials and new equipment that regular students and staff wouldn't be able to afford. On the other hand, some spaces are particularly geared towards the youth (elementary/middle school), especially as a way to introduce STEM into their lives early for future consideration later in life. One student in Arizona describes having a design lab in her local library as a way for "youth [to have] a voice to decide what they want to do and how they want to do it and how it'll affect their lives" (Learning Labs, n.d.). An important development in the Maker Movement is the repurposing of public libraries. Libraries have always been a space that encourages learning in a collaborative environment. However, with the dominance of modern-day electronics and ease of having E-books, libraries have struggled to remain relevant. MakerSpaces offer a solution to bring community members back to libraries in a way that is accessible and non-intimidating (Zansler, 2020). This is an important idea to explore for the research into inclusively in the Maker Movement, especially due to the idea that more technical spaces might intimidated

supposedly welcomed people to join. MakerSpaces have the ability to bring together communities, but there is most likely certain methods of operation and design that are more conducive. Further study into how these human actors interact with the MakerSpace will help to understand their impact on sectors of society.

The main focus of this research is to analyze the true inclusivity of the spaces and discover whether within their expansion, groups are still being left out or not considered and whether this leads to further divisions in other sectors of society. It will be important to understand the various stakeholders in the Maker Movement. This can include the users or members of society physically going to the spaces, as well as those building and managing the spaces. The creators of the spaces play a huge role in determining how welcome others feel to use to the space and how accessibility it is to all corners of society. Another group of stakeholders is the government, both federal and local, who have the ability to promote the Maker Movement financially. The Institute of Museum and Library Services (IMLS) is a federal agency that awards grants for MakerSpaces in places such as libraries and museums; they also brought a Maker Faire to Capitol Hill (IMLS, n.d.). In determining the inclusivity of this movement, it'll be necessary to explore where funding for the spaces go, in terms of physical location and the type of community. Dale Dougherty, founder of the Maker Faire, explains that many cities have zoning restrictions prohibiting the construction of MakerSpaces, and therefore there is a need for lawmakers to be educated on the value of the spaces (Dougherty, 2012). It would be interesting to see why these zoning laws were placed and in what parts of the city. Going further, in schools, are they solely built in wealthier districts? The same question can be asked about public MakerSpaces as well.

Besides class, another factor to look at could be gender roles. The STEM field has continuously been male dominated. Do the emergence of these spaces continue to divide the gender roles, or do they offer a gateway for more women to be motivated to pursue STEM careers? These questions along with others will be answered through both numerical research as well as through reading argumentative papers on social aspects of MakerSpaces. This includes looking at why people go to these places and whether they feel more motivated to by these spaces and the technology available to join the movement. Additionally, the plan is to look through how participating in these spaces affects people's lives outside of them. Are they starting companies, pivoting their careers, or teaching others? This question will be important to understand the impact these spaces have and if groups are excluded, how this can lead to divisions in other places. In terms of factual research, evidence will be needed to back up any stance made on inclusivity. Evidence could range from where the most spaces are located, how many are in existence, the cost placed on the user to participate, etc. Using these facts along with the development of understanding social motivations and social impacts will allow for a strong argument to be executed on the inclusivity of the Maker Movement.

Next Steps

To advance towards the final thesis report, multiple steps need to be done upon reaching completion. For the end of the fall semester, the thesis prospectus will be presented to advisors and peers for review as well as feedback to consider before moving forward with the thesis. With a clear end goal in mind, more research needs to be done in order to develop an organizational structure for the final report along with the ability to create a solid argument in regards to inclusivity of Maker Spaces. Research includes both textual, through scholarly articles and

papers, as well as personal through interviews of participators in the Maker Movement from all angles to hear experiences and opinions. It would be ideal to have many types of people, from various backgrounds and levels of technical experiences along with those who are involved in the opening of MakerSpaces such as colleges or high schools. After sufficient information gathering, the thesis will be consistently worked on during the spring to finalize the report.

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