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Interactive Museum

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**An Interactive Qualifying Project
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Abstract

This project aims to initiate an effort for WPI to design and implement its own campus museum. A university museum should mean more than showing paintings or antiquated artifacts. In this manner this paper includes museum and exhibit ideas for WPI, which we believe would generate awareness and excitement to students, faculty, and visitors through interactive and involved concepts. Additionally, we will design attention-grabbing installations for presentation to the Worcester Art Museum. These exhibit ideas will combine art and technology to add a contemporary edge to the museum, attracting college students in the area. An adjacent goal of this Interactive Qualifying Project is to create an interactive exhibition for placement on the WPI campus.

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1. INTRODUCTION

The Interactive Museum IQP is a means to demonstrate that technology can connect people on a very human level. The purpose behind this project is to contribute to WPI an art and science installation that is both aesthetically stunning and representative of the pride taken in technology at this school. By providing a visually, mentally, and socially stimulating environment, a digital art exhibit would be brilliant way to attract prospective students and to form a bond between existing students. Art can be interpreted in hundreds of different ways, depending on the viewer, and that is a major reason that art is so appealing to so many people. However, technology is a foreign concept to some. To create a marriage between the two concepts would be to bridge a gap from circuit boards and lines of code to humanity and how people interact.

2. Research

In order to create a campus museum or gallery that would attract attention and appeal to the WPI audience, we observed several other museums and museum concepts. First we read about several museums renowned for their unconventional architecture, such as the Denver Art Museum and the Guggenheim in New York. Descriptions and blueprints of these buildings reveal much of the obstacles faced by museum curators who must place exhibits in the most appealing arrangements for visitors. Next we visited museums that acknowledge interactivity as a priority, namely the Museum of Science in Boston. By observing the exhibits and museum visitors, we gained an understanding of the levels of interactivity and about what constitutes a successful installation.

Finally we conducted an interview with the director of the MIT Museum. The interview gave insight into the intricacies of museum management, including layout, security, exhibit acquisition, and maintenance. Through our research, we learned about what types of exhibits are popular and how space is used to optimize the experience of the museum-goer.

2.1 Technical

An important factor in creating a successful exhibit is the space in which the work is installed. We researched museums that utilize space in interesting ways in order to better understand how architecture impacts art.

According to the International Council of Museums (ICOM) Statutes adopted during the 21st General Conference in Vienna, Austria in 2007, "a museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment." Although most museums are formed in traditional buildings, there are great examples of unconventional architecture alternative to the usual white box

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buildings. A prime example is the Guggenheim Museum in New York, where curators have to deal with the continuous slope of the floor to make exhibits appear correctly oriented. Additionally for the Museum of Art in Denver, which has extreme long sharp corners, it was decided that some of these corners would be used for storage and others as extensions of the building, leaving the visitor a common indoor space.

Figure 1: Layout of the Museum of Art in Denver

By looking at these examples, we see that the apparent issue of having unconventional architecture is actually not an issue after all. What is interesting about these buildings is not hidden behind their doors; they are works of art themselves. Many people go to these museums to see the structure itself as well as the exhibitions inside. When people go to these museums, they know that they should expect something unusual by observing the architecture.

When Frank Lloyd Wright designed the Guggenheim Museum, he intended to create an environment where each painting would exist within the entire space, "not within its rectilinear frame in

a rectilinear room."[1] The resulting building was a monumental corkscrew with curved, sloping walls. However, this presented an issue with easily displaying works in the space. Museum director James Johnson Sweeney suggested mounting paintings on poles bolted to the walls, enhanced by artificial lighting. This idea appalled Wright, going against his vision of a flowing, natural space. In response, he wrote an essay entitled "An Experiment in the Third-Dimension," complete with sketches, outlining his goal for the museum interior.[2]
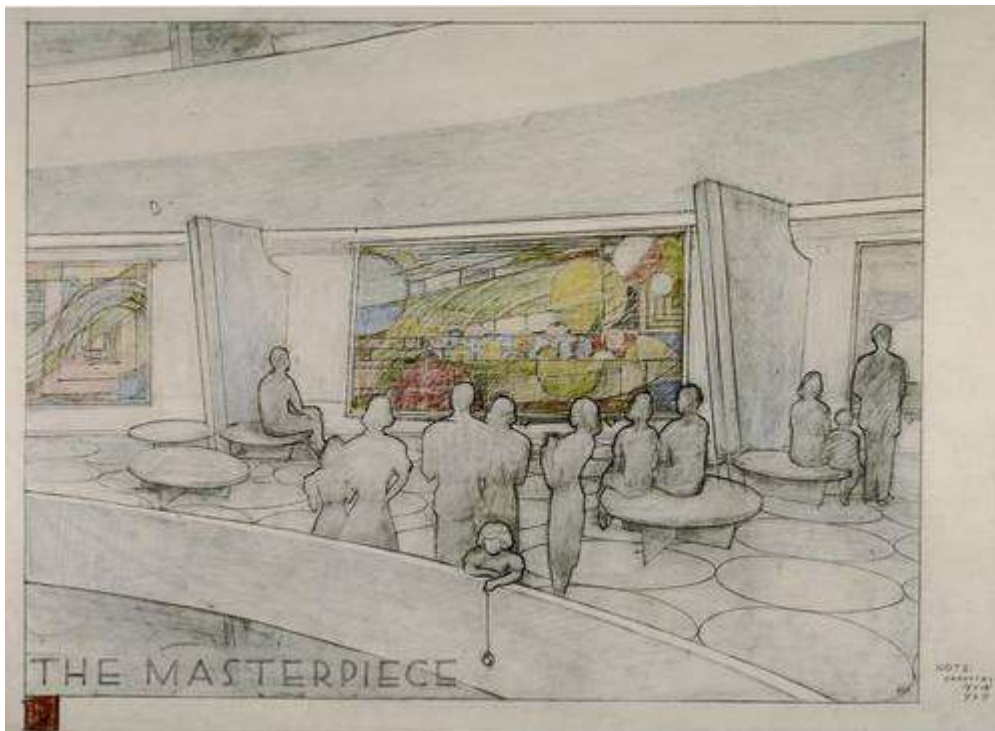
Figure 2: Frank Lloyd Wright's concept of the museum interior

Because the walls, as well as the floors, were slightly sloped, Wright wanted the paintings to be inclined upward toward the viewer, permitting museum visitors to effortlessly peruse the collection. This layout would also allow the works to capture the natural lighting. Freestanding, double-sided

[1] Hilary Ballon, *The Guggenheim: Frank Lloyd Wright and the Making of the Modern Museum* (New York: Solomon R. Guggenheim Foundation, 2009)
[2] Frank Lloyd Wright, *The Solomon R. Guggenheim Museum* (New York: Solomon R. Guggenheim Foundation and Horizon Press, 1960), http://archive.org/details/solowrig00solo (accessed Sep 14, 2012)

screens (also tilted) could serve as additional space for paintings. Wright suggests in his essay that any

sculpture should be mounted on a rounded pedestal made from the same material as the floor and

walls for a cohesive effect. With these applications, each painting would be "seen as a master of [its]

own allotted space," while also blending harmoniously with the atmosphere.[3]

Custom pedestals were built that made the artwork on display appear to be vertical while

actually being at an angle, fixing the illusion caused by the floor and walls.[4] Later, a rectangular building

was attached to the Guggenheim which helped facilitate placement of artwork (Architects).

Figure 3: The exterior of the Guggenheim Museum in New York

There are many other examples of museums that overcome strange layouts to provide a

distinctive viewing space for works of art. In the Denver Art Museum, scale models of each exhibit space

have been created so as to allow for careful planning of the placement of artwork.[5] By creating a

physical (or virtual) model of an exhibit, all parts of an exhibit room can be completely planned out,

including where people will stand and view the pieces. Creating these models is an optimal way of

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[3] Ballon, *The Guggenheim*

[4] J. Canaday, "Museum Director Solved Problem: Guggenheim Official Faces Trouble of Architecture," *The New York Times*, August 17, 1962.

[5] Eric Berkemeyer, "Planning the Layout for El Anatsui: When I Last Wrote to You about Africa," *Denver Art Museum*, September 5, 2012, http://www.denverartmuseum.org/article/staff-blogs/planning-layout-el-anatsui-when-last-i-wrote-you-about-africa (accessed September 16, 2012).

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deciding how to best utilize a space as everything can be planned out before the exhibit is even set up

allowing for possible unforeseen circumstances to be found early on in the process.

Figure 4: The exterior of the Denver Art Museum

Unconventional museum designs draw audiences from around the world because of their

unique architectural feats. The Royal Ontario Museum in Toronto is one of North America's largest

museums. The main entrance (named "The Crystal") features a jagged geometric exterior and enormous

open, arched interior. The goal of The Crystal is to provide accessibility to the museum and to "blur the

lines between the threshold linking the public area of the street and the more private area of the

museum."[6] The entrance suffered from water leakages after enduring its first winter, however because

the museum's exhibits are completely separate, they remained unaffected.

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[6] Laura Mathews, "Royal Ontario Museum," *The Canadian Encyclopedia*,
http://www.thecanadianencyclopedia.com/articles/royal-ontario-museum (accessed February 22, 2013)

Figure 5: The exterior of the Royal Ontario Museum

The National Museum of Art in Osaka, Japan, features titanium steel tubes resembling more of a sculpture than a building. Because of the limited space as well as the irregular shape, it was impractical for the museum itself to be inside of the sculptured exterior. Instead, the exhibits and storage facilities are located underground.

Figure 6: The National Museum of Art Located in Osaka, Japan

The Milwaukee Art Museum boasts a huge, white concrete pavilion with moving, wing-like "brise soleil" (French for "sun breaker") which shades visitors from the sun. It has a wingspan of over 200 feet and will open and close according to the time of day. In addition to this, its location provides passage to and from downtown. Directly below the brise soleil is the Windhover Hall which serves as an entrance to the museum. During regular hours it is open to the public free of charge. Before the pavilion was built, the museum went largely unnoticed because it is located below a War Memorial Center. After renovations, this architectural feat has become a symbol for the town of Milwaukee and draws in visitors from far and wide.

These museums demonstrate that it is possible to utilize unusual architecture while still overcoming obstacles presented by having uncustomary construction. With some ingenuity, it is possible to utilize all the space within a room even when it would seem impossible.

2.2 Museum Visits

To gain insight into how people behave and interact in a museum, we visited the Boston Museum of Science and the Higgins Armory in Worcester. While visiting, we observed and experimented with the various exhibitions to gain a better understanding of how different types of exhibits are displayed. We also observed the other visitors to determine the factors that make up a successful exhibit and to learn about how people interact and learn.

2.2.1 Museum of Science

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At the Museum of Science every exhibit is organized into a category and placed in a room or area with similar exhibits. Some sections of the museum for example, are mathematics, light, electricity, and dinosaurs. This separation makes it easy for visitors to navigate the museum and learn about the things they are personally interested in. It would be wise to incorporate this idea into our on-campus gallery by sorting exhibits by topic, WPI major, or artist inspiration.

Visitors were able to touch exhibits that they were looking at as opposed to just observing them. This made the museum a more exciting experience as it kept the audiences actively engaged in what they were viewing. Another interesting experience was the live presentations. They made people look forward to going to events that were not happening all the time.

Nearly every exhibit at the Museum of Science was simplified to the point where a child could comprehend what the exhibit meant to display. This means that anyone, regardless of their knowledge on the subject, could understand just about every piece in the museum. The museum does not limit nor lose their audience with difficult to understand or complicated exhibits and descriptions.

This is an important aspect that should be taken into consideration for WPI's interactive exhibit. If the concept is not easily understandable, it will deter visitors and students. However, the exhibit should be in-depth enough to hold the attention of more knowledgeable visitors. A simple solution for this could be to have both simple and detailed explanations.

2.2.2 Higgins Armory

The Higgins Armory is museum that boasts an expansive collection of armor and weaponry spanning cultures and time periods. Although it is not entirely dedicated to interactivity, it does have a gallery called Castle Quest where visitors can try on armor, pick up weapons, and build castles. The exhibition is geared toward younger, elementary school-age children, but offered several lessons in what makes a good interactive exhibit.

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First, an exhibit meant for college students should not be too simplistic. The design should be centered on a concept that is familiar, but not simplified to the point where it runs the risk of boring the visitor. The piece should demonstrate a challenging concept and present it in an interesting way.

Second, any interactive exhibit should not take too long to execute. The Higgins Armory has its own medieval-themed version of the game Battleship, where players strategize to defend castles. While the game itself was not particularly interesting, what truly makes it a poor exhibit is the time it takes to play. It is also reminiscent of several exhibits at the Museum of Science that visitors wanted to interact with, but had to wait behind another visitor.

Other than the small interactive gallery, the Higgins Armory has a multitude of armor, weapons, and various other items in glass cases or bolted to the walls. Although the items are strictly for display, it is worth noting that on the description cards of some exhibits there are QR codes with messages such as "Scan with your smartphone to see the war hammer in action." This is a creative method of demonstrating the use of an object that cannot be handled by visitors. To take inspiration from this concept, in our campus museum a video or slideshow can be directly displayed next to any exhibit that is too fragile to allow visitors to experiment with. A more interactive option might be a touchscreen simulation of such an exhibit that can be operated by the visitor. In this way, campus museum visitors can gain a more profound understanding of less robust exhibits than they would had they merely observed the item passively.

2.3 Interviews

We interviewed Massachusetts Institute of Technology's museum director John Durant in order to research museum space, staffing, upkeep, and artifact possession. Durant spoke first of the origins of MIT's museum. He stated that artifacts that had accumulated since the institution's beginning needed a

place to permanently live. It was decided that museum space was to be allocated with the intention of displaying these pieces. The museum has tens of thousands of exhibitions ranging from architectural design to holography.

The main area of the MIT museum is roughly 15,000 to 20,000 square feet and has two smaller galleries. In terms of staff, the museum employs about 25 people to work as curators, publicists, and technology, exhibition, and program managers. The staff also takes care of any security issues by supervising visitors; due to the low market value of many artifacts in the museum, security is not thought to be a problem.

In order to facilitate new artifacts loan agreements or gift agreements are necessary. Creators of exhibitions willingly loan or gift their pieces to the museum. When a piece is gifted, it becomes part of the collection. There is no insurance required in galleries of technology; instead, MIT's the baseline school insurance suffices.

2.4 Legal

There are unique legal issues that museums tend to face; they must negotiate complex agreements for the donations of large collections as well as determine how to respond to art that was illegally imported into the country, stolen, or seized during wartime. Museums must have contracts with artists whose work is displayed and deal with issues when the artist's work involves controversial matters. The art must be authenticated and may be subject to legal claims of a foreign government. Additionally, works of art must be properly valued for purposes such as tax and estate planning; therefore museums must figure out how to go about this.[7]

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[7] *Patterson Belknap Webb & Tyler LLP*, "Art and Museum Law," http://www.pbwt.com/practiceareas/art-museum-law/ (accessed February 22, 2013).

Gifts given to the museum may become problematic. A concrete gift acceptance policy should be established with a separate committee to evaluate and document decisions about proposed gifts and should clearly state the museum's rules. There are three different types of gifts that may be given to a museum: fractional, conditional, and restricted. Fractional gifts allow the artist to keep partial ownership of their work and receive a charitable deduction for tax purposes.[8] Conditional gifts are exchanges made with the museum within reason. The condition cannot be unlawful nor against public policy.[9] A restricted gift is "offered to and accepted by a museum with legally binding conditions that limit the museum's use of potential disposition of the work."[10]

A museum co-owning a work of art with another institution or individual must be carefully arranged. For example if one party cannot pay their share of the needed cash, the other party should have the right to terminate the agreement altogether or find another joint buyer. In the case that one owner passes, a "tenancy in common" in which neither owner is granted full ownership is generally arranged.[11]

3. Exhibit Concepts

After a fair amount of research, we designed a number of exhibits to be placed at WPI or the Worcester Art Museum.

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[8] *Museum of Fine Arts Boston,* "How to Give Art," http://www.mfa.org/give/gifts-art/how-give-art (accessed February 22, 2013).

[9] Shane Simpson, *Donations*, http://www.simpsons.com.au/documents/museums/acquisition/DONATION.pdf (accessed February 22, 2013).

[10] Nicole A. Ferdinando, "A Juggling Act: Balancing Institutional Needs and Donor Restrictions in Art Museums," (2011) Master's thesis, Seton Hall University, http://scholarship.shu.edu/cgi/viewcontent.cgi?article=1013&context=dissertations (accessed February 22, 2013).

[11] Martha Lufkin, "Broken Pledges, Bankrupt Donors and Sharing Works of Art: Hot Topics from the 2011 Legal Issues in Museums Conference," *Art Newspaper*, May 17, 2011, http://www.theartnewspaper.com/articles/Broken%20pledges,%20bankrupt%20donors%20and%20sharing%20works%20of%20art/23659 (accessed February 22, 2013).

In order to poll interest for a museum on campus, our team conducted a survey among WPI undergraduates regarding the project.[12] Out of 100 responses, 68 students agreed that an art or science museum would be a valuable addition to the school. While the majority considered it to less important than a library, 10% considered it to be equally important. Even more students rated a museum to be of equal or higher importance to a gymnasium or lounge area.

Over a quarter of students have no knowledge of exhibits placed on campus, emphasizing the lack of significance placed on the arts at WPI. The school could benefit from having permanent museum or gallery to display art, historical items, and student projects. Almost all of the students who responded to the survey believe that an exhibition for student projects would highlight the technical culture of WPI while also demonstrating the talents of its constituents. Over half of survey-takers expressed some interest in contributing to such a gallery.

Significant interest was also shown in interactive and educational exhibits. Students claimed they were more likely to visit a campus museum if they were able to enjoy a more hands-on experience while learning about technological and science-based concepts. Historical exhibits, especially pertaining to WPI and Worcester history, drew interest from 71 survey-takers. Installations boasting the accomplishments of famous alumni or displaying artifacts and information relevant to the school could be in integral part in demonstrating WPI pride and may draw new students to the school.

3.1 WPI

The team proposes that a museum space be placed on campus to demonstrate a marriage of the arts and sciences and promote a well-rounded, more cultured ambiance. The campus gallery would occupy a space of at least 1000 square feet with 12-foot ceilings. Depending on exhibit size, this space would potentially hold from 40 to 80 exhibits. Some items will be permanent, while others will be on a

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[12] Full results of the survey can be found in Appendix A.

yearly rotation. In the case that there is little available space, exhibits will be distributed throughout the

campus, giving the entire school a more intellectual atmosphere. Multiple locations on campus will

contain smaller galleries. These locations might include hallways, lounge areas, and common spaces.

Exhibits that are spread around the campus will have a logo on them which indicates that they

are part of the WPI Museum. Out of several logo concepts developed by Deniz Ozgoren, the Museum

logo was chosen to be the one below. It incorporates a circular frame which makes it easy to put on any

background. Font and colors are chosen to be modern, and the goat symbol indicates WPI spirit.

Additionally, a map of exhibits could be designed, which would show the exhibits that are spread around

the campus. This map would be available for visitors to pick up in the campus center, or the main

museum gallery.

Figure 8: WPI campus museum logo

The museum space will have three exhibit categories: History, Course Projects, and Art. The

History gallery will permanently display historical items, outdated but interesting equipment and

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machinery, and WPI artifacts. Course Projects will contain any innovative and creative projects completed by students. These will be rotated at least annually or whenever new candidates are presented for display. Finally, the art gallery will display contemporary and digital art. Some exhibits in this gallery will be on an annual rotation, while others may be acquired and displayed permanently.

An artist can be commissioned to present a work for exhibit in the gallery annually. For art brought into the gallery, compensation to the artist must be considered. Funds for hotels, meals, advertising, and transportation will amount to about $5000 per exhibit. This cost may be reduced to roughly $1000 if the artist is local to the area.

Many of the historical and project items will be donated by the owners, and therefore will not require funding for acquisition. However, money will be needed for cleaning and repairing the items in preparation for display. This cost is estimated to be $50 per item. Cost for display may be up $5000 per item, depending on the type of display to be used. This includes display cases and pedestals, exhibit descriptions cards, lighting, and other such necessities. Display type will depend on exhibit type. For instance, photos, paintings, and documents will be framed and hung, while smaller artifacts and fragile items will be placed in glass cases. Large installations may be set directly on the floor with some strategic lighting. Because the exhibits to be displayed in the museum are to be of relatively low market value, insurance and security are not of major concern.

Following are exhibit concepts designed by the team as potential campus museum exhibitions. In order to ensure quality control, our team rated each of the proposed exhibitions and installations based on creativity, interactivity, ease of use, and feasibility. The score for each attribute is given on a scale from one to five.

To determine the creativity of each exhibit, a poll was conducted among the group. Each team member rated the proposals on a scale from one to five. A score of one signified that the exhibition showed little artistry and originality. For example, if an exhibit was based around a pre-existing one this

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would show little originality and would receive a low rating. A score of five indicated that the proposal of high ingenuity and vision. We each used our own intuition in order to determine the uniqueness of the exhibitions. An average score was calculated for each proposal.

The criteria for interactivity are based on levels of user involvement decided upon by the group as a whole. A rating of one corresponds to an exhibit that can only be watched or viewed by a museum visitor. An exhibit with a score of two is responsive to user input on a limited scale. This type of exhibit would be controlled by a visitor, but without complex output (i.e. a switch that turns a light on and off). A rating of three describes an exhibit with a broader range of user input and corresponding output. Such an exhibit takes in data from the user and may produce nearly endless outputs. An example of an item that would score a three in interactivity would be a generative artwork, which can generate unlimited number of visual outputs based on random user input. A rating of four is given to installations that allow a museum visitor to use and experiment with items in order to complete an action. This may include exhibits that require users to make something. The highest interactivity score of five is given to exhibits and installations that allow for the creation or construction of something unique. This type of exhibition would offer complete freedom of control for the museum-goer. Common items that would qualify as a rank five in theory would be a pen and paper or a set of Legos.

The rating for ease of use determines the learning curve required to understand or operate an exhibit. Additionally if the exhibit has a well-designed user interface, it would receive a high rating. The lowest score of one is used for exhibits that require an instructor to teach museum visitors how to use them. An exhibit with a score of two requires supervision by an attendant who can offer help to anyone who needs assistance. To use or fully understand an exhibition with a rating of three, some background research or prior knowledge of the subject is required. For example, there is a significant learning curve associated with using a computer, but for those who are experienced the task is not difficult. Exhibits with an ease of use rating of four may require up to a minute to learn to use. A brief written description

or set of instructions will suffice along with minor experimentation before a user comes to understand the exhibit's purpose. Finally, a rating of five corresponds to an exhibit that requires very little to no time before it is completely understood. Such exhibits have a purpose that is relatively obvious upon sight, which requires better User Interface Design for original exhibits. Any exhibit without a score for ease of use are exhibits that can only be viewed by a museum visitor and therefore does not apply to the ease of use standards agreed upon by the group.

The scoring we set for the feasibility of an exhibition is centered around the amount of time and money that the exhibit would cost to initially construct and the level of maintenance required. These restraints are based on the resources available to the average WPI student or project group. A score of one is indicative of an exhibition that is nearly impossible to build due monetary or time constraints. A rating of two indicates that a proposal is within the realm of possibility, but may be a financial burden, require constant maintenance, or may take many months to construct. A score of three means that the project can be completed by a group of WPI students, but may be costly, require frequent maintenance, or take a few months to complete. A proposal with a rating of four indicates that it has minor restrictions such as monthly or bimonthly maintenance. A score of five shows that a proposal will take a very short amount of time to complete (one week to a month), is inexpensive to construct, and requires little to no maintenance. The maintenance required by the exhibit weighed less heavily in the overall feasibility rating that the proposal received. For example, if an exhibit was difficult to maintain but cheap and easy to build it would receive a higher score than an exhibit that was highly expensive but required little maintenance and was non trivial to construct.

