DESIGN OF AUTOMATIC PORTATIVE PIPE ORGAN AS MUSEUM EXHIBIT TARGETED AT YOUNGER CHILDREN

APPLYING CONSTRUCTIVIST AND SOCIAL LEARNING THEORY IN ONLINE MUSEUM LEARNING OPPORTUNITIES

A Thesis Prospectus

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem: Applying Constructivist and Social Learning Theory in Museum Exhibits

Museums are great resources for teaching people. They provide a center for specialized knowledge to be aggregated and distributed to the general public in a digestible format. Good museum exhibits can display artifacts and concepts alongside important context that can be much more engaging than just reading a simple textbook or article. However, more goes into a good museum exhibit than simply displaying an artifact with a relevant caption. The best museums take extra care in how they curate their content in order to guide their patrons mind to learn most effectively. This begs several questions, such as "How exactly does one learn most effectively?", "How exactly does one learn at all?", and "What exactly does it mean to learn something?". None of these have a clear answer, but there are several distinct approaches, called learning theories that have been taken to better understand them. These theories are important because they often serve as guides for how education is structured. Curriculum that is based in one theory will emphasize different types of learning more than one based in another theory. These decisions will be informed based on what the goal of said curriculum actually is, such as focusing on aspects like long-term information retention, critical thinking, applying skills to the real-world, or, ideally, a combination of all of these things (Donaghey & Halpern, n.d.). As we enter an age of new technologies and ever-increasing access to information, applying robust learning theories to prepare ourselves has become more important than ever.

My technical report is about the design and fabrication of a mechatronic portative pipe organ that can be used as an interactive museum exhibit to teach kids music theory in an engaging manner. My STS topic is about how museums apply social learning and constructivist learning theory through online learning activities. Both topics are connected by the overarching problem of how learning theory is applied in museums.

Technical Problem: Design of Mechatronic Portative Pipe Organ as Museum Exhibit Targeted at Younger Children

My team's technical project is to create a mechatronic portative pipe organ to display at the Virginia Discovery Museum in downtown Charlottesville. This project is important as it will provide an good, interactive demonstration of simple musical theory for younger children and will hopefully spark in them an interest in music, math, and technology. A pipe organ is a good choice for this, as it is a novel instrument and the pipes themselves provide a visual connection between the frequency/pitch of each note and pipe lengths. It can also be designed to utilize and display mechanisms, such as valves and bellows, which will ideally be visually stimulating for kids.

The first pipe organ was invented in classical Greece during the 4th century, and although there have been countless iterations of the instrument since, all of them function using the same basic principles (Thomas, 2018). Pipes sit atop a box, called a windchest, that is filled with compressed air fed from a source, typically bellows or an air compressor. When a key is pressed on one of the keyboards (called manuals or pedalboards depending on if they are played by the hands or feet), a valve is actuated to allow air to flow from the windchest through the corresponding pipe, which causes the pipe to "speak" ("How a Pipe Organ Works", n.d.). As stated above, there is countless variation in how these basic principles are accomplished. Pipe organs can vary in size from having only a couple dozen pipes and being able to be carried by hand to having hundreds of pipes capable of emulating an entire orchestra and taking up an entire building's worth of space. Our pipe organ will be unique in that it will be designed to use a micro-controller to play pre-loaded MIDI files and will also be able to accept MIDI input using an electric keyboard. As it is meant to be an educational tool, care will be taken to design it to be visually interesting as well as informative.

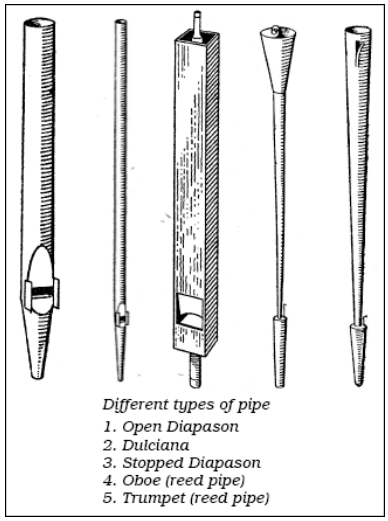

Figure 1: Illustration of different pipe types. Our organ will use Stopped Diapasons (Adams, 2014)