3.1.1 Come Closer

This exhibit presents an alternative to static screens that stream continuous information even when no one is watching. By adding a touch sensitive surface, the screen will play only if someone is

willing to watch, inviting them to get closer. Several buttons can be placed so that the viewer also has

the option to choose what they want to watch instead of watching something random. The installation

can also record the number of plays, so that new video content can be listed by popularity.
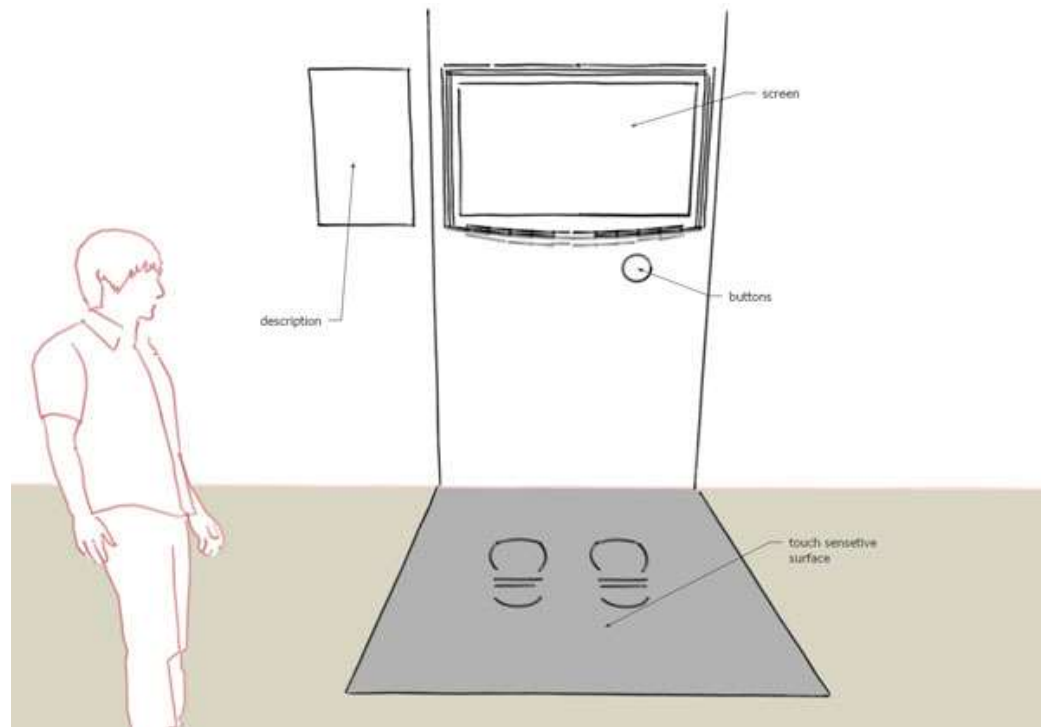
Figure 9: Come Closer installation setup

This exhibit idea received a high feasibility rating for several reasons. First, the major cost for

this exhibit would be the LCD screens which are already installed in several places on campus such as

the entrance of Atwater Kent Labs. Additional materials would include a simple pressure sensor to be

placed on the floor, several buttons that would be placed under the screen, and an inexpensive

microprocessor like any in the Arduino series. Thus the overall cost is very low. Furthermore, actual

implementation would not be time consuming. The process would involve installing the buttons and

pressure sensor and connecting them to the microprocessor, which would control what commands to

send to the video player.

Figure 10: Come Closer implementation

The scoring for this exhibit is given in the following table.

Table 1: Come Closer scoring

Creativity	2.5
Interactivity	2
Ease of Use	5
Feasibility	5

3.1.2 LED Algorithms

For a computer science exhibit, LEDs can be displayed on a board and light up following the path that a computer algorithm would take. They would be connected using either string or marker on the

board. A short description of how the algorithm works can also be posted next to the display so that those who are unfamiliar with it can have a basic understanding of what they are viewing.

An example of what the exhibit would look like using Prim's Algorithm is shown below. Prim's Algorithm is used for determining a minimal spanning tree (a subgraph which connects all vertices) in a connected, weighted, undirected graph.
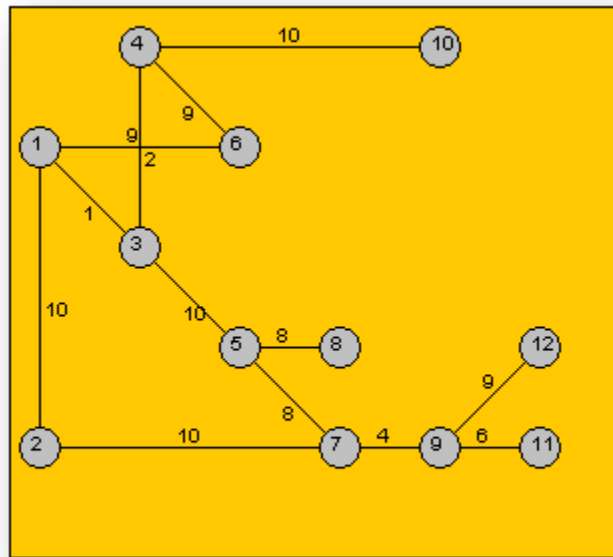
Figure 11: A weighted, connected, undirected graph

The figure above shows what the display would look like. Each LED would be one of the numbered, greyed-out circles. A string would connect each LED representing the lines connecting each grey circle. Numbers could be written on the board to represent the numbers in the above image connecting each grey circle.

The LEDs will light up, taking the path that the algorithm would take.

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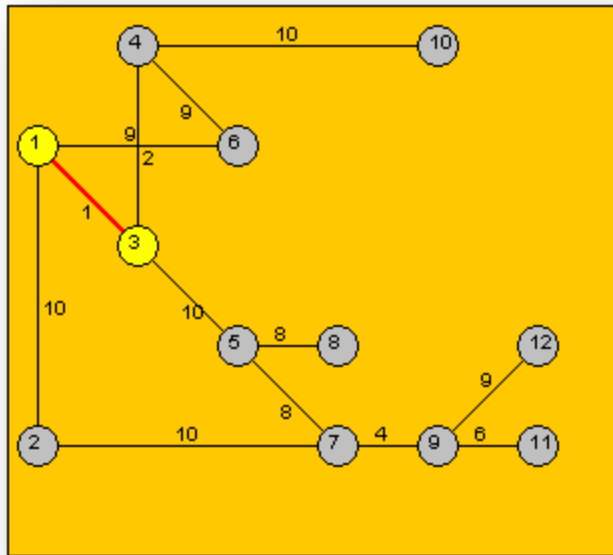
Figure 12: First path taken by the algorithm

The first LED that lights up is the one that labeled "1" in the above picture, and then number "3" would light up because this is that path that the algorithm takes.
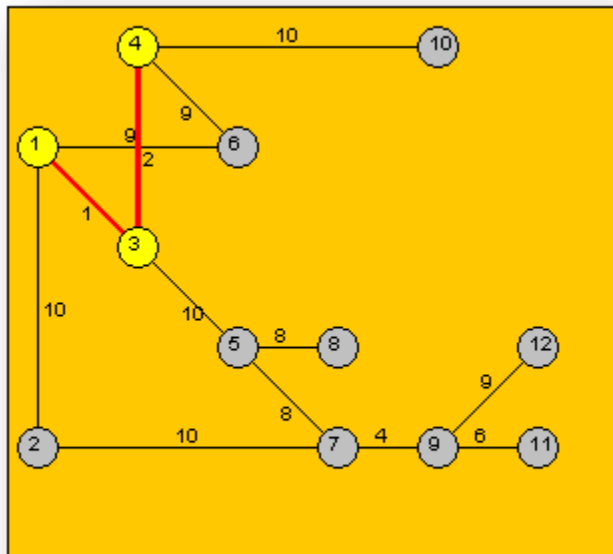
Figure 13: Algorithm's second path

The LED in place of the "4" would light up next, and so on until it reaches its final form shown in the image below.
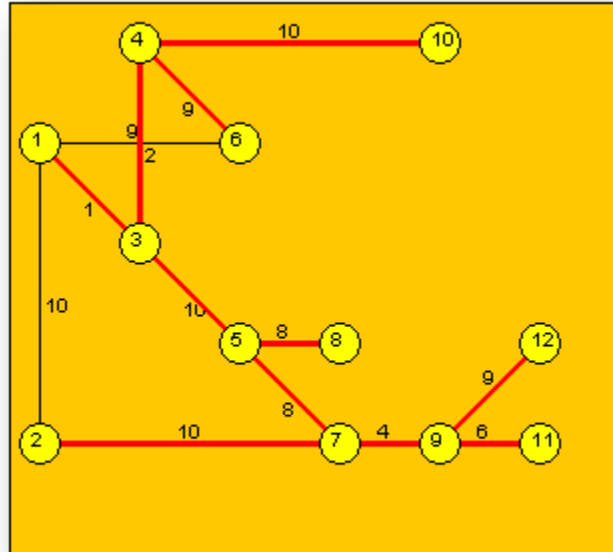
At this point all the LEDs will be lit up. They will then all turn off and restart. There are many different algorithms that this can be applied to. Also the numbers connecting the states can change and any number of states can be used.

We would need a minimum of 10 LEDs of the same color per algorithm so that viewers can get an idea of how the algorithm works.

Table 2: Cost estimates for LED Algorithms installation

Item	Price
LEDs	$3.00 - $6.00 for 50 pieces
Arduino	$20.00 - $30.00
Board	$10.00
TOTAL:	~ $33.00 - $46.00

The project would cost approximately $46.00 to complete. The scoring for this exhibit is given in the following table.

Table 3: LED Algorithms scoring

Creativity	2.5
Interactivity	1
Ease of Use	3
Feasibility	4

3.1.3 Theremin

A Theremin can be constructed to show how Electrical and Computer Engineering can be used to make a simple instrument that can be played by using capacitive plates. Normally, a Theremin costs approximately $500 but this cost can be brought down by constructing one out of readily available materials and a few inexpensive components. Usually a Theremin operates with two antennas which act as capacitive plates one of which controls volume and another that controls pitch, and depending on the distance of the hands from these antennas the instrument plays the appropriate sound. A custom constructed antenna could, however, have anywhere from one to three capacitive plates, the number depending on the number of functions desired.

The advantage of building a Theremin is that more options than capacitive plates are available. Instead of a capacitive plate, a rangefinder can be used, such as an ultrasonic or infrared which would be able to tell how far away the hand is. This would work in the same way as a capacitive plate; any of the methods have to interpret the distance of a hand from the sensor to change the pitch. One large drawback of this however is that the users hand has to be in line with the sensor, unlike a plate which has a much larger range for sensing. For simplicity, all options will henceforth be called an antenna.

A Theremin with one antenna would only have the option of controlling pitch and would have a constant volume. This design allows for the reduction of cost (depending on the sensor chosen) at the sacrifice of functionality.

A Theremin with two antennas operates as previously described. The two antennas are used to control pitch and volume. This method is the most common Theremin.

A Theremin with three antennas can be developed to work slightly differently while using the note mapping method. One antenna would control the volume, another pitch, and the last could control the instrument that the note is played in. A buffer would have to be designed so for example between 0" – 4" one instrument is played to make sure that it does not produce unstable output.

With each of the Theremins, additional features can be displayed to give the user more information about what is happening. An LED screen can be used to display the frequency, the instrument, and the volume being played. For a less expensive alternative, LEDs can be used which will light up next to a label that would show the same information showing the relative frequency or note and the volume.

The below figures show a possible model for a custom made Theremin that uses three antennas and an LED panel to show the volume and frequency of what is being played by the user.
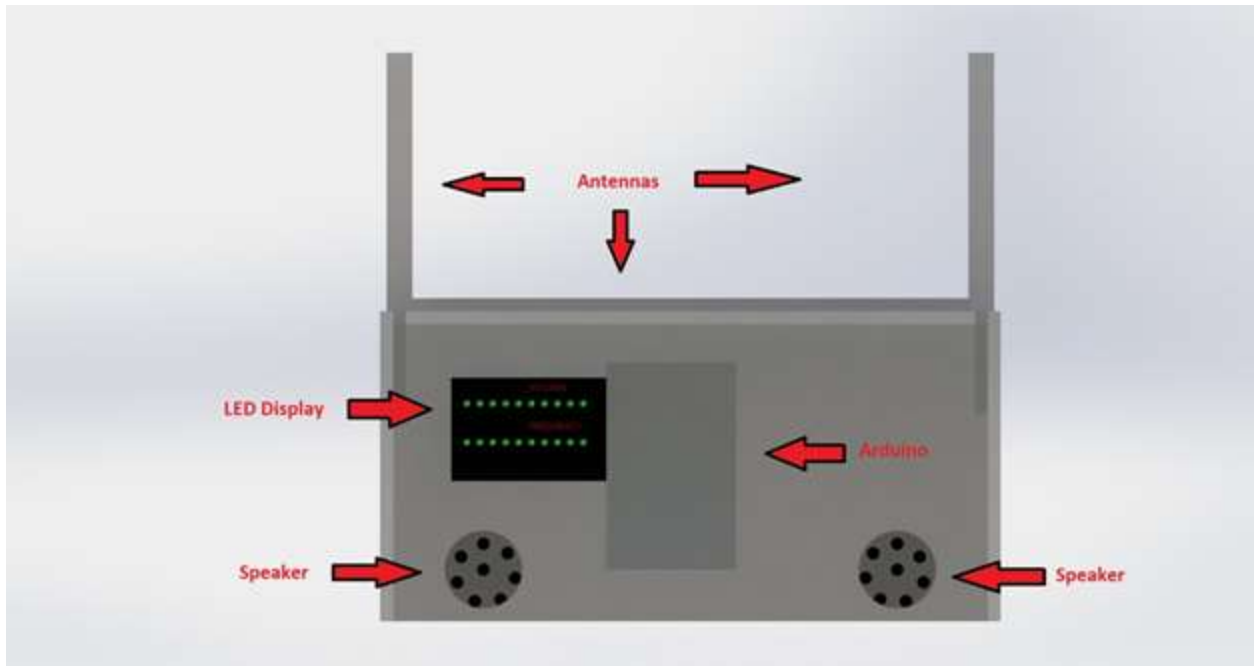
Figure 15: Theremin with three antennas
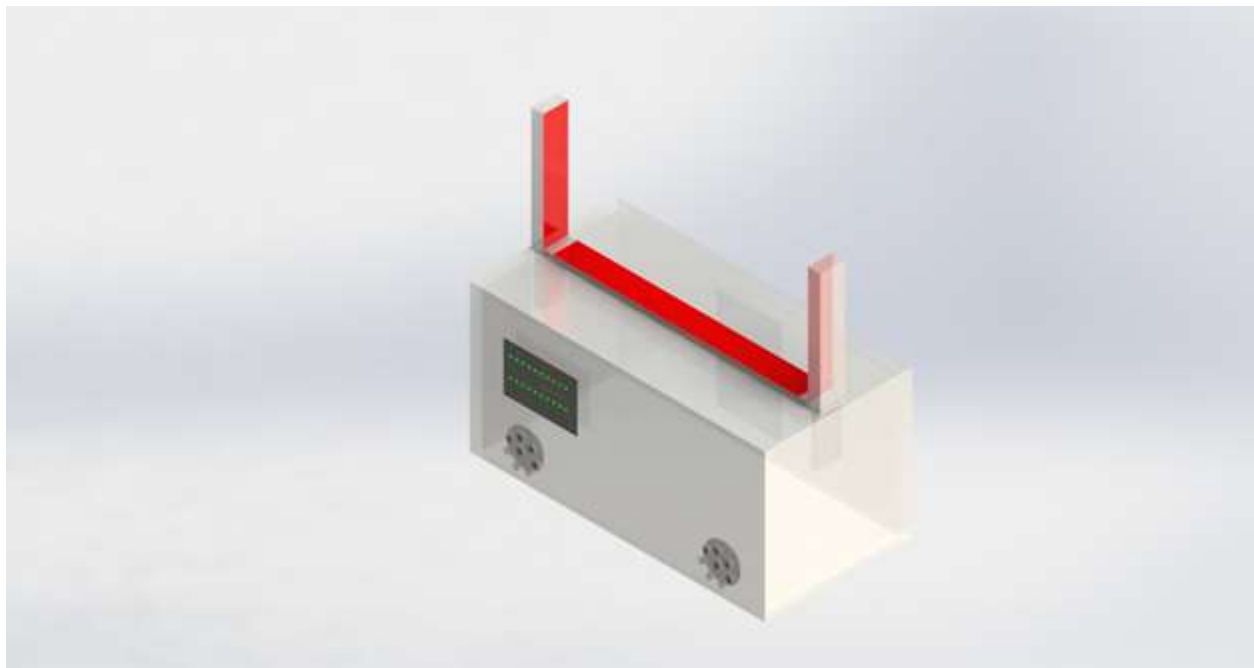
Figure 16: Angled view of Theremin
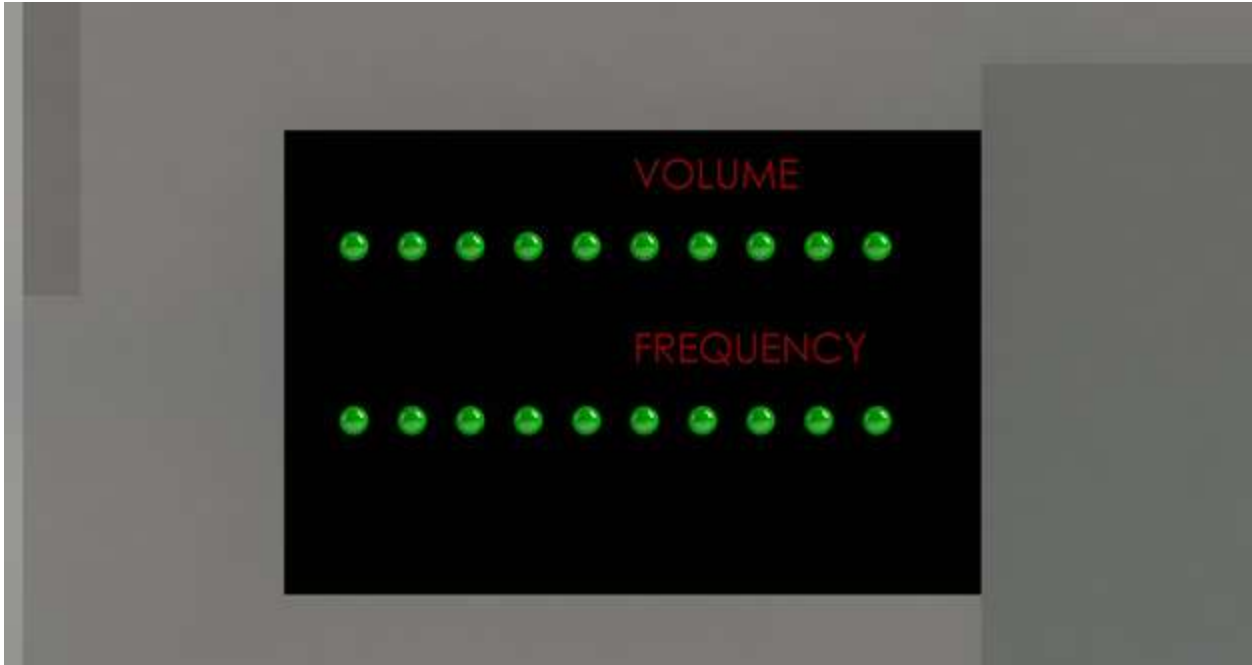
Figure 17: LED information panel

The scoring for this exhibit is given in the following table.

Table 4: Theremin scoring

Creativity	1.8
Interactivity	5
Ease of Use	4
Feasibility	4

3.1.4 Population Counter

The Population Counter is a concept for the installation of sensors at the entrance and exit of the library in order to count the number of people inside. This information will then be transmitted to a CPU which will create an artistic representation of the data. The piece will be a cluster of hanging lights. With every ten people that enter the library, an LED will light up, and with every ten that leave an LED will be unlit. The installation keeps track of every ten as opposed to every one person in order to minimize the

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number of lights, thereby minimizing cost. The library is the ideal location for this exhibit because it is frequently visited by most students. It also has a separate entrance and exit, halving the number of necessary motion sensors. The materials needed would be as follows:

- 100 LEDs
- 100 Resistors
- Wire
- Arduino microcontroller
- 2 IR transmitters
- 2 IR receivers
- Breadboard
- Wooden mount
- USB flash drive

Suggested specifications for the LEDs are as follows:

- Color: white
- Forward voltage: 3.2V
- Forward Current: 25mA
- Power supplied: 3.3V[13]

The fixture will consist of 100 LEDs in a rectangular arrangement. The LEDs will hang from wires strung through holes in a wooden board, on top of which the circuitry will be hidden. The wooden piece will be painted or stained to be more appealing to the eye and will be attached to the ceiling.

An infrared (IR) transmitter and receiver will be placed at both the entrance and exit of the library and will draw power from the Arduino microcontroller. The receiver will constantly pick up a signal from the transmitter. When a person walks between the two diodes, the beam will be broken. When the beam is interrupted at the entrance, one person is added to the count, which is the number of people in the building. When the beam is interrupted at the exit, one person is subtracted. This computation is implemented in Microsoft Excel, which outputs the total count to be utilized by the microcontroller. The Excel file will be placed on a USB flash drive plugged into the Arduino. The counter must be installed when no one is in the library or must be set so that the number cannot be negative.

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[13] Arduino supply voltage

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Each of the 100 LEDs will be placed in series with a 4.7Ω resistor and connected to a breadboard. The breadboard is necessary because there are not enough connections on the Arduino itself for all 100 LEDs. Depending on the count, a voltage is output by the microcontroller to the LEDs. The count is divided by ten and that number of LEDs is activated. LEDs in the center will be lit first and move out radially as the count rises.
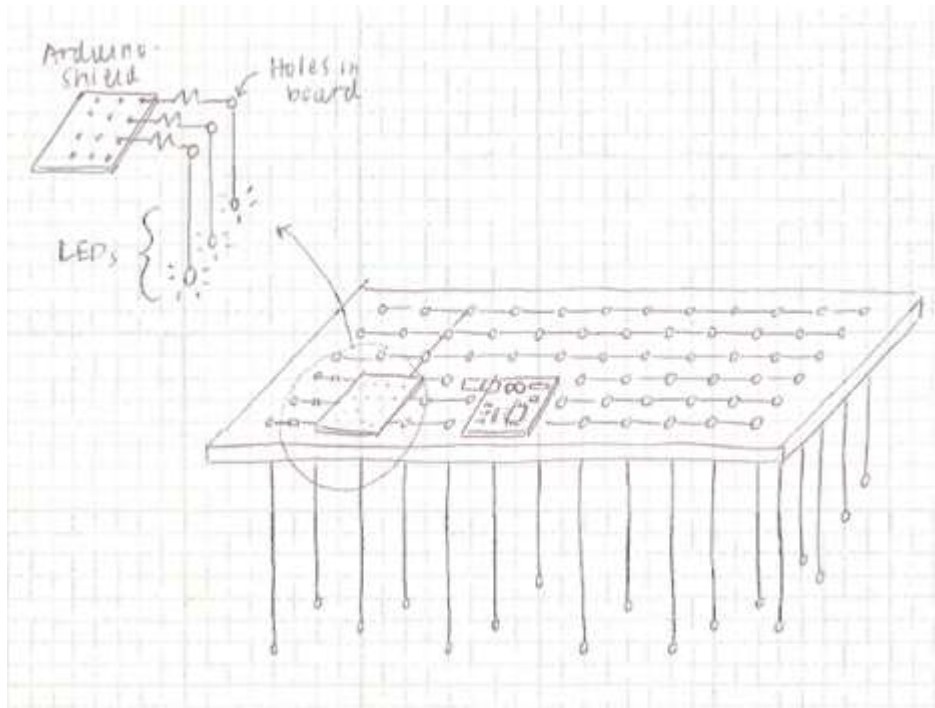
Figure 18: Preliminary sketch of display from top of fixture

The following table gives a rough estimate of what the total project will cost.

Table 5: Cost estimates for Population Counter

LEDs	$25
Resistors	$10
Wire	$6
Wooden board	$10
Arduino	$35

Breadboard	$8
IR sensors	$6
Flash drive	$10
Miscellaneous[14]	$50
TOTAL	$160

The scoring for this exhibit is given in the following table.

Table 6: Population Counter scoring

Creativity	2.5
Interactivity	2
Ease of Use	4
Feasibility	2

3.1.5 Laser Harp

The Laser Harp exhibit would be an instrument made from light. Breaking the beams will create MIDI information that can be used by a synthesizer to create sound. Each of the beams would act similarly to a string in an actual harp and play a different note depending on where the beam was broken. Using infrared sensors to view the laser beams, the lengths of each beam can be detected. Using this length information, this data can be transformed on a microcontroller into a note that will be played as if a harp chord was strung and then wait for the next note to be played. Each of the beams would be broken into short segments which would represent the different notes and stop the microcontroller from constantly playing notes based off of unsteady movements of a user's hands.

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[14] Includes mounting and installation, extra materials, shipping costs, paint/decoration for wooden board, tools and supplies, etc.

Figure 19: An image of a fully functional laser harp

The laser harp would be a representation of ECE and what can be done with sensors and microcontrollers as well as humanities and arts for music. This is a highly interactive exhibit that would also encourage people to communicate with others around to try to create music. To make it more entertaining for museum goers, games similar to Guitar Hero® could be created by making users hit a certain note at a designated time and have points awarded for doing well. A high score table could then be kept of everyone who has tried the exhibit and did well while at the museum. The scoring for this exhibit is given in the following table.

Table 7: Laser Harp scoring

Creativity	2.8
Interactivity	5
Ease of Use	4
Feasibility	3

3.1.6 Linkages

This installation dedicated to Mechanical Engineering would display multiple linkages. Many different types of kinematic chains would be shown which could be driven by hand or a motor to demonstrate to the viewer how they function. Each of the links would have a short description accompanying it that would explain some uses for that particular linkage configuration. All of the configurations will have their motion paths drawn behind them so that the user can see the full path the links will take at all times which will help them to envision more uses for them.

Figure 20: Visitors would push a button or turn a crank to see the mechanisms in motion

There are two possible ways to drive the links. The first is to have buttons that will activate a single linkage, or a button to activate all at once, which will drive them with a motor. This way, a user can give their full attention to observing how the links work without having to do anything but press a button. A second way to show the motion path is to have a crank on each of the links that a user can manually turn to make it follow its path. This implementation will add to the level of interactivity, but would cause the user to have to do more work with little gain as it would be more beneficial for them to be observing the path of motion.

An example of some four bar linkages and their corresponding paths of motion can be seen below represented by the green lines.
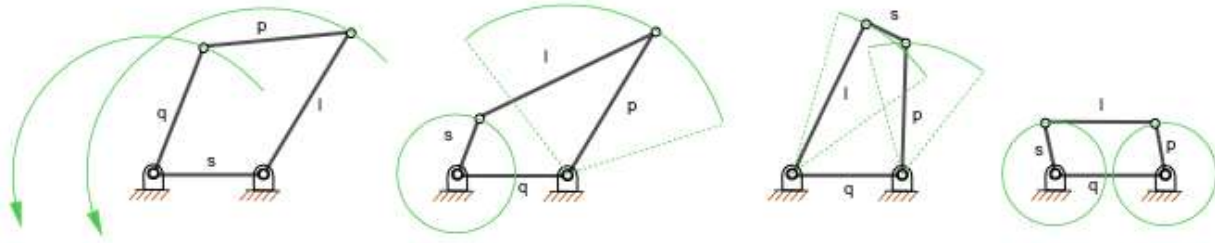
Figure 21: Four bar linkage motion paths

The scoring for this exhibit is given in the following table.

Table 8: Linkages scoring

Creativity	2.3
Interactivity	2
Ease of Use	5
Feasibility	2

3.1.7 Global Map

This exhibit would be a digital globe that shows where WPI students, faculty and staff   are from as well as an image from their hometown. Users will be able to select their hometown in an interface much like Google Earth and upload their names and a photo if they so choose.

Figure 22: Example of what a Global Map would look like

When looking to browse where students are from, the Earth can be viewed along with pinpoints representing each person from WPI. The globe will be fully controllable and be able to be rotated, zoomed in and out on and panned around to view all of the different areas everyone is from. Different markers could be used to help expand the amount of data shown, a person's place of birth could be shown if they emigrated from their original home and now live somewhere else where they would have already as explained. This exhibit will help to give an idea of where all WPI students, faculty and staff are from and show the diversity of the school. The scoring for this exhibit is given in the following table.

Table 9: Global Map scoring

Creativity	3.3
Interactivity	3
Ease of Use	3
Feasibility	2

3.1.8 Following LEDs

A string of LEDs will be placed along a staircase on campus. The lit LEDs will that track movement down the steps using infrared sensors. This installation would encourage students to forego use of the elevator in favor of the stairs, promoting a healthier lifestyle.

The installation would involve a series of proximity sensors and LEDs. The sensors will be calibrated to detect anything within a distance of three or three feet, depending on the staircase on which it is installed. LEDs will be paired with the sensors and emit light when something or someone gets within range. Once the proximity sensor no longer detects a presence, the LED will turn off. The lit LEDs will then essentially "follow" a person along the staircase, creating a stunning visual.

Depending on the length of the staircase and the spacing of the LEDs, the number of necessary components will vary. If 300 LEDs are used, the cost would be approximately $130.00. The 300 proximity sensors will cost another $150.00, but if each sensor controls two or three LEDs, this portion of the cost

can be more than halved. Therefore, a stair installation of 300 LEDs can cost anywhere between $180.00 and $280.00, depending on complexity.

The ideal placement for an installation such as this would be a stairway on campus that exists in a frequently visited building, but not one that gets so much foot traffic that the visual appearance of motion would be depleted. The library stairway meets these criteria. It is also an excellent candidate because it is located directly adjacent to an elevator, which many students prefer to use. With the installation of the following LEDs, students will be inclined to use the stairs instead. The scoring for this exhibit is given in the following table.

Table 10: Following LEDs scoring

Creativity	2.8
Interactivity	2
Ease of Use	5
Feasibility	3

3.1.9 WPI History Timeline

A touch screen timeline will be created that students can scroll through and view pieces of WPI history. Information and old pictures that make up the content of the timeline can be found in the WPI Archives at the campus library. This data can be researched and selected for the timeline. The timeline will start at the establishment of WPI (or its founders) and end at the present day.

By swiping their hands side to side, users can effectively scroll through and learn of WPI's history. Important dates such as the founding of the school can have markers indicating that the user can tap on that time period to learn more about it. Images and descriptions will pop up when tapped on; this information bubble can then be closed so that the viewer may resume scrolling through the timeline.

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Instead of having a singular line encompassing all of WPI's history, multiple timelines can be implemented. WPI's Archives contain a number of presidential papers, yearbooks, course catalogs, student newspapers, and magazines from a wide variety of dates ranging from 1871 to the present. Each of these can be contained in its own timeline.
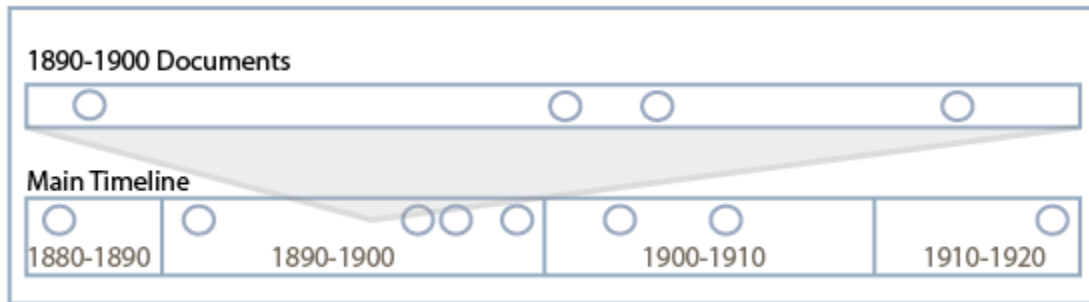
Figure 23: An example of the main timeline with another timeline branching off of it by tapping on the time period box

Students can program the timeline and link the pieces to the online archive of WPI's documents. The timeline could also be used to redirect users to these online libraries so that users can locate and view the full documents if they wish.

An alternative to a touchscreen timeline could be a web-based application, such as the Worcester Art Museum's *Early American Paintings* site (see below).
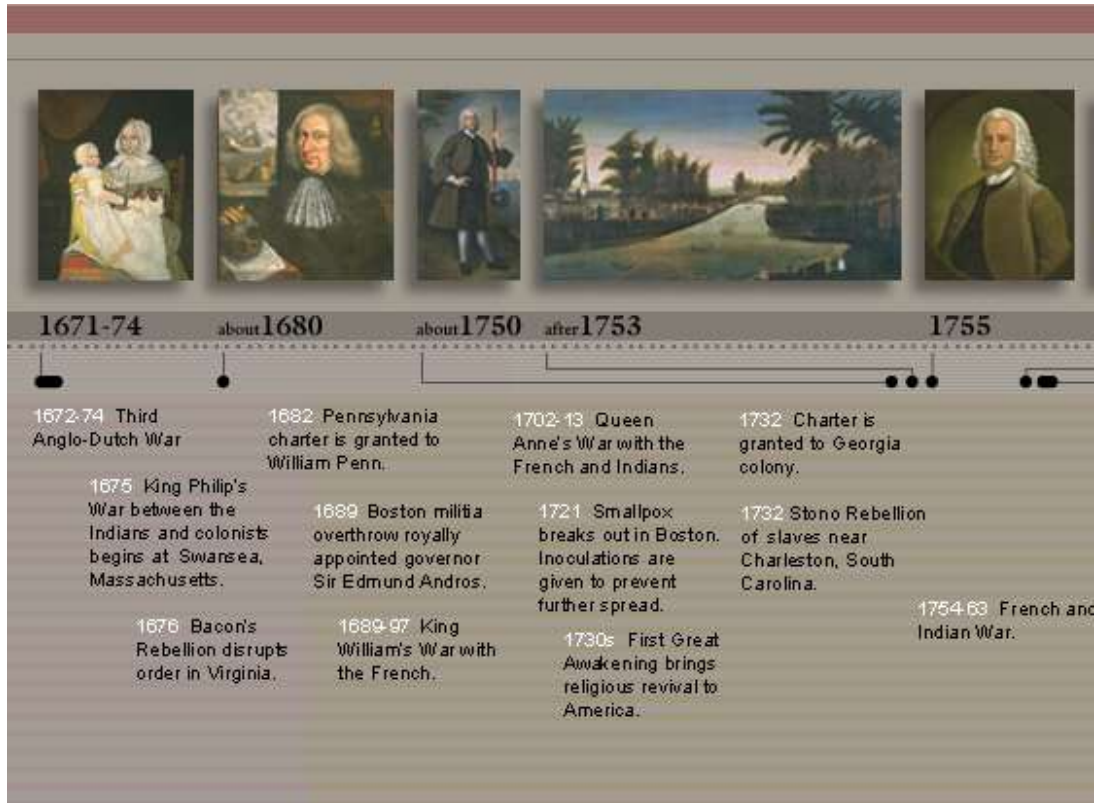
Figure 24: The Worcester Art Museum's *Early American Paintings* online timeline

The scoring for this exhibit is given in the following table.

Table 11: WPI History Timeline scoring

Creativity	2.8
Interactivity	2
Ease of Use	5
Feasibility	2

3.1.10 Face of Tomorrow

A photo booth or designated area will include a mounted camera with which students can take a picture of themselves. A pre-existing program will be used to combine and overlap the pictures and display the result on a screen so viewers can see what the average WPI student looks like. Alternatively,

face-recognition software can be used and automatically take a picture of anyone standing in front of the camera as long as their face is positioned correctly. The software will need to continuously update the image, so it will need to be connected to a computer.

Figure 25: The average face of male and female residents of Chile

If a motion sensor is added, the screen can display the current average face that has been accumulated thus face, and when a student walks up to the screen the display can change to show what the camera sees. This way the subject will understand that their picture is to be taken. The camera will then take their picture and average their face with the faces of other students who have already been averaged in. In order to provide consistency in the images, a mat on the floor can be set up indicating where the student should stand, or the screen can show what the camera sees with markers on the screen to show where their face should line up. These markers can be as simple as a box which shows where their head should be positioned.
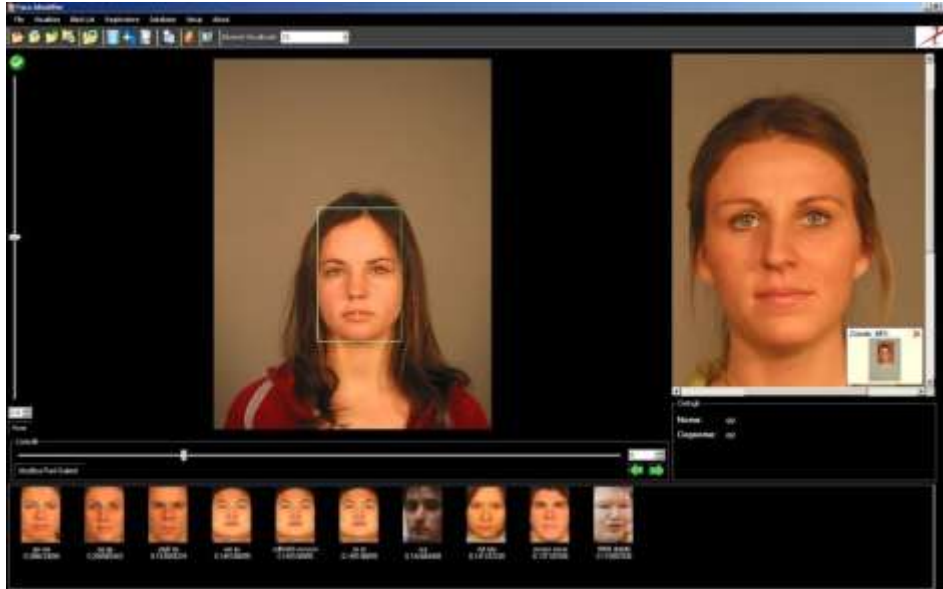
Figure 26: An example of face recognition software highlighting a woman's face and marking the positions of her eyes, nose, and mouth

Unfortunately, there is no simple way to prevent students from tampering with the software by having their picture taken multiple times. Adding a wait time after each picture is taken may help to reduce this problem, but it may also inconvenience legitimate users as a group of friends may all want to add their faces to the averaged image. The scoring for this exhibit is given in the following table.

Table 12: Face of Tomorrow scoring

Creativity	3
Interactivity	3
Ease of Use	4
Feasibility	3

3.1.11 Before I Graduate

On a large wall a black chalkboard can be setup with multiple instances of the phrase "Before I graduate I want to _____" spray painted onto it in rows and columns. The blank space is meant for students to enter the goals and aspirations they wish to accomplish before finishing college here at WPI.

For example, a student may write in the space "visit a foreign country" or "publish a book". The installation would be easy and inexpensive to implement on campus, with the only costs being that of a chalkboard, chalk, chalk holders, and spray paint.

In order to construct this, an entire wall of a room is required. If it is a permanent installation, chalkboard paint can be rolled onto the wall in order to make it such that students are able to write on it with chalk. If the installation is not permanent, then a setting up a regular chalkboard will do. Next, stencils of the phrase "Before I Graduate I want to _____" must be made from thick paper in a font size that allows for the most number of instances of this phrase to fit on the wall, while maintaining readability. It is necessary to measure, space, and mark each line of the phrase for consistency and a formal look. Spray paint is then applied to the stencils along the text. Lastly, the chalk holders must be nailed and securely fastened to the wall so that students will not be required to provide their own chalk or accidentally use a permanent writing instrument.

An additional feature to this installation could involve a camera set to automatically capture the state of the chalkboard at the same time every day. Students could then go online to find these images and view the progression of goals and aspirations over time.

Figure 27: Stencils being spray painted

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The wall must be frequently checked, as the chalk may need to be resupplied. If the wall is completely filled in, it should be washed so that more students may write their aspirations.

Figure 28: A filled chalkboard being washed

The scoring for this exhibit is given in the following table.

Table 13: Before I Graduate scoring

Creativity	2.3
Interactivity	3
Ease of Use	5
Feasibility	4

3.1.12 Voltmeter

One of the most interesting items on campus that can be utilized for an interactive exhibit is the old electrical measurement tool on the main floor of Atwater Kent Labs. The tool is a large version of modern electrical tools such as a voltmeter. Turning it into an interactive piece would make it a tool to

teach basics of electrical engineering in a very playful and interesting way. This project would involve

repairing and modifying the historic ECE tool in Atwater Kent while still preserving it. It would be

displayed with a concise description of the interactions and the concept of electronics, and also a

historic description of the original instrument.

Figure 29: Control panel in AK Labs

Several elements of the current historic tool can be converted into interactive parts. First, the

levers could represent binary numbers, and bringing them to different positions can output different

decimal representations. For instance if they are all low, the indicator would show a 0, or if first two

were high the indicator would show 3. The following two images show an example of this concept.

Figure 30: Left: binary 010 = 2. Right: binary 110 = 6.

The input would be received by a simple microcontroller, which then can be used to move the

motors inside the displays. An example display for the output is shown below.

Figure 31: Ammeter portion of electrical control panel

The current tool includes elements such as different displays, buttons, levers, and knobs.

Additional parts can also be made interactive. For instance a part can be made into an ohm-meter to

measure resistances, or different cables can be connected which would let visitors build a circuit that

can turn on a light bulb.

Figure 32: Museum visitor experimenting with control panel switches

The scoring for this exhibit is given in the following table.

Table 14: Voltmeter scoring

Creativity	2
Interactivity	2
Ease of Use	4
Feasibility	3

3.1.13 Solder Me

An iconic solderable board in the shape of Gompei the Goat will be developed. The exhibit will be a work station which contains tools, equipment, and assembly instructions. Visitors can learn to solder or obtain information on ECE basics such as how LEDs work or a short history of electricity.

The Crimson tour guides will be the instructors. Under their watch and aid, visitors will solder and assemble their own Gompei pins. WPI visitors and prospective students will enjoy the interactivity of this installation. The scoring for this exhibit is given in the following table.

Table 15: Solder Me scoring

Creativity	3.3
Interactivity	4
Ease of Use	2
Feasibility	2

3.1.14 The Mystic Tree

A realistic tree will be built in an indoor area of the campus. The installation will include speakers that produce sound effects in addition to motors that make the tree shake periodically. The

circuitry and technology will be hidden as it should look and feel completely natural. The scoring for this exhibit is given in the following table.

Table 16: Mystic Tree scoring

Creativity	3.8
Interactivity	3
Ease of Use	4
Feasibility	2

3.1.15 IMGD Models

This exhibit is designed to display 3d modeled sculptures of IMGD students in WPI in a tangible and different way. Students in the IMGD department create very attractive digital 3-D models. This installation exhibits selected pieces in an equally attractive way. Several models will be 3-D printed and displayed in a glass case with appropriate lighting. The models will be placed in such a way that they appear to be floating in midair. Each model will have an elegant title below them. Hidden motors will be installed on top which will be able to control each model separately, along with a touch-sensitive surface underneath the display which visitors will be able to use to rotate the model.
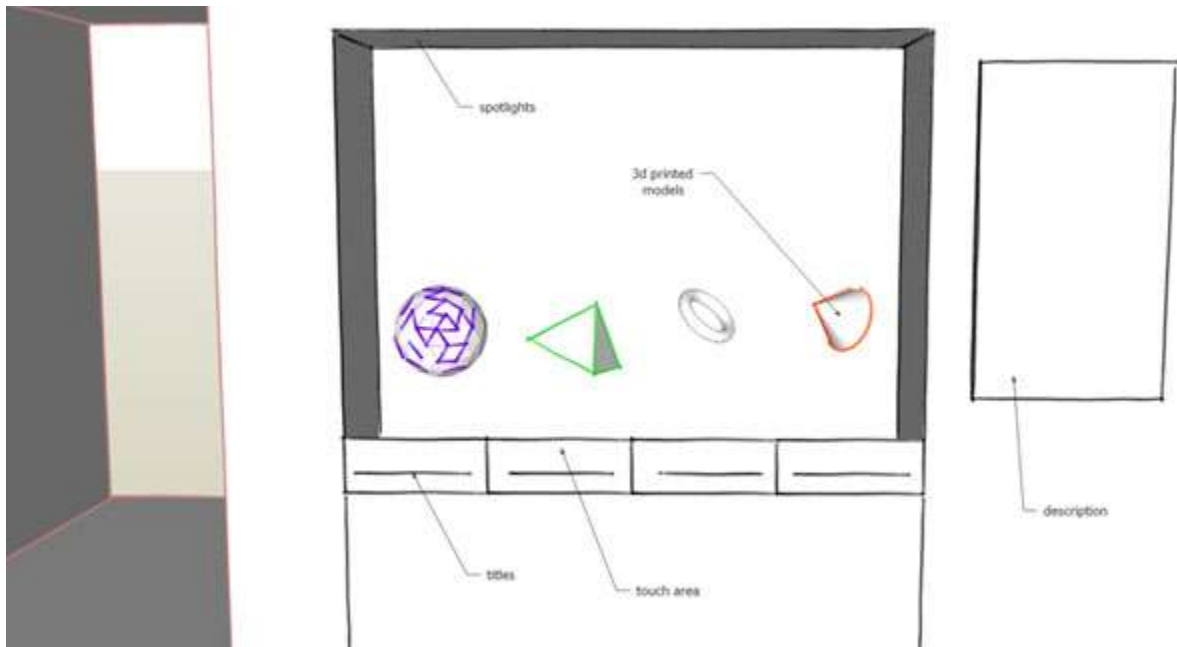
Figure 34: 3-D model display case

Although the concept received a high rating on creativity, ease of use and interaction, real world implementation would require a higher budget and time commitment relative to other exhibits. Tasks to build this exhibition include obtaining models and 3-D printing them, creating smooth mechanical sliders, building or purchasing a frame for the entire piece, and implementing inexpensive touch surfaces that offer seamless interaction with the models.
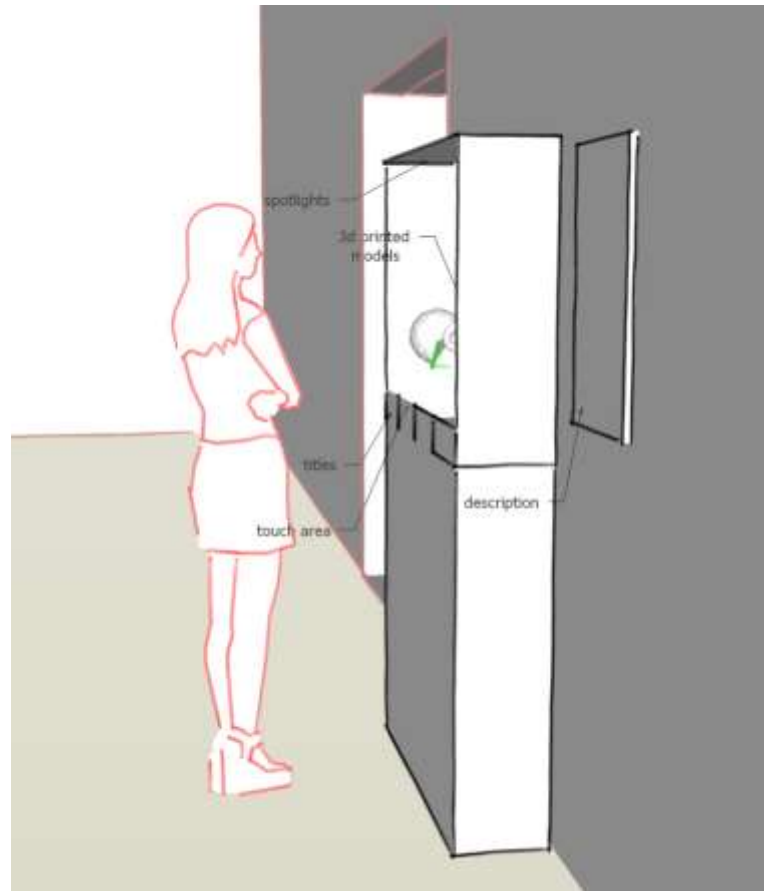
Figure 35: A museum visitor viewing the 3-D models

The scoring for this exhibit is given in the following table.

Table 17: IMGD Models scoring

Creativity	4
Interactivity	2
Ease of Use	5
Feasibility	2

3.1.16 Robotics Display

The Robotics Display is an interactive exhibit which showcases selected student robotics

projects from the robotics department at WPI. There already exists a display with several robots in it;

however these robots are in static condition. The goal of the new display is to use the existing robots

and space for the display, and modify the presentation to look more professional and add interactivity to enable visitors to better understand the concepts by seeing the working robots. Additionally, the robots are made to be in motion and in interaction with people and objects. For this reason, this concept of having an interactive display is a very appropriate way of displaying robotics projects.

Figure 36: Robotics display

General lighting should be dimmed, and several focused lights should be put inside the display case. The robot that is being interacted with at the time should be brighter to increase the focus. This will improve the experience of the user. The number of robots should be decreased and each robot should be clearly separated from each other visually.

Each robot should have a clear title and description which includes their mission and which course they were built in. A simplified link at the end should be provided for more interested visitors. An attractive title should be put at the top followed by general information about robotics in WPI. Most of the robots and if possible all robots should have interactivity.
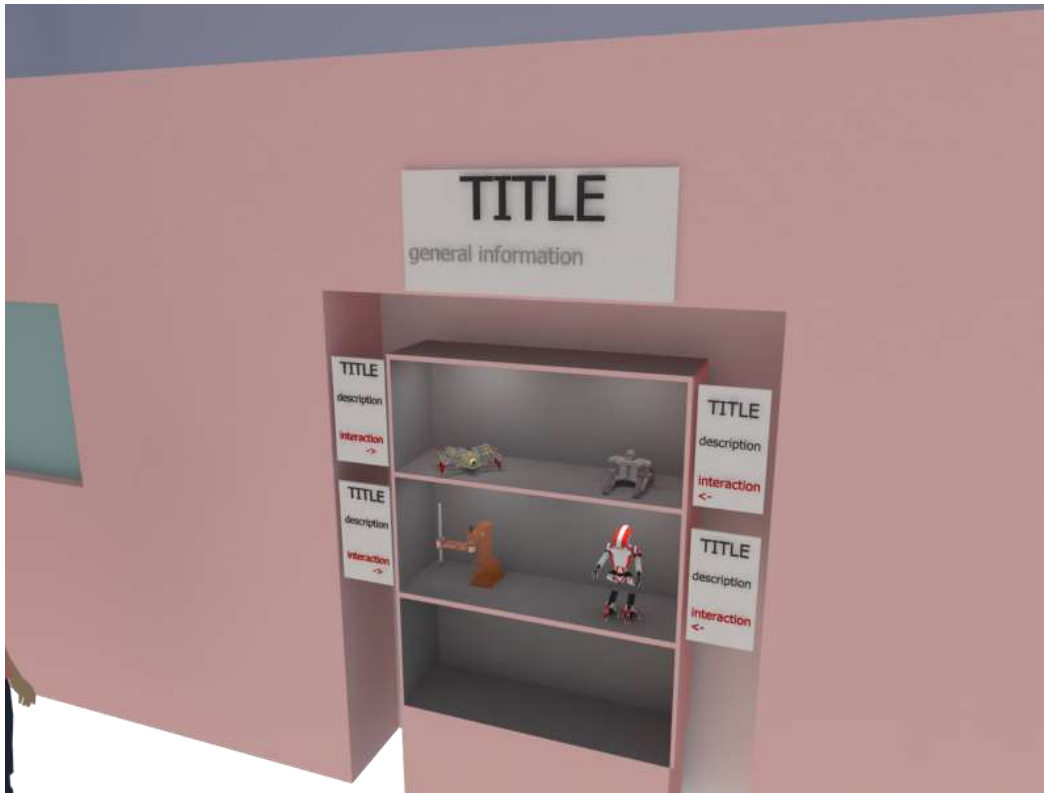
Figure 37: Example robotics display case

Some examples of robots that can be used in the display are the fire extinguisher robot, nuclear plant robot, and savage soccer robot. For the fire extinguisher robot, multiple LEDs are used in order to extend the experience. When this robot is selected, other robots are dimmed and the scene where robot is in becomes red by LEDs, which represents fire. The interaction to the side instructs the user to blow gently, which starts rotating the robot's fans. Several strips of fabric on the fan make the fan blow more visible. After few seconds, the scene fades to a blue color, representing that the fire is extinguished.

For the nuclear plant robot, the scene is designed so that it feels like the robot is inside a damaged nuclear plant (green color is dominant). In the actual project, the robot communicates using Morse code. For this reason, the interaction area includes a telegraph. When the robot is chosen by the user to be interacted with, the area will start an alarm by making a rotating LED, similar to the ones used on police cars. The user is then expected to communicate by pressing the telegraph. After few seconds

the robot receives the message and nuclear problem is fixed, which fades the scene back to normal

lighting.

Figure 38: Telegraph machine

The Savage Soccer Robot has a very large arm. When the robot is selected, the user will be able

to rotate a small lever-like controller to rotate the robotic arm.

Figure 39: Long-armed robot

3.1.17 Command Following Robot

This concept was inspired by an exhibit at the Museum of Science. A robot that follows

commands would be developed and placed it in a small pen where it is able to perform a set of

predefined actions. An application for Android and iOS could be created that would allow for people to

use their smartphones to easily communicate with the robot. Sensors could be added onto the robot

that could then relay back data to the user such as orientation, velocity, arm position and a camera feed

from the robots point of view. Various tasks could be within the pen that the user would be able to

perform such as pressing a button or moving an object from one area to another.
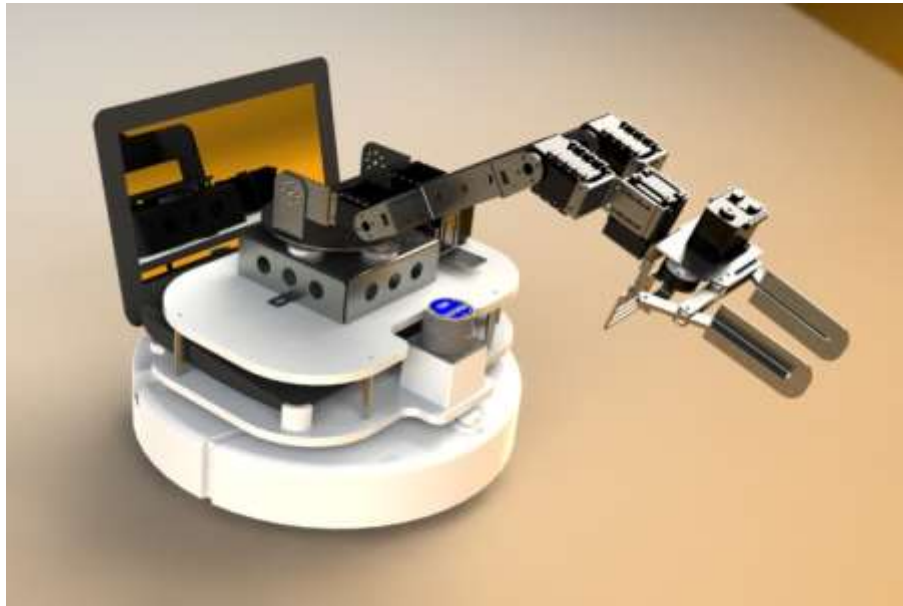
Figure 40: Command Following Robot model

The scoring for this exhibit is given in the following table.

Table 18: Command Following Robot scoring

Creativity	3
Interactivity	3
Ease of Use	4
Feasibility	2

3.2 Worcester Art Museum

The Worcester Art Museum has dedicated time and energy into providing an extensive

collection of art spanning multiple cultures and eras. However, the museum would benefit from a more

contemporary, technology-based exhibition of both historical and interactive items. WAM is located

within walking distance of several colleges and universities and would profit from taking advantage of

this demographic as potential museum-goers. College-age students would be attracted to the museum's technology exhibition. By accepting a proposal for a technology-based exhibition and implementing a plan to install an interactive gallery, the Worcester Art Museum would appeal to a market of new visitors and create a new reason for existing visitors to return.

An interactive gallery would do much to benefit the flow of visitors to the Worcester Art Museum. Students from colleges and high schools in the area will take interest in the subject matter and be more likely to visit the museum, possibly on a regular basis. Overall, a new technology exhibition will increase the number of incoming visitors to the museum.

Below are ten project proposals for exhibitions to be displayed in the Worcester Art Museum. These differ from the Worcester Polytechnic Institute proposals in that they are designed for a larger museum space and greater monetary allowance.

3.2.1 3D Projection Mapping

3D Projection mapping is essentially projecting and moving two dimensional images onto three dimensional objects. Unlike regular projection, 3D projection allows multiple sides of objects to be projected onto, not just a flat surface. Below are two images demonstrating this idea.
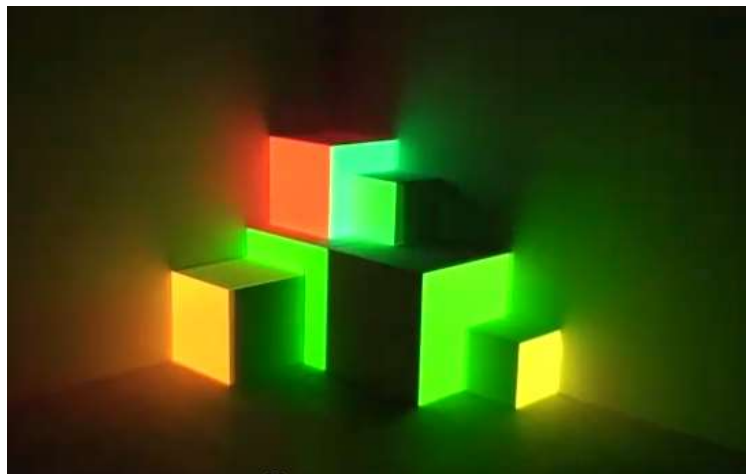
Figure 41: Multiple sides of the boxes are projected onto at the same time

Figure 42: The colorful butterflies move on both walls, but not on the boxes

These are simple examples of what can be done with 3D projection mapping on small boxes. However, on a much larger scale, some intriguing things can be done with such tools. These optical illusions can be projected onto the Worcester Art Museum building itself, with its varying wall sizes can become an exhibition.

If the walls themselves are projected onto from the outside, any passersby have to stop and watch. Due to the high traffic volume and number of traffic lights, the Worcester Art Museum will capture the attention of thousands of onlookers.

Figure 43: Left: Building without projection. Right: Building with projection

3D Projection does have its drawbacks, however. The only time that the projection could occur is at night; due to the nature of the projection, it would be nearly impossible to see the images during the daytime. The projector itself will need to be secured or watched over. In addition to this, projection mapping is time consuming, and requires maintenance. Projectors themselves are extremely expensive; a 10,000 lumen projector is required for a show such as this, costing upwards of $20,000. Renting a projector such as this will likely cost $500-$900 per day. 3D Projection mapping is better suited for a one-time showing, rather than a permanent exhibition.

One more thing to keep in mind with this is that cars passing by may become distracted; it is important to get permission from the city to put on a projection showing such as this. Slow moving images may be simpler and less dangerous to drivers, and it will still draw attention. Also, projecting onto a side of the Worcester Art Museum that is not facing high volume car traffic would be safest.

Figure 44: A building with a face projected onto it

Keeping these drawbacks in mind, the possibilities are endless with 3D projection. The images could be as simple as having a spinning 3D model of an artifact that is in the WAM projected onto the

side of the building will still capture the attention of passersby. The Worcester Art Museum can become a black canvas for any time of artistic representation desired.

Figure 45: Conceptual projection onto the Worcester Art Museum

A showing like this can bring in thousands of viewers, as very few people have seen such a large scale 3D projection mapping. The rarity of this display will likely draw the attention of those in neighboring cities as well as local residents. Due to the high technical demand of this kind of presentation, students from Worcester Polytechnic Institute will also be drawn in, and because of its artistic nature, many other college students and younger audiences will want to see it. The scoring for this exhibit is given in the following table.

Table 19: 3D Projection Mapping scoring

Creativity	3
Interactivity	1
Ease of Use	n/a

3.2.2 Come Find Me

The idea behind the "Come Find Me" game is that visitors will have small snippets of artwork (mostly paintings), and will have to find the pieces they belong to in the museum. This will work best as a smartphone application, as visitors will be able to carry the snippets around with them while viewing works of art, but this is not necessary. It encourages visitors to view every painting and appreciate them for their intricate details. It will also encourage younger viewers to look at earlier pieces of art than what they are generally drawn toward.

Figure 46: Various pieces in the Worcester Art Museum

Additionally, the application can include a hint feature. Tapping on a square with a section of a piece would give a hint such as the general location or wing that the piece is located in, or a cryptic

message. Tapping a picture multiple times could either give more hints or reveal the name and exact location of the piece. Also, each piece can have its own barcode. By scanning the barcode with their smartphone, the user can automatically check off which pieces have been found.

Figure 47: Smartphone with a check, indicating that the piece has been found

Another way to represent this idea is to have large prints on either entrance with the words "Come Find Me" and a short paragraph explaining that the snippets are real pieces in the museum that they can try to find. This is the less preferred method, however, because the visitor will not be able to reference the snippets with the pieces and may forget what they are looking for. The scoring for this exhibit is given in the following table.

Table 20: Come Find Me scoring

Creativity	3.3
Interactivity	2
Ease of Use	4

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3.2.3 Face of WAM Exhibition

The idea behind a face morph exhibit is to find what the average face looks like given a number of subjects. The subjects in this case are visitors of the Worcester Art Museum.

Figure 48: The average face of male and female Londoners

In order to do this, visitors can take pictures of themselves in front of a mounted camera with face recognition software. There will be a pad on the ground indicating roughly where the subject should stand. Given varying heights of visitors, a screen located below the camera can show what will be taken a picture of. When the person is in focus and their face is lined up (all subjects eyes should be in the same place), the camera will automatically take a picture and the morphing software will integrate this person's image into the collection. Conversely, a projector can be set up in the same room to display the faces of those who have contributed to the exhibit. This way the screen below the camera will not need to change, and a larger composite image can be shown.

This exhibit is fairly volatile; it is up to the visitor's discretion whether or not he/she takes multiple photos and skews the overall picture.

A supplementary feature for this exhibit would be allowing subjects to morph their faces with their friends': instead of adding one image to a large collection of images, they can see what their face would look like when combined with a few other people. The exhibition set up will look similar to the image below.
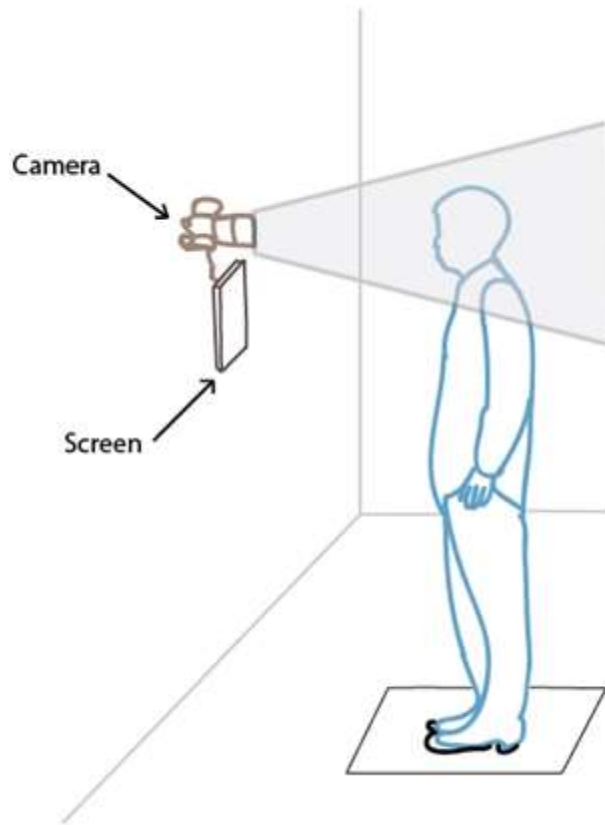
Figure 49: Diagram of the Face of WAM exhibition

A stationary camera would need to be securely set up in a room. This can be of any quality depending upon budget, as long as the camera has face recognition software installed. A screen would need to be installed in order to display the results of the face morphs as well as show where the subject's face should line up. Lastly, the software for morphing the faces together will be needed. The scoring for this exhibit is given in the following table.

Creativity	2.8
Interactivity	3
Ease of Use	4
Feasibility	3

3.2.4 Touchscreen Timeline

The idea is to have an interactive catalog of the pieces in the Worcester Art Museum. A large touchscreen with a timeline ranging from the time period of the earliest artifact to the latest can be put on display.
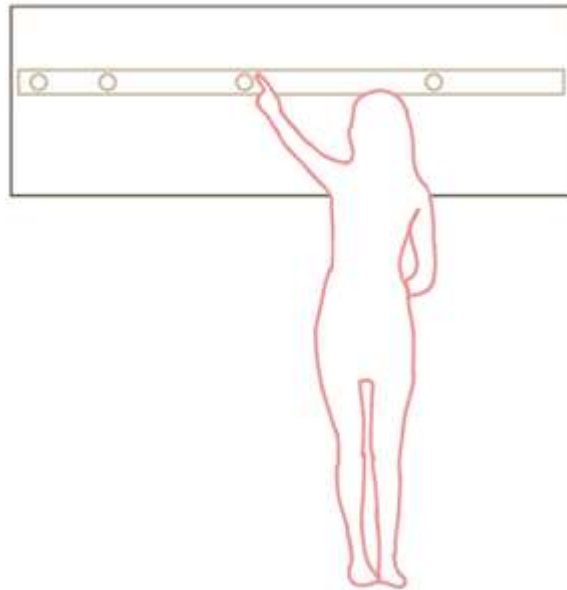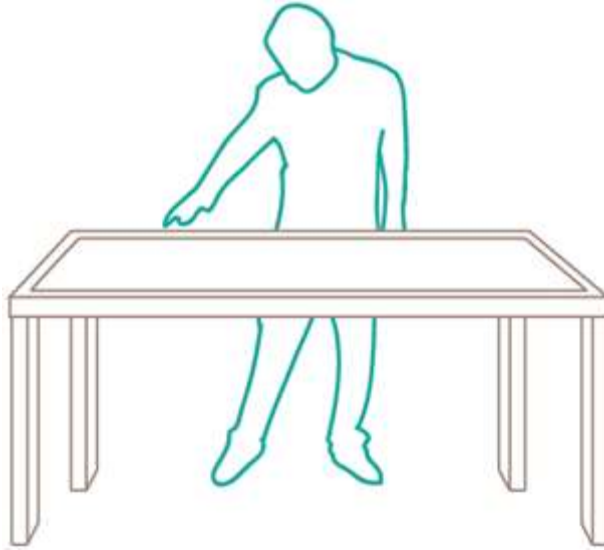
Figure 50: Diagram of touchscreen timeline users. The exhibition may either be a table or mounted on a wall.

Viewers can scroll through the timeline by swiping their finger side to side. Tapping on a time period will bring up all the pieces the museum owns or has once owned that were made in that period. Viewers can then tap on individual pieces and be presented with an image and short description of the artifact as well as where in the museum they can find it.
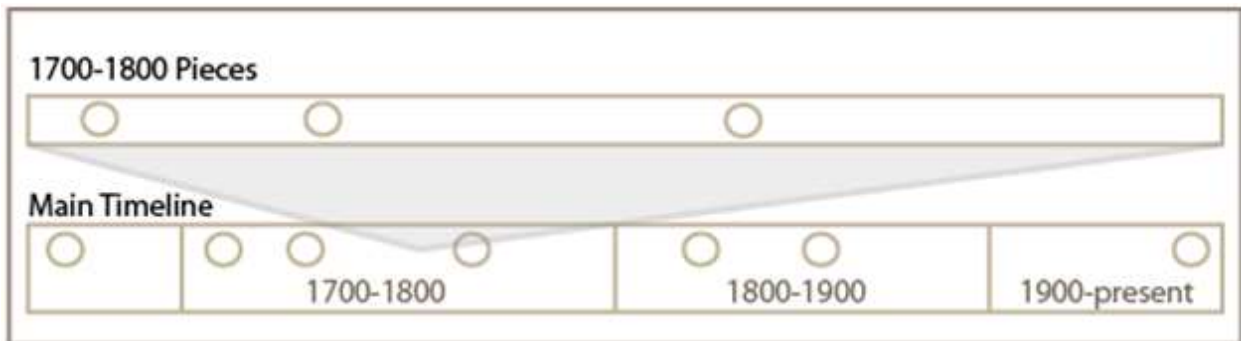
Figure 51: This is an example timeline. Tapping on time period boxes will bring up new timelines.
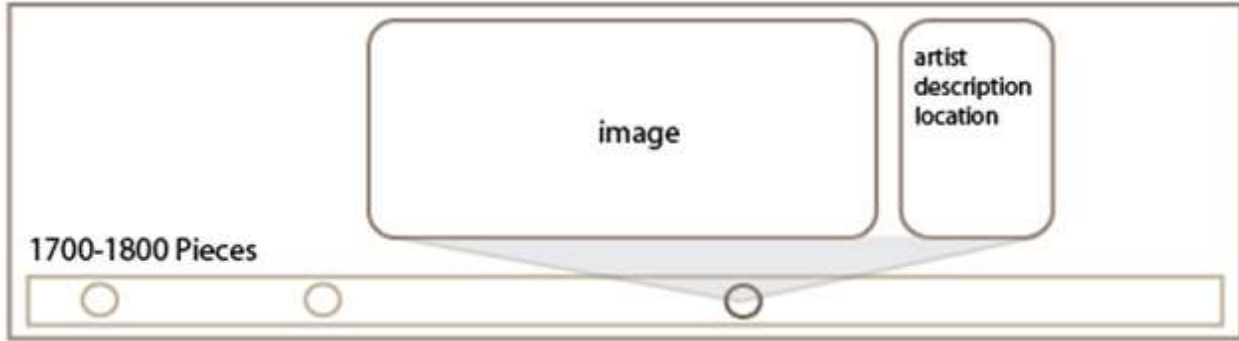
In addition to these functionalities, the main timeline can branch out into multiple timelines. For example, if visitors want to view all the pieces of a specific artist, they can tap on an artist's name and they will be presented with a separate timeline of that artist's pieces in the Worcester Art Museum. Due to the fact that pieces change locations almost constantly, the timeline can also act as a tracker; if the piece is not in the WAM, the location would be updated to say where it is. This way visitors can keep track of where their favorite pieces are and the timeline itself does not have to change significantly.

The museum will need to hire programmers to create the timeline and make it robust enough that information can be edited (such as changing the location of artifacts or inserting new artifacts into the timeline) or linked to an online or local archive of the museum's pieces. A fairly large touchscreen will need to be purchased and installed as well. The scoring for this exhibit is given in the following table.

Table 22: Touchscreen Timeline scoring

Creativity	2.5
Interactivity	2
Ease of Use	5
Feasibility	2

3.2.5 Infinity Mirror Room

Figure 53: A woman posing in an infinity mirror room.

An infinity mirror is an illusion created by mirrors facing each other. The images reflect back and forth from one mirror to the other, resulting in what looks an array of images without an end. This illusion can be seen in the picture below.

Figure 54: The infinity mirror illusion on a candle

Now what if this idea were applied to an entire room? Replacing each wall with a mirror, this same effect will take place but on a much grander scale. Hanging oil paintings on these walls could

produce an interesting addition to the illusion as well; visitors themselves will become part of the art. They will be able to view both the paintings in this room and the infinite reflections of the pieces.

It is also possible to produce this effect on a single piece, as seen below. This illusion is much simpler to produce; it requires only two significantly smaller mirrors, a wooden frame to contain it, and lighting. Essentially, the piece being reflected is placed between the two mirrors. This causes the piece to be reflected back and forth; when viewed from outside the two mirrors, the infinity illusion can be seen. It can also be applied to nearly any artifact because the container's size and the dimensions of the mirrors are the only variables.

Figure 55: An example of the infinity illusion on a single piece

Although having a singular piece be mirrored is far more feasible, one thing to keep in mind with oil paintings is lightning. This effect does not require bright fluorescence as seen in the above picture, but it does require a decent amount of light in order to adequately view both the piece and the illusion.

An exhibition such as this will appeal to a wide variety of visitors. Older viewers will be intrigued by the paintings and pieces on display, while younger college-goers and teens are captivated by the simple yet powerful illusion.

Expenses include large mirrors to cover the walls with and hiring someone to install the mirrors. For a displaying a single piece: one two-way mirror, one glass mirror sheet, a wooden frame, and lighting are needed. The scoring for this exhibit is given in the following table.

Table 23: Infinity Mirror Room scoring

Creativity	3
Interactivity	1
Ease of Use	n/a
Feasibility	2

3.2.6 X-Ray Painting

Macro-scanning x-ray fluorescence spectrometry (also known as MA-XRF) is a noninvasive technique that can be applied to paintings in order to reveal hidden layers that have been painted over. It detects pigments and chemical compounds underneath the top layer of paint to show earlier compositions of paintings.

Art historians estimate that one in five paintings have different pictures beneath them. For example, Van Gogh's *Patch of Grass* has been scanned to reveal a painting of a woman's face beneath it (see below).

Figure 56: Left: Van Gogh's 'Patch of Grass'. Right: Hidden portrait of a woman revealed through x-ray technique.

Although it may be unlikely that such a substantial finding will occur if this technique is applied

to a piece at the Worcester Art Museum, it can still reveal the intriguing past of a painting. Scanning the

painting with the MA-XRF technique will reveal a variety of chemicals used by the artist and in what

concentrations they were used. This can show an entirely different image when certain chemicals are

"picked out". For example, in Rembrandt's *Old Man with Beard*, when copper is singled out, an entirely

different outline of an image is shown (see below).

Figure 57: Top left: Copper distribution showing an outline of a figure. Top right: Lead distribution. Middle left: Mercury distribution. Middle right: Iron distribution. Bottom: Finished painting.

For an exhibition, these images can be printed out, scaled to the same aspect ratio as the finished painting, and hung in a row on a wall. This will allow for visitors to first see portions of the painting followed by the original itself, effectively showing a vague construction of the piece. As it may be difficult for some visitors to understand what they are viewing, an in-depth description of how the x-ray images are formed and what each represents may be necessary. The scoring for this exhibit is given in the following table.

Creativity	3.3
Interactivity	1
Ease of Use	n/a
Feasibility	1

3.2.7 Old Master Gallery Reinstallation

Many 17th Century European paintings are marked by a sharp contrast between dark and light. This contrast is used to depict concepts such as the real and the surreal. The exaggerated lighting elements serve to convey and provoke intense emotions. This is a proposal to use this juxtaposition between dark and light to exhibit the Old Master Gallery installation in a way that emphasizes the drama depicted in the paintings.

Figure 58: Museum visitor viewing the Old Master Gallery

The space required is a very dimly lit room with a dividing wall in the center. Each painting will be framed and mounted on the walls. Above each painting will be a lighting fixture, and below each painting will be installed a small proximity sensor.

Figure 59: Aerial view of the room layout

Figure 60: Angled view

When a visitor approaches a painting, the light above that painting will be activated, creating a spotlight for the individual work of art. In this way the paintings being viewed are framed by light against

the darkness of the room. Each work will be highlighted and the dramatic essence of the subject matter will be magnified. The spotlight on each painting will draw the eye of the viewer and evoke intrigue.

Figure 61: Completed Exhibit

To prevent any lights from turning on while people walk past, the sensors will have a slight delay. Only when the sensor detects a person standing in front of the frame for several seconds will the associated light turn on.

Figure 62: Proximity sensor placed under a painting

Overall, this approach provides a simple means of promoting each of the works in the gallery as individual masterpieces, while also highlighting their dramatic use of color and imagery.

The scoring for this exhibit is given in the following table.

Table 25: Old Master Gallery scoring

Creativity	3.5
Interactivity	2
Ease of Use	5
Feasibility	4

3.2.8 Changing Sheet

It is simple to imagine the three physical dimensions of height, length, and width, but how can a fourth dimension be expressed to museum-goer in a way that is simple to understand? This piece explores the concept of form by allowing viewers to change the shape of an object. Using this method, the viewer can perceive form as an important element in both art and the natural universe.
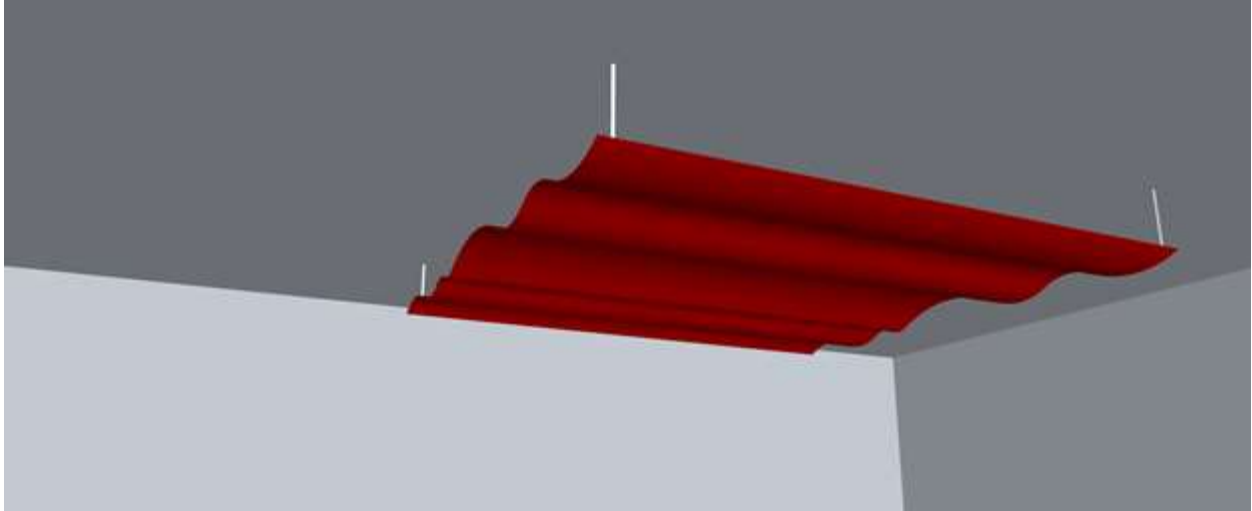
Figure 64: A suspended cloth sheet demonstrating form

A sheet of cloth will be suspended from the ceiling, given form by a network of conductive wires. Visitors will control the amount of power delivered to the wires using a wall mounted button. When a current passes through the wires, they will expand and contract, causing the sheet to move and change shape. When the button is released, current flow ceases.

Figure 65: A visitor pressing a button which, when pressed, causes the cloth to morph in shape

The schematic below shows the very simple circuit needed for this display. Here, V1 in the battery and S1 is the button on the wall. The two lengths of wire indicated by the arrows will be traced throughout the sheet.
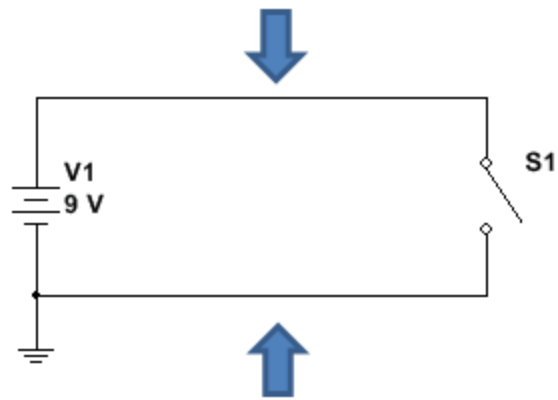
The piece will provide an interesting focal point for any room it is displayed in and has an elegant appearance. It is lightweight and easily suspended by thin wires. A simple 9V battery can be used as a power source. The scoring for this exhibit is given in the following table.

Table 26: Constellations scoring

Creativity	2.3
Interactivity	2
Ease of Use	4
Feasibility	2

3.2.9 Constellations

It is difficult to enjoy the sight stars in a city filled with bright lights. This exhibit is designed to make this phenomenon available to anyone visiting the Worcester Art Museum.

The space required is a dark, dome shaped room approximately 25 feet in diameter. A projector will project the stars onto the ceiling. The viewer can select which time of night and which season to display using a control panel at the center of the room. Seating will be provided so visitors can sit and observe the stars.
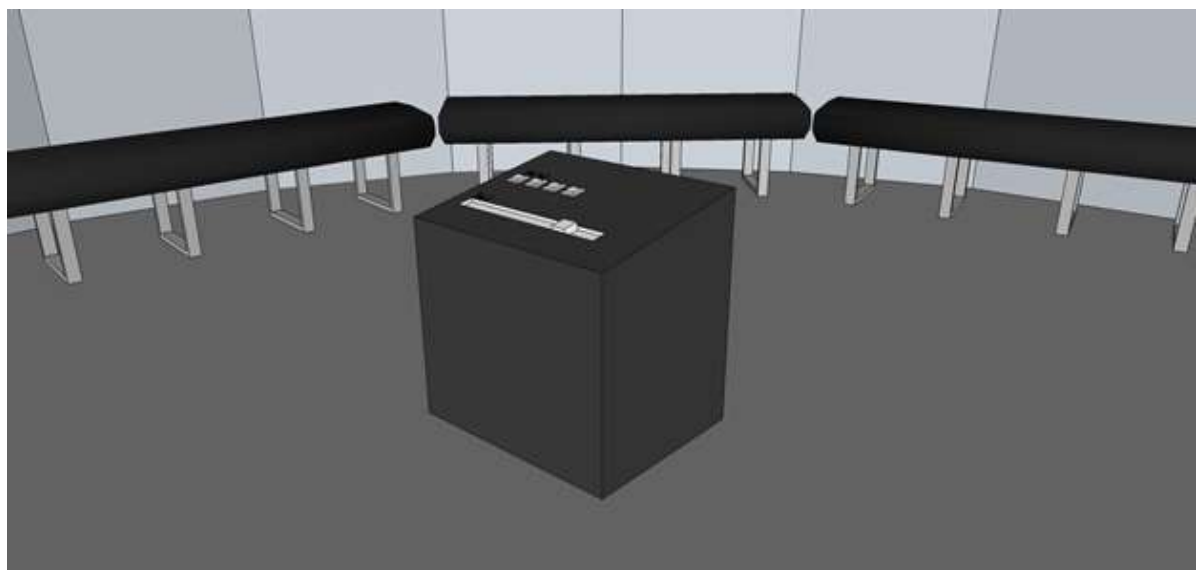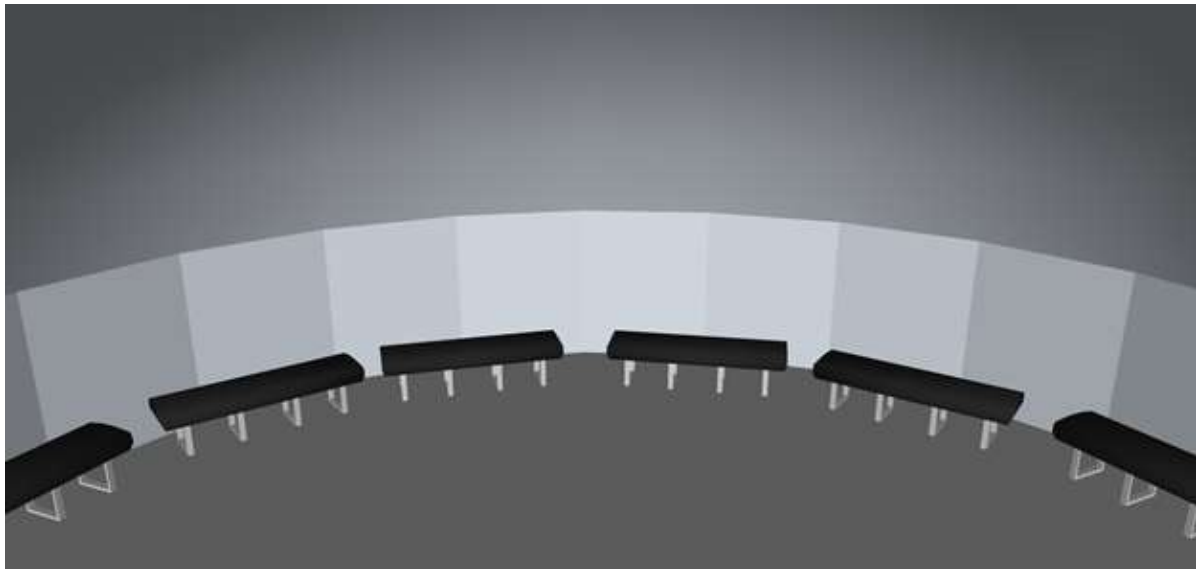
Figure 67: Top: Seating for constellations exhibit observers. Bottom: The control panel used to operate and change what is displayed in the room.

Worcester is the second largest city in Massachusetts and as such does not offer the

opportunity to stargaze. This exhibit would be a wonderful means of allowing visitors to feel in touch

with nature and contemplate a universe that they experience only an infinitesimal part of every day. It

provides a serene setting for any museum visitor.
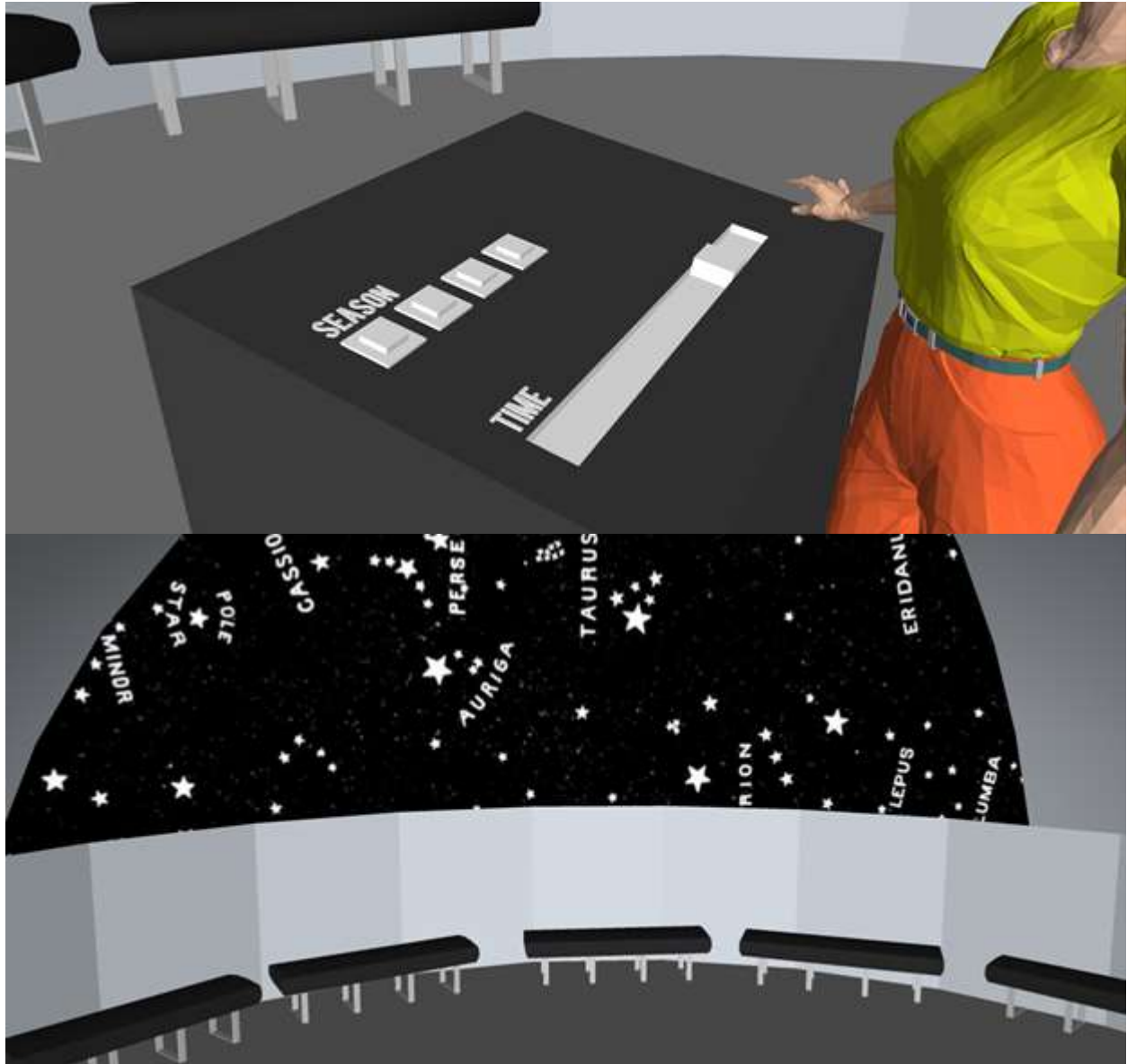
Figure 68: Top: Close up view of the control panel showing the controls for the seasons and time slider. Bottom: Complete view of the constellations exhibit.

The scoring for this exhibit is given in the following table.

Creativity	2.3
Interactivity	2
Ease of Use	4
Feasibility	2

3.2.10 The Wall

So often people inspect and analyze a work of art in an attempt to truly understand it. Rarely do we experience this occurrence from the opposite perspective. The purpose of this installation is to reverse the roles between the viewer and the subject.
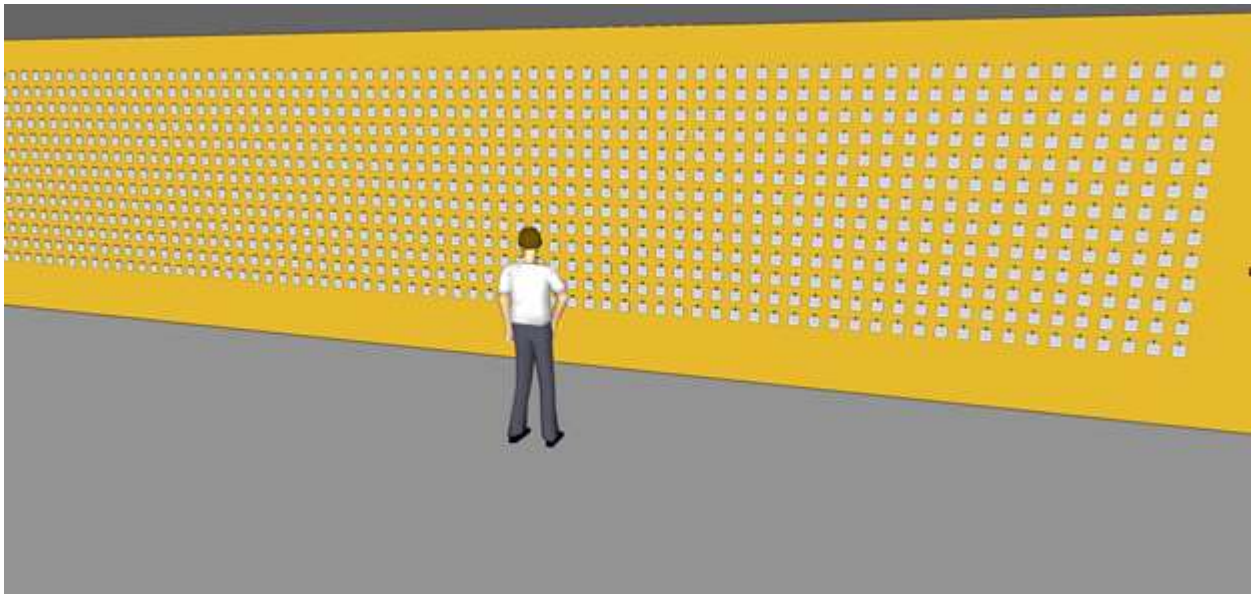
Figure 69: A subject observing The Wall exhibition

The space required is a long wall approximately 35 feet across and at least 7 feet tall. A Polaroid camera will be mounted at one end where visitors can take photographs of their eyes. The photos will then be hung by the visitor from one of many hooks lined up on the wall. It will become a collage of curious eyes that takes the viewer out of their natural element. By converting the museum-goer into the

subject of observation, The Wall will simulate the concept of art from the perspective of the piece.

Figure 70: A close up of a visitor taking a picture of their eye using a Polaroid camera

The camera element also personalizes the experience for the viewer. In taking a photograph and placing it on the wall themselves, visitors will feel personally linked to the piece. The eyes are often associated with the expression of soul, passion, and emotion. By including images of the eyes of actual WAM visitors, the exhibit will connect each individual on an emotional level. The wall of eyes will become a wall of expression, and in this sense the visitor is the subject in a second way.
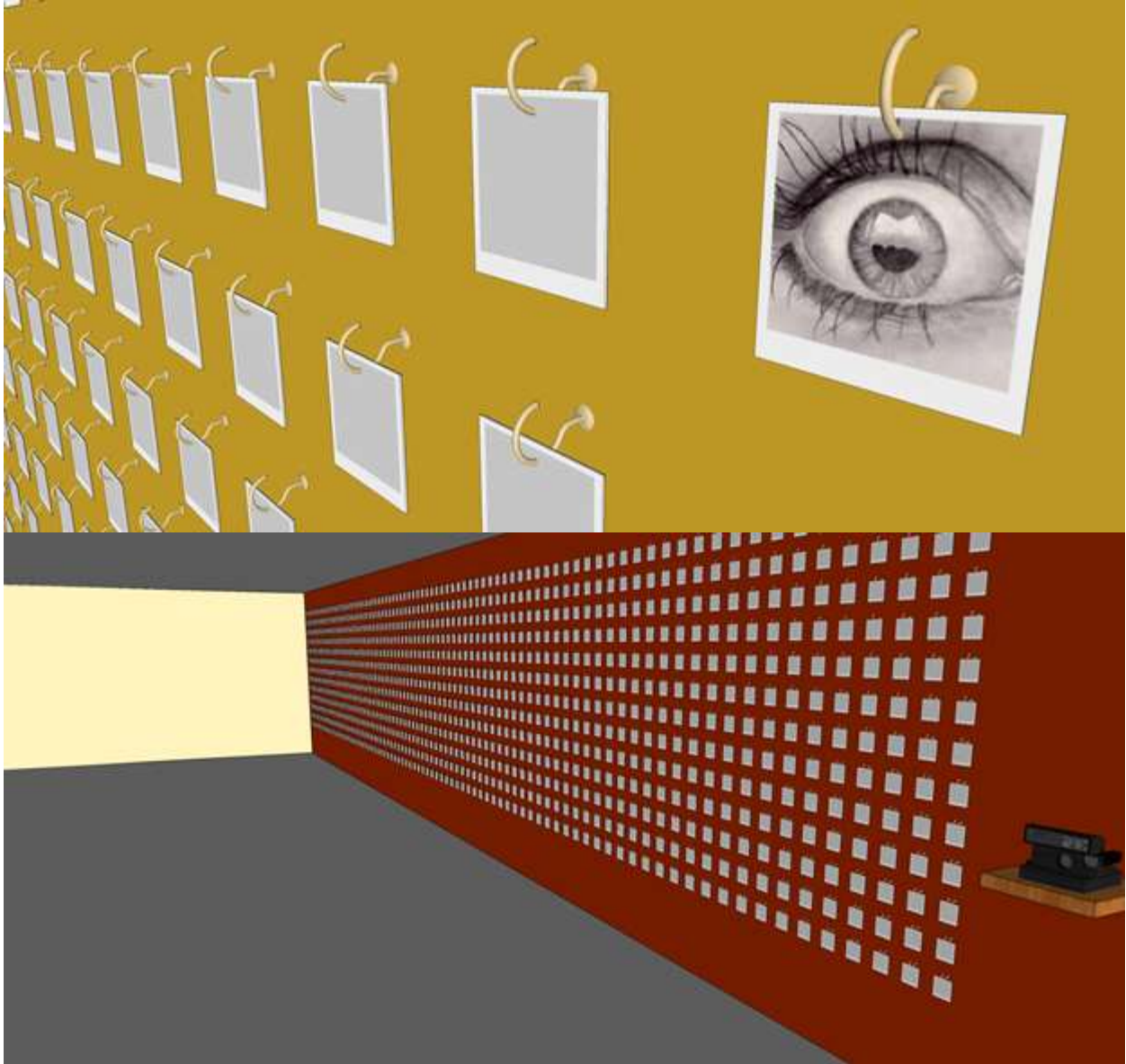
Figure 71: Top: Close up of a Polaroid image of an eye hung on The Wall. Bottom: The complete exhibition

The scoring for this exhibit is given in the following table.

Table 28: The Wall scoring

Creativity	3.3
Interactivity	3
Ease of Use	4
Feasibility	3

4. WPI Build: RFID Music Box

After exhibit ideas and concepts were generated, one was chosen for creation. The RFID Music Box received the highest average creativity score of 4.3 out of 5.0. The main idea behind the chosen project was to create a highly interactive and entertaining device incorporating technology to represent WPI. The overall themes that were focused on were musical creation and Radio-Frequency Identification (RFID) technology. The scoring for this exhibit is given in the following table.

Table 29: RFID Music Box scoring

Creativity	4.3
Interactivity	4
Ease of Use	4
Feasibility	3

The objective was to have multiple RFID readers that represent different musical components: percussion, bass, and melody. The three sections will have their own corresponding batch of RFID tags, or "sound objects," which will only work in their specific area. When placed on the appropriate area, a sound that corresponds to the tag will play based off of what is stored in the database. When an area has a sound object placed or removed before the next iteration of the music loop, the appropriate action will be taken. If a sound object was placed, then the area will be illuminated and the music corresponding to the tag will be played. If a tag was instead removed, the light and music will be deactivated unless a new tag was placed in which case the music will just switch to that tag. Videos of the final working project can be found on Vimeo.com.[15]

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[15] Electronic Edition: http://vimeo.com/61075521, Acapella Edition: http://vimeo.com/61075102

Figure 72: The RFID Music Box exhibition concept

Each tag will have different markings for a complexity rating on them, so the user will have an idea when looking at one of what they will be putting in for music, an early example of this can be seen below where the dots represent the complexity of the music. The user is free to mix and match the complexity of each space, allowing for a large range of musical qualities to be produced. This piece is highly interactive and the goal is to get a user to experiment with the different combinations of music and allow them to be able to hear different music based off of moving around the different tags to their respective area.

Figure 73: The laser cut acrylic pieces. The RFID tags can be seen to the right.

As this device will be making a lot of noise and will have the potential to disrupt other individuals from working, it is desired to limit the disturbance it will be creating. A speaker will placed within a cone fixed at a low volume so that it will cause a minimal amount of disturbance to those around.

The exhibit is to be aimed at people who are interested in science, technology, and engineering, regardless of age. Most people who use it however will be perspective WPI students and their family members while on campus tours as well as some current WPI students.

4.1 Space

Multiple locations on campus were considered for placing the exhibit that would best accentuate its features and best represent the technology employed. The place that was believed to best accomplish this is Atwater Kent (AK) as the exhibit is mainly an Electrical and Computer Engineering (ECE) project and AK is an essential building for ECE majors. The best possible location believed to

display the music box is seen below as it is a slightly darker area that will make the project look better when the lights turn on.

Figure 74: The space available in Atwater Kent Laboratories

The main issue with this placement is that it does not have a power outlet and would have to have one installed. Speaking with a member of faculty that has dealt with outlet installations, the cost was approximated to be about $1000 which would add much more than expected to the cost of the project. This area was ultimately deemed unfeasible due to cost and another place within AK was found.

A more open area in AK with power outlets already installed is within the student lounge space (Pumpkin Lounge). This area will also be more noticeable and easier to have more than a small group of people look at it at a time which is helpful during campus tours. This also has the noticeable benefit of cameras being on the area where it would be placed, which would help to boost the security of the exhibit as it could be defaced or have components stolen.

Figure 75: The student lounge space in Atwater Kent Laboratories

Another place to put the exhibit would be Salisbury Labs due to its being a central location on campus. It can be placed in the lounge area as it is the most prominent space and will easily be accessible during tours and people will be able to crowd around it easily and view a brief demonstration. The largest disadvantage to this placement is that it does not really represent the project in anyway as Salisbury is a humanities building.

There are many more places on campus that the exhibit can be placed, but ultimately the aforementioned areas were felt to be ideal. Several emails and phone calls were made to schedule arrangements for the project in AK, chiefly with the ECE department head and the manager of computational facilities. Ultimately, a permanent placement for the project was not found due to difficulties in contacting members of faculty with the ability to authorize a location. Unfortunately, this is indicative of the lack of responsiveness on campus to the desire for art and design exhibitions expressed by WPI students. This is an obstacle that must be overcome if a museum is to exist on campus.

4.2 Design

The design chosen for each of the areas is meant to give off a futuristic-style feel, similar to Walt Disney's movie, Tron: Legacy. The design is intended to give the feeling of interacting with something vastly advanced and will help to awe a user and hopefully make the exhibit have much more of an impact on the user.

Everything is to be mounted onto and in a folding 4'x2' table so that it will be at an ideal height for anyone to easily use, as well as easy to move and setup again. The acrylic pieces selected were four 2'x1' black, ⅛" pieces that will have the shapes laser cut into them and then a piece of ¼", 4'x2' placed on top to protect the pieces and help prevent physical damage to the more fragile pieces. The table will then be cut out where the shapes will be to allow light through and material will be placed beneath the black layer so that the electrical work cannot be seen, but the light can shine through. A section of the top of the table will be cut open and a piece of plywood laid down inside with all electronics mounted on it besides the readers to keep them in a central location accessible by lifting one of the panels up. Finally, the speaker will be mounted inside a conical casing to prevent sound from disturbing others nearby and helping to ensure that the only person to hear any sounds will be the user when they hold it up to their ear.

The way that it is intended to work is to have an ATMega328 connected to each of the RFID readers that will be responsible for reading tags and controlling the lights. This will then connect to an

Arduino Uno that will interpret the communication from the ATMega and then control an audio shield that will play the appropriate music corresponding to the tags that are in play from the speaker.

4.3 Hardware

The project was created by using all off the shelf hardware that is interconnected to read the RFID tags and play music based off of the tag that was read. The main component that interfaces everything is the Arduino Uno which receives the active tags and plays the appropriate music. Three 125kHz RFID readers are employed with corresponding breakout boards and 125kHz RFID tags to act as "keys" which will select the correct music files to play through the speakers. These three readers connect to an ATMega328 which will read appropriate tags on each of the designated areas and then forward this to the Arduino Uno and control the lights under each area. The three lights are connected to a 5V, 4 channel mechanical relay that keeps the low voltage DC circuit and high voltage AC circuit separate from one another as they are not directly compatible and need a device to bridge them together. When a tag is detected on one of the spaces, it will trigger the lights, and when no tag is detected it will turn off the light. The final piece of hardware is the Wave Shield that is connected to the central Arduino which has all of the music on an external SD card and through the communication with the Arduino is able to access and play them.
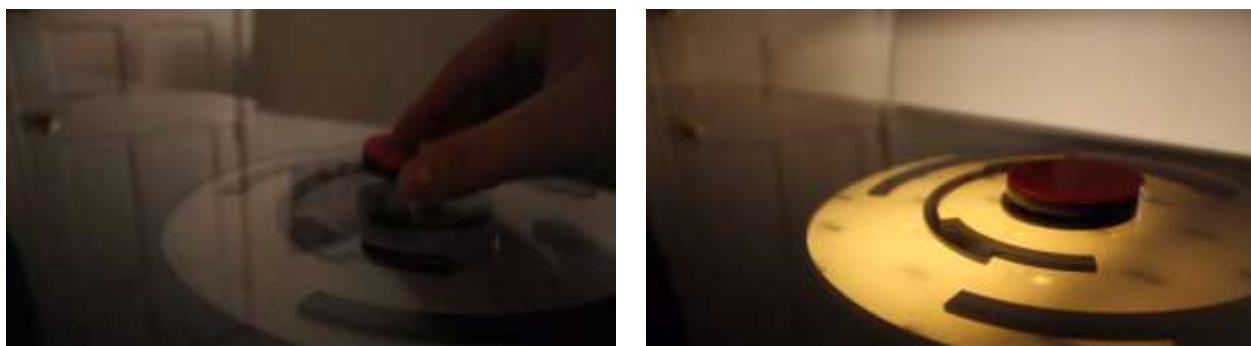
Figure 78: Table lights up when corresponding RFID tag is read in

4.4 Software

The code had to be broken up into two parts to deal with the two separate tasks, reading the tags and playing the music. The reader will be run on a single ATMega328 which communicates with the music player which interprets the received communication. The music playing Arduino will then select the appropriate sound files to play and will output it to the speakers for the user to hear. To save money, the code was then uploaded to an ATMega with a burned bootloader with inexpensive parts added to save money on the cost of an Arduino as it expensive compared to the ATMega.

The RFID readers were dealt with first to make sure that they could communicate the read tags to the music controller. The idea is to monitor the RFID reader's output port for a change and begin to collect the data and store it into an array in successive bytes. This is shown below for one of the readers.

```
while(portOne.available()){
    int readByte = portOne.read(); //read next available byte
    if(readByte == 2) reading = true; //beginning of tag
    if(readByte == 3) reading = false; //end of tag
    if(reading && readByte != 2 && readByte != 10 && readByte !=
13){
       tagString[index] = readByte;  //store the tag byte
       index ++;
    }
  }
```

This loop is repeated until the tag is fully read, and is done on each reader individually, one at a time in the order of circle, triangle and then the square. After reading a tag, its value is checked against the database to see if it matches one of the tags. The database was created by creating constants with the values of the available tags after successfully setting up the readers so their values could be recorded and stored, in the meantime it just prints out the value of the tag to the screen. If the tag is a match, it then sets a flag to an appropriate value corresponding to the tag and enables the light bulb, otherwise it disables the light and sets the flag to an empty state, meaning that nothing was read or there was no matching database entry. Finally, a serial transmission will be sent to the music controller and from there the Arduino Uno will take over. Once working, this code was uploaded to the

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ATMega328 by connecting it to another Arduino and uploading the code and then placing it into a breadboard.

Now that the RFID readers are coded and able to read tags, the music controller can be dealt with. The best way to obtain tag data was determined was to wait for an interrupt on the serial port and then act on it appropriately as this will make sure that as soon as data is received it can be acted upon. This is better than polling the port because there is much less of a potential to miss any bits in a transmission as polling could be elsewhere in the code when a transmission starts to come in, meaning data would be missed. An interrupt will immediately stop the Arduino from whatever it is doing and address what just caused the interrupt, which in this case, is receiving tag data from the ATMega328. However, because the Arduino also controls the music, the shield had to be initialized properly to allow for music to be played first. The first step is to configure the connection pins between the shield and the Arduino to allow for communications to be established between the two boards. Pins 13, 12, 11 and 10 are for communicating with the SD card, and pins 2, 3, 4 and 5 are for the DAC that controls the output of waveform for sound.

```
// Set the output pins for the DAC control. This pins are defined
in the library
 pinMode(2, OUTPUT);
 pinMode(3, OUTPUT);
 pinMode(4, OUTPUT);
 pinMode(5, OUTPUT);
 // pin13 LED
 pinMode(13, OUTPUT);
```

The SPI bus now has to be setup to communicate with the SD card at 8MHz which is done with the below statement, if an error is found it stops running and prints an error message.

```
if (!card.init()) { //play with 8 MHz spi (default faster!)
   putstring_nl("Card init. failed!"); // Something went wrong,
lets print out why
   sdErrorCheck();
```

```
    while(1); // then 'halt' - do nothing!
  }
```

The next step is to look for a File Allocation Table (FAT) file system to make sure the SD card was setup properly. There are 5 different slots that this can be found on, so they need to be checked one at a time until it is found, and if nothing comes up, print an error message and stop the program.

```
uint8_t part;
 for (part = 0; part < 5; part++) {      // we have up to 5 slots
to look in
    if (vol.init(card, part))
      break;                             // we found one, lets
bail
 }
 if (part == 5) {                        // if we ended up not
finding one  :(
    putstring_nl("No valid FAT partition!");
    sdErrorCheck();       // Something went wrong, lets print out
why
    while(1);                           // then 'halt' - do
nothing!
 }
```

The very last step is to try to open up the highest level directory on the card (root) and then any music files stored in the root can be selected and played from there. This is done with the below code that will stop the program with an error message if the root cannot be accessed.

```
if (!root.openRoot(vol)) {
    putstring_nl("Can't open root dir!"); // Something went wrong,
    while(1);                            // then 'halt' - do
nothing!
 }
```

Now, the shield is setup properly, music can now be read and played from the shield when placed onto an SD card. All that needs to be done is to call the music file by using the code below which find and play the music file.

```
// look in the root directory and open the file
 if (!f.open(root, name)) {
    putstring("Couldn't open file "); Serial.print(name); return;
```

```
}
// OK read the file and turn it into a wave object
if (!wave.create(f)) {
  putstring_nl("Not a valid WAV"); return;
}
// ok time to play! start playback
wave.play();
```

This will look in the root for the file name that was requested and if found it will play it

back. There are some distinct disadvantages to this however, the first of which is that nothing else can

be playing when calling a new WAV file to play, and the second of which is that this always starts from

the beginning of the file. The issue with only being able to play one file at a time means that mixing

cannot be done with hardware, therefore it must be done before which means that prior to uploading

any files and all combinations must be mixed by hand. With having to start at the beginning of the WAV

file, the disadvantage is that it is not possible to have long audio files and just play bits at a time when

tags are placed.

The last major step is to setup the interrupt service routine so that the RFID data will be

received properly. The routine needs to read all the data from the reader as it comes in and store it into

a variable then decode it into three bytes that will be used to select the filename.

```
char c;
// function that executes whenever data is received from master
// this function is registered as an event, see setup()
void receiveEvent(int howMany){
 while(1 < Wire.available()) // loop through all but the last
 {
   c = Wire.read(); // receive byte as a character
 }
 int x = Wire.read();    // receive byte as an integer
 a1 = x%6; //decode the data and store each in global
 a2 = (x/6)%6;
 a3 = (x/6)/6;
 timedb2 = millis();
}
```

All basics of the code are now fully functional and tags can be read and transmitted to the music controller. The full code for each the reader and the music controller can be found in Appendix B under its respective section.

4.5 Building

The first step before starting to build anything is to create test code to make sure that everything works and to create a schematic of the system. The pinouts had to be found by finding the appropriate datasheet for the RFID reader and the ATMega, so that the necessary connections could be formed. The created schematic can be seen below which include the music controller, a single RFID reader and its corresponding Arduino.
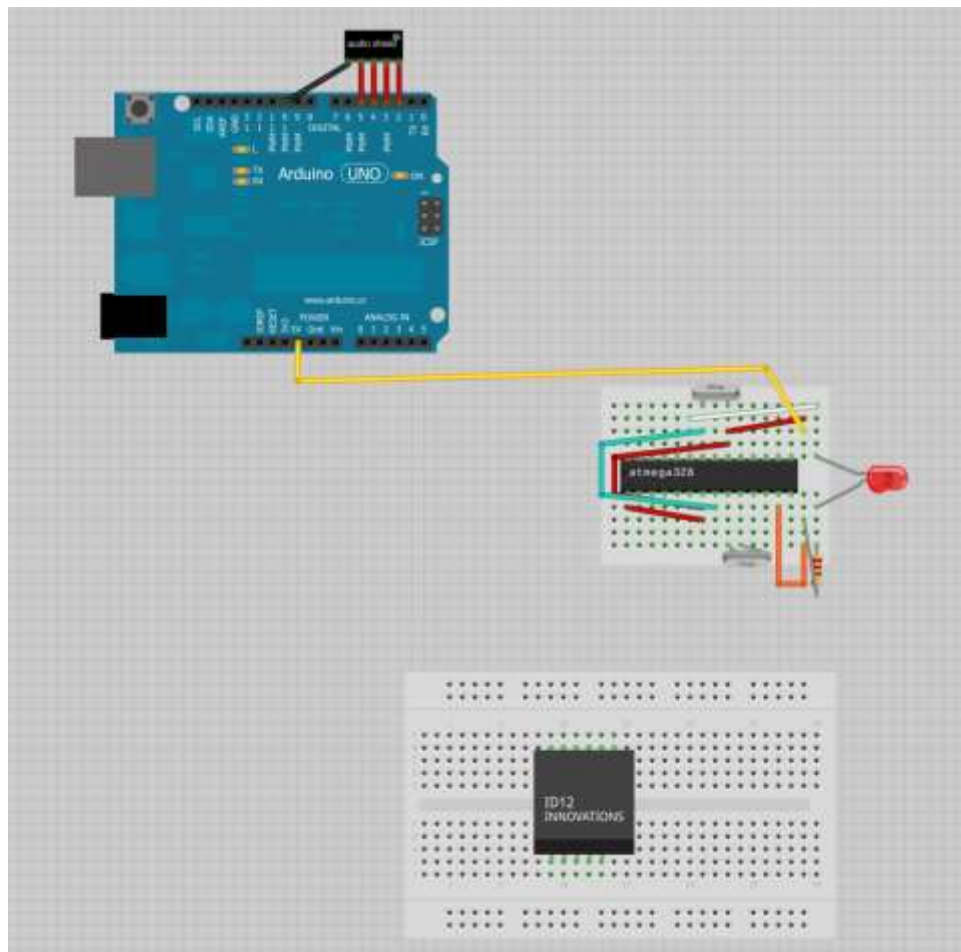
Figure 79: The music controller, a single RFID reader, and its corresponding Arduino

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Everything had bare minimum code created for it by making sure that the very basics of everything worked, it was checked by putting an RFID tag up to one of the readers and by checking that it could communicate over serial to the Arduino serially and then trip the relay and then turn on the lights. The results of this can be seen below, where the light was successfully was lit by using an RFID tag.
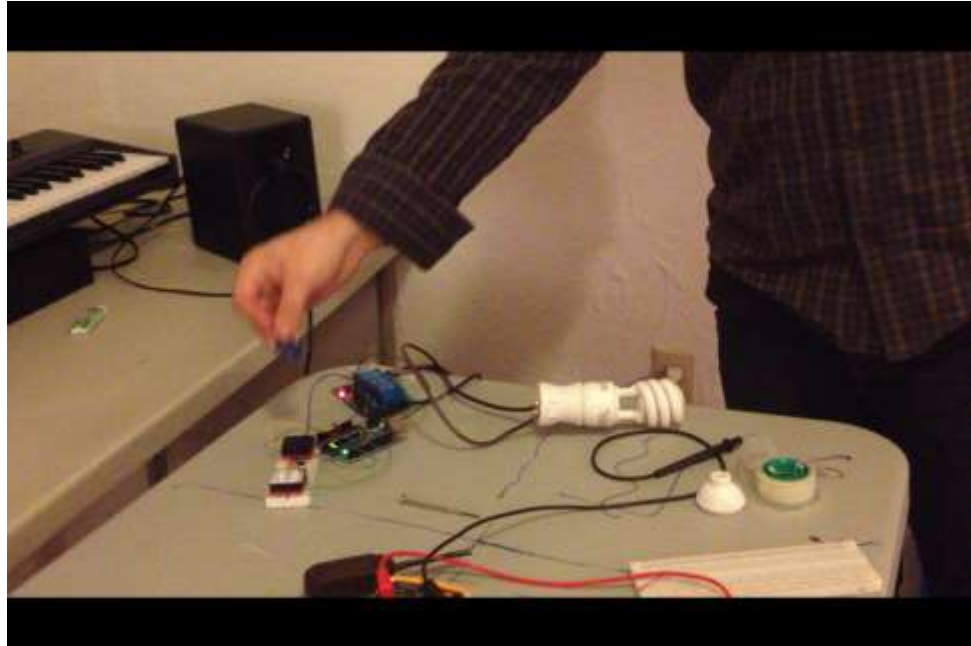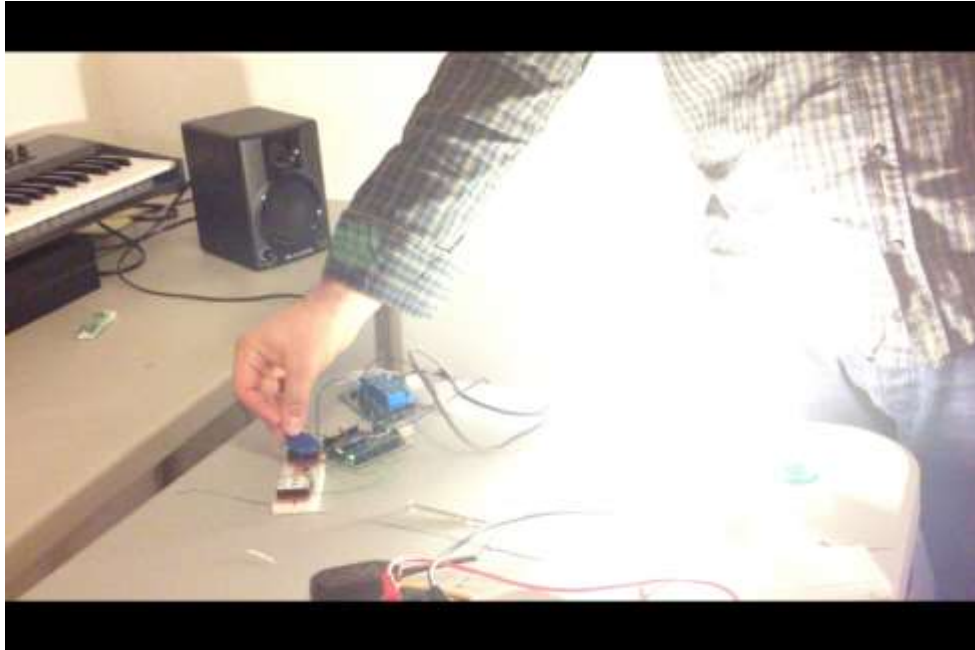
Figure 80: Top: Unlit light bulb with no RFID tag touching the reader. Bottom: RFID tag tripping the relay and lighting the bulb.

The first step in constructing the music box was to begin to purchase the necessary hardware and electronic parts needed for construction. The electronic materials were purchased through online retailers and any hardware was acquired through local retailers. All materials used were standard, off the shelf parts easily obtainable by anyone that desires them.

The next step was to create the Google SketchUp files of the shapes to be cut out of the acrylic for the table as seen below so they can be laser cut. These could then be exported into AutoCAD so that the laser cutter in Washburn Shops at WPI could read the design and cut it when setup with the material properties.

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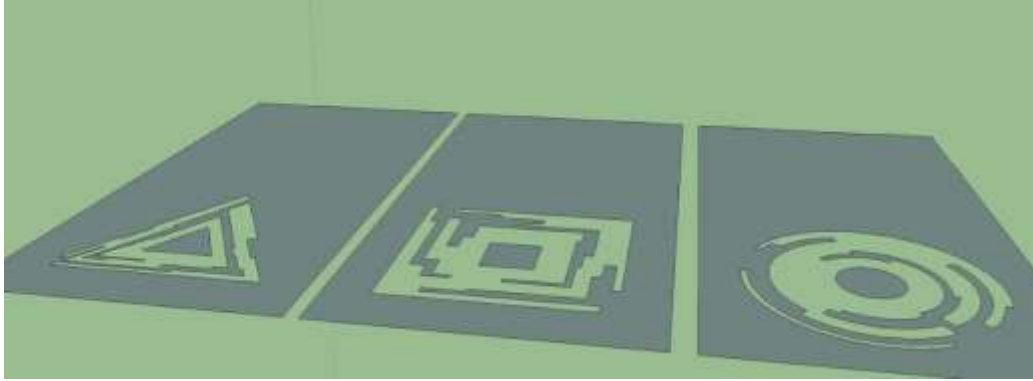
Figure 81: The AutoCAD design for the acrylic sheets

The lights then had to be mounted by creating a bar that they can all attach to along with dividers so that light doesn't get into the wrong area, making it look like a tag is on a space it is not. The lights were then connected to a mechanical relay that would be able to interface between the low DC voltage Arduino circuit and the high AC voltage circuit that powers fluorescent bulbs. Once connected, the acrylic was able to be attached to the table by which ensured they would not be moved when the table is in use. The clear layer is then placed on top to protect the acrylic below along with making sure nothing is put into the cutout areas, this sheet was then attached to the table.

Figure 82: Final table setup

Next, the Arduino's electronics were mounted onto a piece of plywood and inserted into a hole that was cut into the table. This allowed for the electronics to be hidden and allow for easy access to them by lifting up one of the sections that would then act as a type of access panel.

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4.6 Possible Future Improvements

Throughout the project, many design decisions were made. The consequences of these decisions brought about several advantages and disadvantages.

The main limitations were budget and time. These made it very difficult to choose materials and to process them once they were obtained. For instance a pre-made table had to be bought which was different from the one planned in the initial design. It had metal supports under it, which made it very difficult to implement the light installation. Additionally cheaper electronics had to be selected, which had imperfections that had to be dealt with and caused unforeseen problems.

One of the major limitations for the final design was the audio module. Because a computer could not be afforded for the project, the audio processing had to be done in a simple microcontroller which does not have much processing power. For this reason, the initial intention to create generative sounds to let visitors experiment and create unique music could not be achieved. Instead a less flexible but still functional method was implemented which limits the user creatively. The audio model limitation also made it very difficult to implement the audio playback. Instead of letting the module generate sounds, all combinations of sounds were pre-recorded on a computer individually. Each of the files were then named individually by hand, which required a significant amount of time.
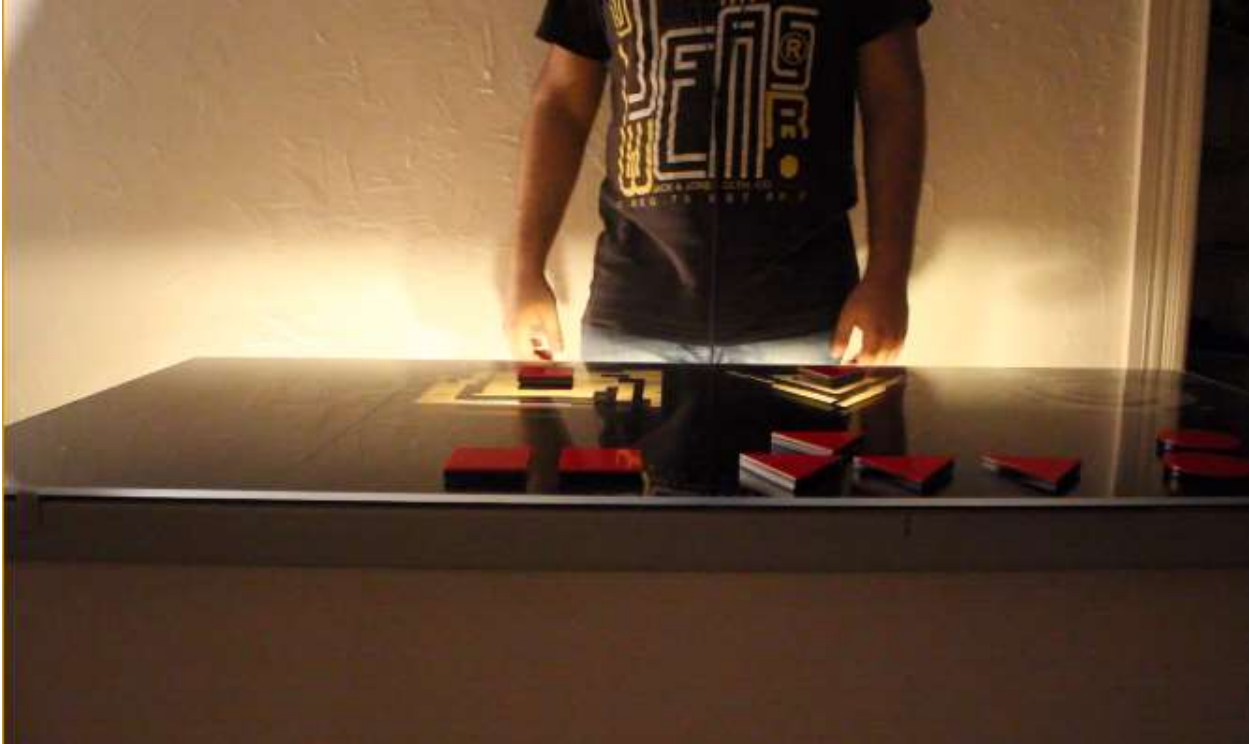
Figure 83: User creating sound combinations using the RFID Music Box

Having all these restrictions, however, only limited the initial concept. The final piece is one that

is visually attractive, fun to play with, and portable. A new set of sound can easily be added in the future

and parts can easily be replaced. Not having the desired computer connected also made the end result

much more portable.

5. CONCLUSION

Through this Interactive Qualifying Project we hoped to learn about interactivity of museum exhibitions and gather the knowhow to design and construct our own exhibition for WPI's campus. We visited and carried out research in the Museum of Science in Boston, the Massachusetts Institute of Technology museum, Higgins Armory, and the Worcester Art Museum. We focused greatly on the Museum of Science due to the high interactivity of all exhibitions on display. Through online research we concluded that the highest form of interactivity results from creation. That is, the user's ability to design and form his or her individual understanding of the exhibition completely unconstrained.

An interview and survey were also conducted in order to gather more knowledge on the initial development of collegiate museums and to learn about what the student body desired if an on campus museum was constructed. The interview with Massachusetts' Institute of Technology's museum director John Durant gave us great insight into the creation and origin of MIT's on-campus museum as well as the staffing, curation, and technical aspects. This gave us a general understanding of how a museum for WPI's campus could begin to be planned and developed. The survey that was sent to the undergraduates of WPI returned intriguing results that helped us understand the students' desire for an on-campus museum. Through it we can conclude that the majority of students believe that a museum would be a valuable addition to the WPI campus and would like to see student projects on display.

After researching interactivity and the creation of museums and exhibitions, we used this knowledge to assemble an installation of our own as well as 21 exhibition ideas for WPI and 10 proposals for the Worcester Art Museum. Each of these was rated on a scale ranging from 1.0 to 5.0 on creativity, interactivity, ease of use, and feasibility. Our project team anonymously voted on the creativity ratings which were then averaged and voted as a whole on the interactivity, ease of use, and feasibility ratings. Through our rating system our team produced just two WPI exhibition ideas that averaged a creativity rating greater than 4.0: the IMGD Models and the RFID Music Box. The RFID Music

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Box generated the highest average creativity score from our four team members with a rating of 4.3.

This was the installation that we set out to design and build.

Appendix A: Survey Results

Q1: Do you believe an art or science museum would be a valuable addition to the WPI campus?

Q1 received 100 responses
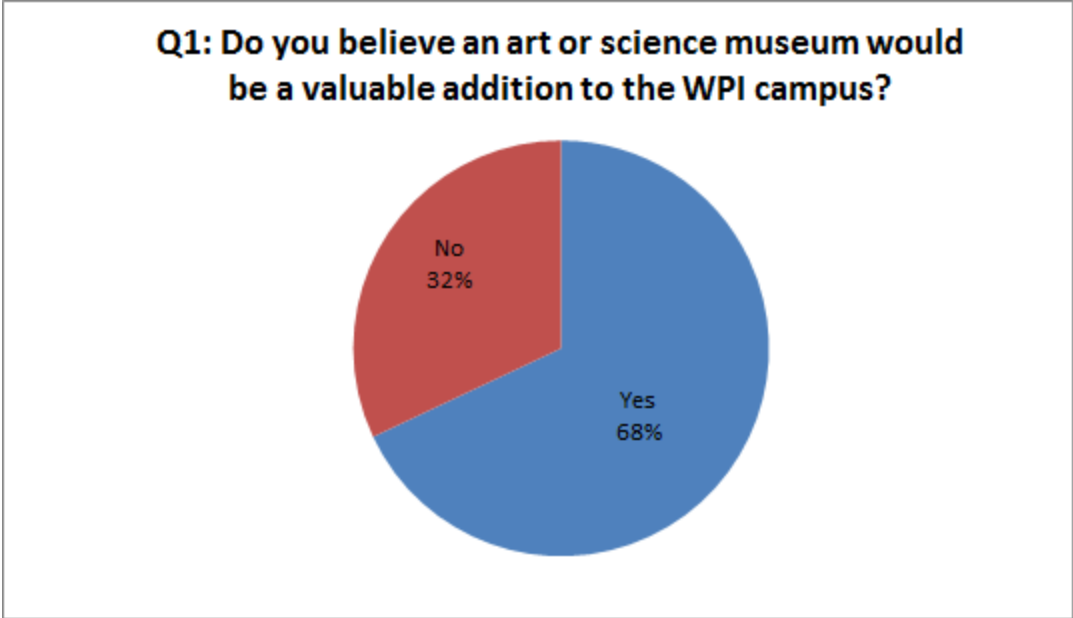
Q2: How important is a campus museum compared to a library?

Q2 received 100 responses
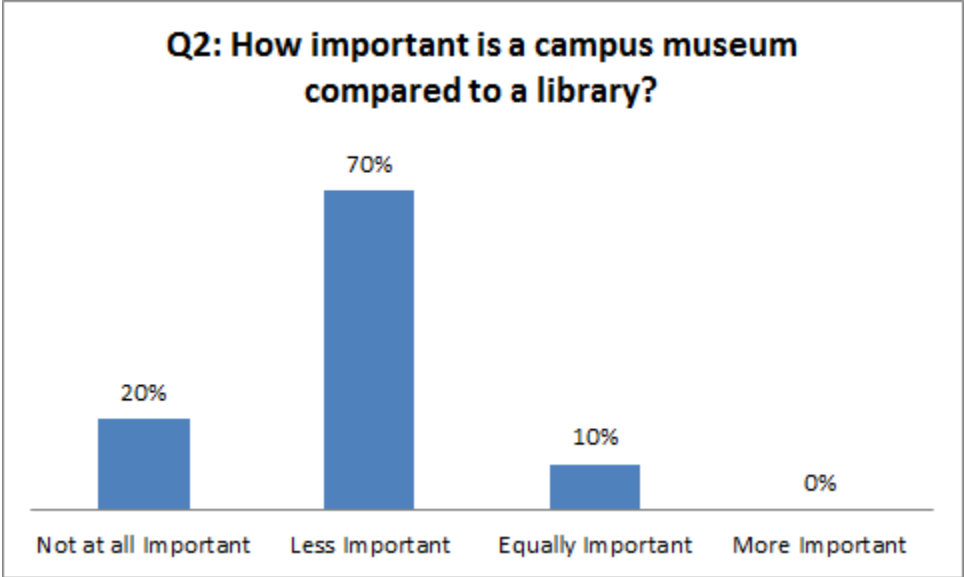
Q3: How important is a campus museum compared to a gymnasium?

Q3 received 100 responses

Q3: How important is a campus museum compared to a gymnasium?

19% — Not at all Important
59% — Less Important
15% — Equally Important
7% — More Important
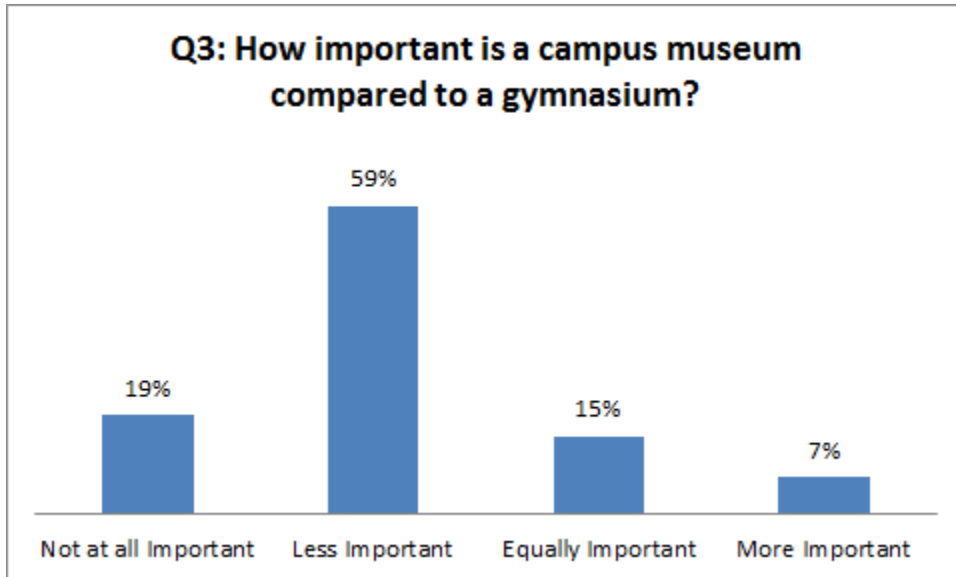
Q4: How important is a campus museum compared to a any one of the student lounges (i.e. in AK or

Fuller Labs)?

Q4 received 100 responses

Q4: How important is a campus museum compared to any one of the student lounges (i.e. in AK or Fuller Labs)?

14% — Not at all Important
49% — Less Important
27% — Equally Important
10% — More Important
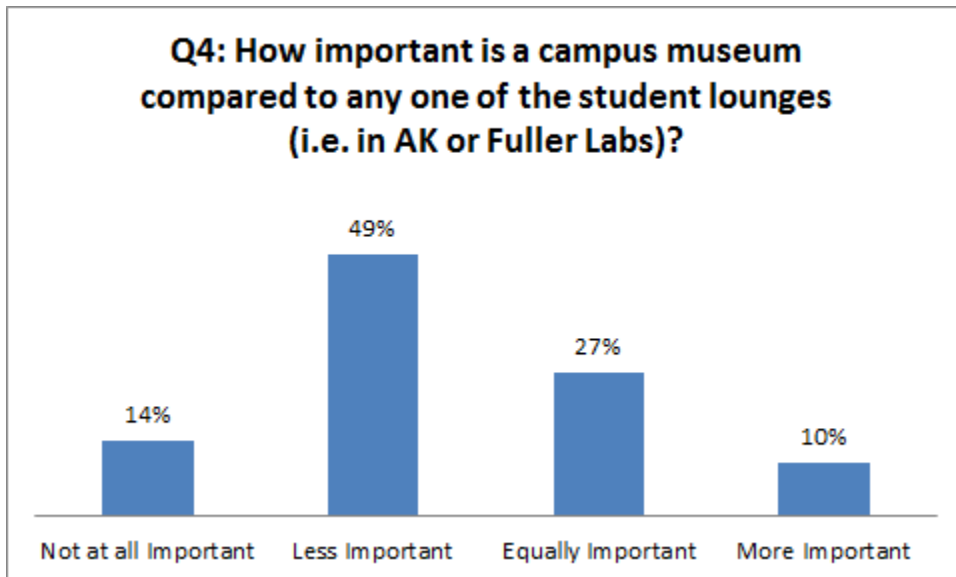
Q5: What exhibits have you heard about on campus? (check all that apply)

Q5 received 100 responses

Q5: What exhibits have you heard about on campus? (check all that apply)

Exhibit	Percentage
Library exhibit featuring past WPI students such as Robert Goddard	46%
Gallery in the Library 3rd floor	61%
Deborah Aschheim installation on Fuller Labs stairway	32%
Others	14%
None	27%
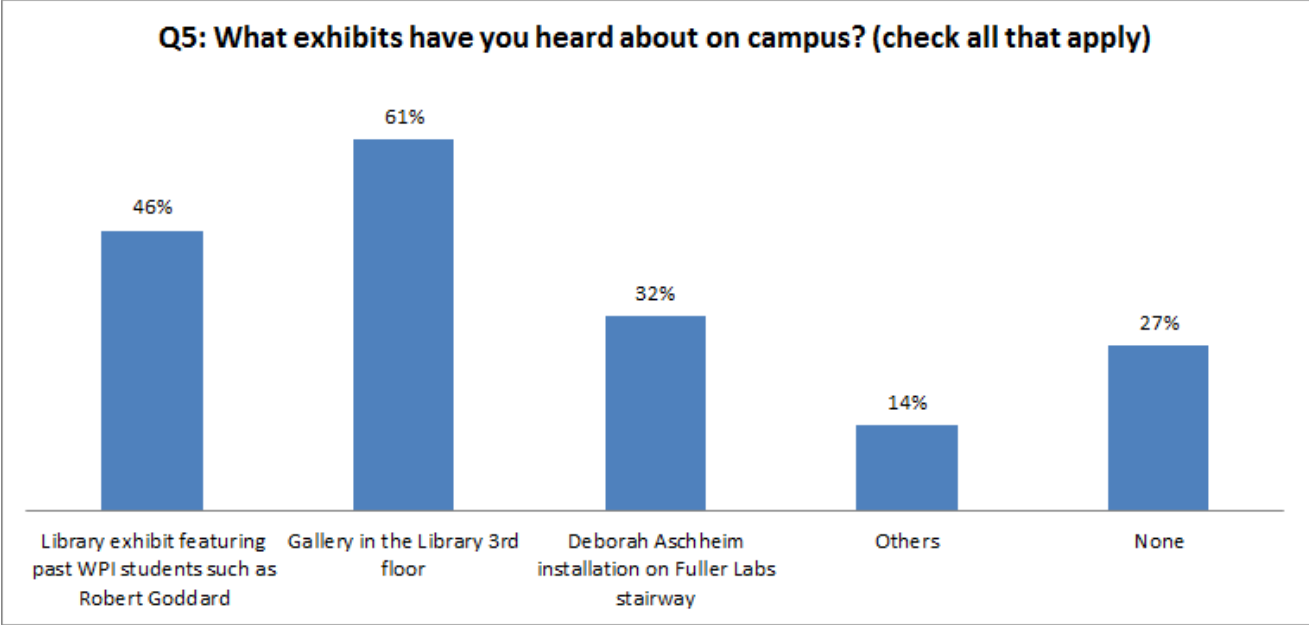
Q6: What exhibits have you visited? (check all that apply)

Q6 received 99 responses
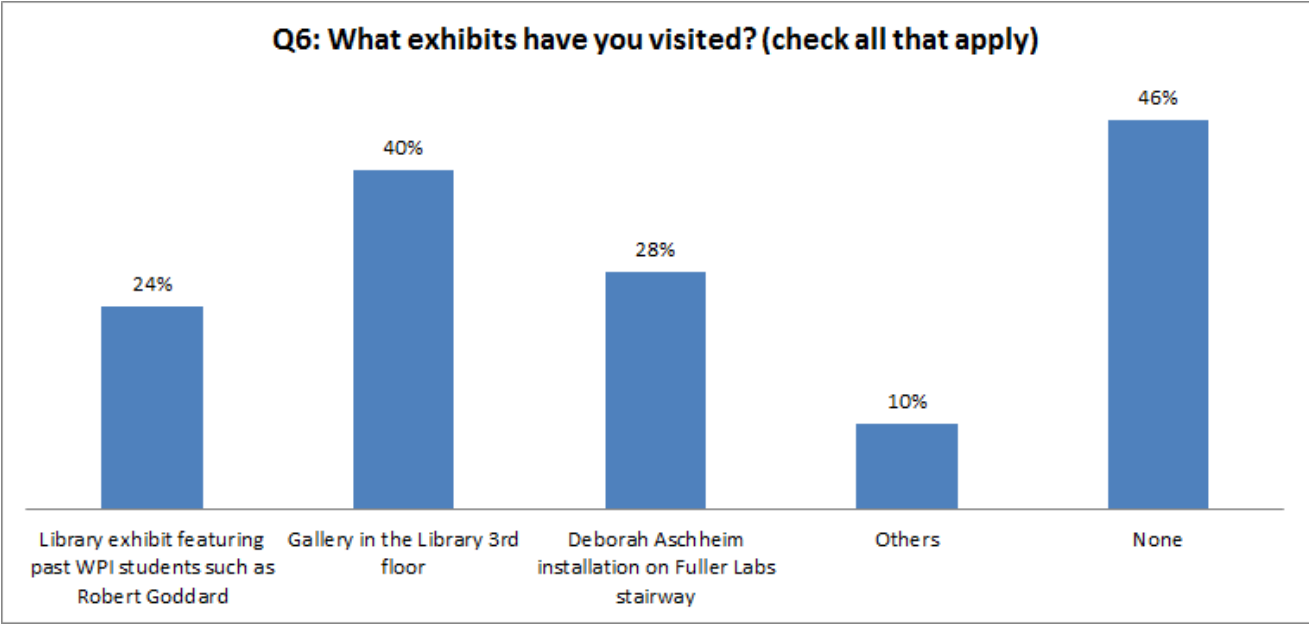
Q6: What exhibits have you visited? (check all that apply)

Exhibit	Percentage
Library exhibit featuring past WPI students such as Robert Goddard	24%
Gallery in the Library 3rd floor	40%
Deborah Aschheim installation on Fuller Labs stairway	28%
Others	10%
None	46%

Q7: Would you be interested in contributing works of art or projects to a campus museum in the future?

Q7 received 100 responses

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Q7: Would you be interested in contributing works of art or projects to a campus museum in the future?

- Yes 13%
- No 44%
- Maybe 43%
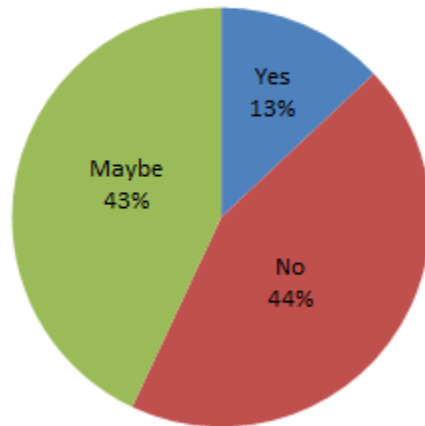
Q8: If only one option were available, would you prefer to visit interactive or passive exhibits?

Q8 received 99 responses

Q8: If only one option were available, would you prefer to visit interactive or passive exhibits?

- Passive 27%
- Interactive 73%
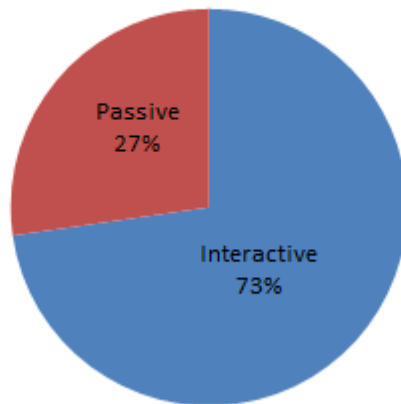
Q9: What types of exhibits would you like to see at a WPI campus museum (i.e. historical, interactive, fine art, student projects, etc.)?

Q9 received 58 responses. Of the people who responded, many listed several types of exhibits. Below is a bar chart representing the frequency with which each type was mentioned.

Q9: What types of exhibits would you like to see at a WPI campus museum (i.e. historical, interactive, fine art, student projects, etc.)?

Category	Count
ME	1
RBE	2
ECE	3
IMGD	3
Video Games	3
Educational	3
Music	4
Student artwork	6
Science	39
Fine art	46
Interactive	63
Historical	71
Student projects	97
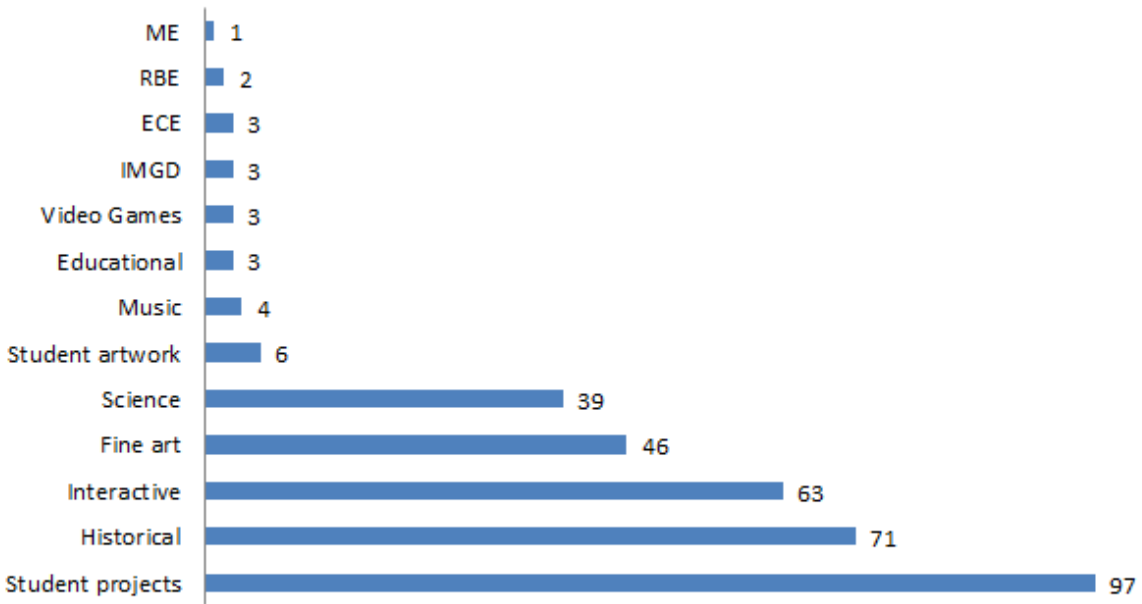
Q10: What current locations on campus could serve as a WPI museum or gallery?

Q10 received 47 responses. Of the people who responded, many listed several locations on campus.

Below is a bar chart representing the frequency with which each location was mentioned.

Q10: What current locations on campus could serve as a WPI museum or gallery?

Location	Frequency
Fuller Labs	2
Boynton Hall	2
Unused Classroom	2
Riley Commons	2
Bartlett Center	2
Skull Tomb	3
Quad	3
Alden	3
Wedge	3
Octo-wedge	3
Harrington Auditorium	3
Washburn Labs	4
Any Lounge	4
Rec Center	4
No location	6
Higgins House	9
Throughout campus	12
Salisbury Labs	16
Campus Center	26
Library	29
Alumni Gym	38

Appendix B: Code

The following is code used to implement the functionality of the RFID Music Box.

Music Control

```
#include <FatReader.h> //these are for audio shield
#include <SdReader.h>
#include <avr/pgmspace.h>
#include "WaveUtil.h"
#include "WaveHC.h"
#include <MsTimer2.h> //for easy timer interrupts


//------------
#include <Wire.h> //to communicate with the rfid Arduino
int a1;
int a2;
int a3;
//------------


#include <SoftwareSerial.h> //not needed anymore
SoftwareSerial mySerial(8, 9); // RX, TX


SdReader card;     // This object holds the information for the card
FatVolume vol;     // This holds the information for the partition
on the card
FatReader root;    // This holds the information for the filesystem
on the card
FatReader f;       // This holds the information for the file we're
play
WaveHC wave;       // This is the only wave (audio) object, since we
will only play one at a time


//not used anymore
#define DEBOUNCE 5  // button debouncer
char b;
// here is where we define the buttons that we'll use. button "1"
is the first, button "6" is the 6th, etc
byte buttons[] = {
 14, 15, 16, 17, 18, 19};
// This handy macro lets us determine how big the array up above
is, by checking the size
#define NUMBUTTONS sizeof(buttons)
// we will track if a button is just pressed, just released, or
'pressed' (the current state
volatile byte pressed[NUMBUTTONS], justpressed[NUMBUTTONS],
```

```
justreleased[NUMBUTTONS];



//////////////////////////////////////////////////////////////////
///////////////////////////////////// my globals

unsigned long int timedb;
unsigned long int timedb2;
char filename[13];


//////////////////////////////////////////////////////////////////
///////////////////////////////////// helpers 1

// this handy function will return the number of bytes currently
free in RAM, great for debugging!
int freeRam(void)
{
 extern int  __bss_end;
 extern int  *__brkval;
 int free_memory;
 if((int)__brkval == 0) {
   free_memory = ((int)&free_memory) - ((int)&__bss_end);
 }
 else {
   free_memory = ((int)&free_memory) - ((int)__brkval);
 }
 return free_memory;
}


void sdErrorCheck(void)
{
 if (!card.errorCode()) return;
 putstring("\n\rSD I/O error: ");
 Serial.print(card.errorCode(), HEX);
 putstring(", ");
 Serial.println(card.errorData(), HEX);
 while(1);
}


//////////////////////////////////////////////////////////////////
///////////////////////////////////// setup

void setup() {

 byte i;

 // set up serial port
```

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```
 Wire.begin(4);                      // join i2c bus with address #4
 Wire.onReceive(receiveEvent); // register event
 Serial.begin(9600);               // start serial for output
 mySerial.begin(9600);
 putstring_nl("WaveHC with ");
 Serial.print(NUMBUTTONS, DEC);
 putstring_nl("buttons");

 putstring("Free RAM: ");          // This can help with debugging,
running out of RAM is bad
 Serial.println(freeRam());        // if this is under 150 bytes it
may spell trouble!

 // Set the output pins for the DAC control. This pins are defined
in the library
 pinMode(2, OUTPUT);
 pinMode(3, OUTPUT);
 pinMode(4, OUTPUT);
 pinMode(5, OUTPUT);

 // pin13 LED
 pinMode(13, OUTPUT);

 // Make input & enable pull-up resistors on switch pins
 for (i=0; i< NUMBUTTONS; i++) {
   pinMode(buttons[i], INPUT);
   digitalWrite(buttons[i], HIGH);
 }

 //  if (!card.init(true)) { //play with 4 MHz spi if 8MHz isn't
working for you
 if (!card.init()) {              //play with 8 MHz spi (default
faster!)
   putstring_nl("Card init. failed!");  // Something went wrong,
lets print out why
   sdErrorCheck();
   while(1);                              // then 'halt' - do
nothing!
 }

 // enable optimize read - some cards may timeout. Disable if
you're having problems
 card.partialBlockRead(true);

 // Now we will look for a FAT partition!
 uint8_t part;
 for (part = 0; part < 5; part++) {     // we have up to 5 slots to
```

```
look in
   if (vol.init(card, part))
     break;                              // we found one, lets bail
 }
 if (part == 5) {                        // if we ended up not
finding one  :(
   putstring_nl("No valid FAT partition!");
   sdErrorCheck();      // Something went wrong, lets print out why
   while(1);                             // then 'halt' - do
nothing!
 }

 // Lets tell the user about what we found
 putstring("Using partition ");
 Serial.print(part, DEC);
 putstring(", type is FAT");
 Serial.println(vol.fatType(),DEC);      // FAT16 or FAT32?

 // Try to open the root directory
 if (!root.openRoot(vol)) {
   putstring_nl("Can't open root dir!"); // Something went wrong,
   while(1);                             // then 'halt' - do
nothing!
 }

 // Whew! We got past the tough parts.
 putstring_nl("Ready!");

 MsTimer2::set(80, flash); // 80ms period
 MsTimer2::start();

}

//////////////////////////////////////////////////////////////////
///////////////////////////////////// interrupted helpers

int flashCount = -1;

void flash(){

 flashCount++;
 flashCount = (flashCount%(33*4)) ;

 filename[0] = a1+48; //use the decoded data from recieveEvent.
Combine the numbers to make a file name
 filename[1] = a2+48;
 filename[2] = a3+48;
```

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```
 filename[3] = '.';
 filename[4] = 'W';
 filename[5] = 'A';
 filename[6] = 'V';



 Serial.println(flashCount+1);
 Serial.println(filename); // call the file name
if( flashCount == 0)
 playfile(filename,1);


}


char c;
// function that executes whenever data is received from master
// this function is registered as an event, see setup()
void receiveEvent(int howMany){
 while(1 < Wire.available()) // loop through all but the last
 {
   c = Wire.read(); // receive byte as a character
 }
 int x = Wire.read();    // receive byte as an integer
 a1 = x%6; //decode the data and store each in global
 a2 = (x/6)%6;
 a3 = (x/6)/6;



 timedb2 = millis();


}


//////////////////////////////////////////////////////////////////
////////////////////////////////// loop

//loop isnt needed anymore, just interrupts
void loop() {

 //  while (millis() - timedb < 3000 ){
 //    int timelocal = millis() - timedb;
 //    if (timelocal > 3000) break;
 //
 //    else if (1003 > timelocal &&  timelocal > 1000)
Serial.println("tick1");
 //    else if (2003 > timelocal &&  timelocal > 2000)
Serial.println("tick2");
 //  }
 //  Serial.println("ticktack");
```

```
 //   timedb = millis();
 //   if (millis() - timedb2 < 1000){
 //     Serial.println("alright, I will play it");



 //    filename[0] = a1+48;
 //    filename[1] = a2+48;
 //    filename[2] = a3+48;
 //      filename[3] = '.';
 //      filename[4] = 'W';
 //      filename[5] = 'A';
 //      filename[6] = 'V';
 //
 //
 //
 //     Serial.println(filename);
 //playcomplete(filename,1);

 //   }
 //   else Serial.println("silence, no song was input");
}


//////////////////////////////////////////////////////////////////
//////////////////////////////////// play helpers

// Plays a full file from beginning to end with no pause.
void playcomplete(char *name) {
 // c = '_';  //this causes problem, but i could put it in the
beginning of this function?
 // call our helper to find and play this name
 playfile(name);
 while (wave.isplaying) {
   // do nothing while its playing
 }
 // now its done playing
 wave.stop();

}


void playfile(char *name) {
 // see if the wave object is currently doing something
 if (wave.isplaying) {// already playing something, so stop it!
   wave.stop(); // stop it
 }
 // look in the root directory and open the file
 if (!f.open(root, name)) {
   putstring_nl("Couldn't open file ");
```

```
    Serial.print(name);
    return;
  }
  // OK read the file and turn it into a wave object
  if (!wave.create(f)) {
    putstring_nl("Not a valid WAV");
    return;
  }


  // ok time to play! start playback
  wave.play();
}


//---------------------modified players for breaking Wav into
multiple sounds--------------------

// Plays a full file from beginning to end with no pause.
void playcomplete(char *name, byte beat) {
  // c = '_';  //this causes problem, but i could put it in the
beginning of this function?
  // call our helper to find and play this name
  playfile(name, beat);
  while (wave.isplaying) {
    // do nothing while its playing
  }
  // now its done playing
  wave.stop();

}


int offset = 0;
void playfile(char *name, byte beat) {
 // see if the wave object is currently doing something
 if (wave.isplaying) {// already playing something, so stop it!
   wave.stop(); // stop it
 }
 // look in the root directory and open the file
 if (!f.open(root, name)) {
   putstring_nl("Couldn't open file ");
   Serial.print(name);
   return;
 }
 // OK read the file and turn it into a wave object
 if (!wave.create(f)) {
   putstring_nl("Not a valid WAV");
   return;
 }
```

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```
  // ok time to play! start playback


  // 2 -> 0
  // 3 -> 5000


  if(beat == 4) offset = 4000;
  else if(beat == 3) offset = 0;
  else if(beat == 2) offset = 0;
  else offset = 0;
  unsigned long int sizedb = (wave.getSize()*(beat-1)/4) - offset;
//5000 is offset back
  if (sizedb <= 0) sizedb = 0;
  Serial.println(sizedb);
  wave.seek(sizedb);
  wave.play();
}
```

Tag Reader

```
#include <SoftwareSerial.h>  // for communication with RFID readers
#include <Wire.h> //for communication with the other arduino

SoftwareSerial portThree(2,5); // RX=10, TX=11
SoftwareSerial portTwo(3,6); // RX=8, TX=9
SoftwareSerial portOne(4,7); // RX=2, TX=3


//----------------------------------------------------------------
----------------tag numbers
char circle1[13] = "0300284C7E19"; //circle
char circle2[13] = "04006A479CB5";
char circle3[13] = "0400753AB1FA";
char circle4[13] = "04006A32CD91";
char circle5[13] = "020019F742AE";


char triangle1[13] = "03002DA6F47C"; //triangle
char triangle2[13] = "03003667C193";
char triangle3[13] = "04006B2C0B48";
char triangle4[13] = "050014CF5F81";
char triangle5[13] = "04007624F5A3";


char square1[13] = "02001C5A8BCF"; //square
char square2[13] = "020088BD7344";
char square3[13] = "040068BDD706";


//----------------------------------------------------------------
----------------globals
```

```
#define RFIDResetPin 13 //used to reset RFID readers so that they
read not just once
unsigned long time;
int sound1 = 0;
int sound2 = 0;
int sound3 = 0;
int soundCombined = 0;
byte x = 0;


#define lCircle 10 //if circle is present D10 will be HIGH, so that
it can turn the light bulb on
#define lTriangle 9
#define lSquare 8


//--------------------------------------------------------------
----------------loop begin

void setup(){
 Serial.begin(9600);  //for debugging
 Wire.begin(); // join i2c bus (address optional for master)
 portOne.begin(9600);
 portTwo.begin(9600);
 portThree.begin(9600);

 pinMode(RFIDResetPin, OUTPUT);
 digitalWrite(RFIDResetPin, HIGH);

 pinMode(lCircle, OUTPUT);
 pinMode(lTriangle, OUTPUT);
 pinMode(lSquare, OUTPUT);
 digitalWrite(lCircle, HIGH); //turn initially high so that we know
if they work or not
 digitalWrite(lTriangle, HIGH);
 digitalWrite(lSquare, HIGH);


}

void loop(){
 ///////////////////one///////////////////////////////////////////
////////////////
 portOne.listen(); //focus on portOne now
 resetReader(); //reset the RFID reader

   char tagString[13];
 int index = 0;
 boolean reading = false;
```

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```
  while(portOne.available()){

     int readByte = portOne.read(); //read next available byte

     if(readByte == 2) reading = true; //begining of tag
     if(readByte == 3) reading = false; //end of tag

     if(reading && readByte != 2 && readByte != 10 && readByte !=
13){

        tagString[index] = readByte;  //store the tag byte
        index ++;
     }
  }

  checkTag(tagString); //Check if it is a match
  clearTag(tagString); //Clear the char of all value

  /////////////////two/////////////////////////////////////////////
/////////////////
  portTwo.listen();
  resetReader(); //reset the RFID reader

     char tagString2[13];
  int index2 = 0;
  boolean reading2 = false;

  while(portTwo.available()){

     int readByte2 = portTwo.read(); //read next available byte

     if(readByte2 == 2) reading2 = true; //begining of tag
     if(readByte2 == 3) reading2 = false; //end of tag

     if(reading2 && readByte2 != 2 && readByte2 != 10 && readByte2 !=
13){
        //store the tag
        tagString2[index2] = readByte2;
        index2 ++;
     }
  }

  checkTag2(tagString2); //Check if it is a match
  clearTag(tagString2); //Clear the char of all value
```

```
//////////////////three////////////////////////////////////////////////////
//////////////////////////

portThree.listen();
resetReader(); //reset the RFID reader

   char tagString3[13];
int index3 = 0;
boolean reading3 = false;

while(portThree.available()){

   int readByte3 = portThree.read(); //read next available byte

   if(readByte3 == 2) reading3 = true; //begining of tag
   if(readByte3 == 3) reading3 = false; //end of tag

   if(reading3 && readByte3 != 2 && readByte3 != 10 && readByte3 !=
13){
      //store the tag
      tagString3[index3] = readByte3;
      index3 ++;
   }
 }

 checkTag3(tagString3); //Check if it is a match
 clearTag(tagString3); //Clear the char of all value

 ///////////////////////Calculate and Communicate to other
Arduino///////////////////////

 int soundCombined = sound1*36 + sound2*6 + sound3; //base 6
system. assuming options of none & 1-5
 Serial.println(soundCombined); //for debugging


 //other arduino will receive these in order and decide them
 Wire.beginTransmission(4); // transmit to device #4
 Wire.write("x is ");        // sends five bytes
 Wire.write((soundCombined));                // sends one byte
 Wire.endTransmission();    // stop transmitting

 x++;
```

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```
    //////////////////////////////////////////////////////////////////

}

//----------------------------------------------------------------
----------------loop end

//----------------------------------------------------------------
----------------checkTag's
void checkTag(char tag[]){
 if(strlen(tag) == 0) {//if empty, ...
   sound1 = 0; //sound1 is none -> 0
   digitalWrite(lCircle, LOW); //turn off the light bulb
   return; // ...no need to continue, break the function here
 }

 else if(compareTag(tag, circle1)){  //if tag matches to circle1
tag
   sound1 = 1; //sound1 = 1
   digitalWrite(lCircle, HIGH); //turn light bulb on so that the dj
knows its present
 }

 else if(compareTag(tag, circle2)){
   sound1 = 2;
   digitalWrite(lCircle, HIGH);
 }

 else if(compareTag(tag, circle3)){
   sound1 = 3;
   digitalWrite(lCircle, HIGH);
 }

 else if(compareTag(tag, circle4)){
   sound1 = 4;
   digitalWrite(lCircle, HIGH);
 }

 else if(compareTag(tag, circle5)){
   sound1 = 5;
   digitalWrite(lCircle, HIGH);
 }
 //  else if(compareTag(tag, tag2)){
 //     sound1 = 2;
 //  }
 //  else if(compareTag(tag, tag3)){
```

```
//      sound1 = 3;
//   }


 else{
   sound1 = 0;
 }




}


//----------


void checkTag2(char tag[]){
 if(strlen(tag) == 0) {//empty, ...
   sound2= 0;
   digitalWrite(lTriangle, LOW);
   return; // ...no need to continue
 }



 else if(compareTag(tag, triangle1)){
   sound2= 1;
   digitalWrite(lTriangle, HIGH);
 }
 else if(compareTag(tag, triangle2)){
   sound2= 2;
   digitalWrite(lTriangle, HIGH);
 }
 else if(compareTag(tag, triangle3)){
   sound2= 3;
   digitalWrite(lTriangle, HIGH);
 }
 else if(compareTag(tag, triangle4)){
   sound2= 4;
   digitalWrite(lTriangle, HIGH);
 }
 else if(compareTag(tag, triangle5)){
   sound2= 5;
   digitalWrite(lTriangle, HIGH);
 }



 else{
   sound2 = 0;
 }
```

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```
}

//----------

void checkTag3(char tag[]){
 if(strlen(tag) == 0) {//empty, ...
   sound3= 0;
   digitalWrite(lSquare, LOW);
   return; // ...no need to continue
 }


 else if(compareTag(tag, square1)){
   sound3= 1;
   digitalWrite(lSquare, HIGH);
 }

 else if(compareTag(tag, square2)){
   sound3= 2;
   digitalWrite(lSquare, HIGH);
 }

 else if(compareTag(tag, square3)){
   sound3= 3;
   digitalWrite(lSquare, HIGH);
 }
 //  else if(compareTag(tag, tag8)){
 //    sound3= 2;
 //  }
 //   else if(compareTag(tag, tag9)){
 //    sound3= 3;
 //  }

 else{
   sound3 = 0;
 }


}

//-------------------------------------------------------------
----------------helpers
```

```
void lightLED(int pin){
 //////////////////////////////
 //Turn on LED on pin "pin" for 250ms
 //////////////////////////////
 Serial.println(pin);

 digitalWrite(pin, HIGH);
 delay(250);
 digitalWrite(pin, LOW);
}


void resetReader(){
 //////////////////////////////
 //Reset the RFID reader to read again.
 //////////////////////////////
 digitalWrite(RFIDResetPin, LOW);
 digitalWrite(RFIDResetPin, HIGH);
 delay(150);
}
void clearTag(char one[]){
 //////////////////////////////
 //clear the char array by filling with null - ASCII 0
 //Will think same tag has been read otherwise
 //////////////////////////////
 for(int i = 0; i < strlen(one); i++){
   one[i] = 0;
 }
}


boolean compareTag(char one[], char two[]){
 //////////////////////////////
 //compare two value to see if same,
 //strcmp not working 100% so we do this
 //////////////////////////////

 if(strlen(one) == 0) return false; //empty

 for(int i = 0; i < 12; i++){
   if(one[i] != two[i]) return false;
 }

 return true; //no mismatches
}
```

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