To carry out this project, the first task of my team is to design and produce pipes that can be tuned accurately to the pitches we are aiming for. This will be done by rapidly iterating prototypes of the flues (the bottom whistle part of the pipes) using 3D printing until we reach a satisfying result. The lengths of the pipes themselves will be fabricated by laser cutting wood and then assembling the pieces. The pipes themselves will be stopped diapasons (the center pipe in Figure 1), as they will be easier to tune more precisely than other varieties with our given resources. The organ will only have a range of two octaves, which translates to 24 pipes. The valves controlling the airflow to the pipes will be actuated by small solenoids. These will be controlled by a microcontroller, such as an Arduino) that will be integrated into the organ so it will be able to play MIDI files as well as take MIDI input from a keyboard. Wind will be supplied using two box bellows (Figure 2) for as close to continuous air pressure as possible. These will be powered by a single motor. A pressure regulator between the bellows and the pipes will keep the system pressure constant regardless of changes in air demand caused by pipes opening and closing. Again, if all goes as planned, the final product will be presented in a form that is intuitive for a child to operate, durable enough to handle expected day-to-day abuse, and aesthetically attractive to younger minds. The windchest and bellows will have clear fronts, so that the mechanisms that operate the instrument can be observed from the outside. The biggest constraint to this project is cost. We have a relatively limited budget, so it is very

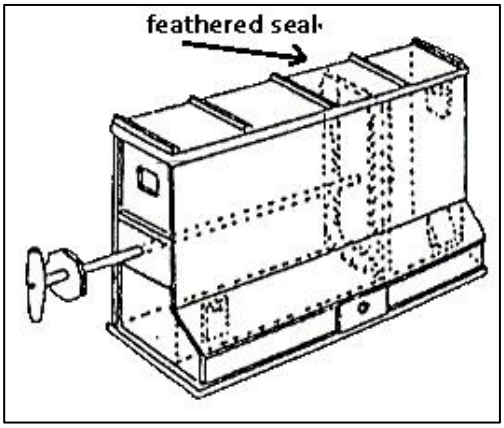

Figure 2: Diagram of Chinese Box Bellows Similar to what will be used to Supply Air to the Pipes (Carr, 2017)

important that we reduce material costs as much as possible. This is especially important with regard to flue and pipe design, as we will be producing 24 of them.

STS Research Problem: Applying Constructivist and Social Learning Theory in Online Museum Learning Opportunities

How are museums using the internet to apply constructivist and social learning theory to their exhibits? As stated above, museums are great resources for people of all ages and knowledge levels to immerse themselves in the accumulated knowledge of those who came before us. Each museum is unique in how they present themselves, depending on what they specialize in, what resources they have at their disposal, and what messages they want to communicate to their visitors. In order to most effectively do this, attention must be paid not only to what patrons are supposed to be learning, but also how they are learning. The definition of learning itself is not a clearly defined one, but there are multiple distinct approaches that have been taken to try and understand it better.

Through most of the 20th century, learning theory was dominated by behaviorism and cognitivism. Behaviorism, which was the first approach to gain popularity, views learning basically as a function of conditioning from repeated exposure to stimuli and reactions from the environment (McLeod, 2022). Cognitivism began to come into prominence due to perceived weaknesses in behaviorist methodology, and it focuses more on learning through the internal analysis of information in one's mind (Kumari, 2022). In recent decades, other theories that have evolved from these two broad approaches have gained traction. Constructivism focuses on the learner itself and their experience over the material to be

learned. Rather than trying to reach an objective truth, it is about creating one's own personal meaning and order out of the vast amount of stimuli that bombards one's senses (Hein, 1992). Social learning theory places great importance on how one learns by observing those around them (McLeod, 2016). It still holds on to behaviorist principles like the reinforcement of stimuli and responses, but it also accounts for the cognitive processing of information about the environment, as well as how different factors can affect how information is retained (Donaghey & Halpern, n.d.).

With the ubiquity of the internet in the current year, human activity has seemingly become irreversibly intertwined with digital media. The ways in and speed at which people interact and communicate has evolved dramatically from even only ten years ago. In order to stay relevant in these ever-changing times, museums must understand their audiences, particularly with regard to these digital proclivities (Chen, Lai, & Yu, 2021). A modern website with up-to-date news and hours of operation is the bare minimum of what is to be expected to be accessible to potential patrons. Many museums have recognized the possibilities that the internet has to offer in relation to providing learning experiences. While controversial to some, virtual galleries and tours can provide a comparable experience to visiting in-person in the comfort of one's own home at any time, and they can even allow visitors to interact with exhibits in novel ways. Without the spatial constraints of the real world, museums can virtually display artifacts that would normally be in storage (Walhimer, 2022). Both recorded and live streams of guided tours and lectures have the potential to reach much larger audiences than a single tour group or auditorium and can even offer new experiences through, for example, collaboration with other institutions. One

notable example of this was a 2017 collaborative livestream between five different museums that showcased five different versions of Van Gogh's *Sunflowers,* which would be a virtually impossible undertaking in the real world (Carlsson, 2020). Combining virtual experiences with online forums can help improve user engagement and foster discussion across the globe (Chen et al., 2021). With the COVID-19 pandemic, even museums slow to adopt online learning activities have been forced to confront the issue of the internet's potential in order to continue to fulfill their role in society ("Facing Challenge with Resilience: How Museums are Responding During COVID-19"**,** n.d.).

This paper will focus on how museums offer constructivist and social learning experience through their online offerings. This paper will draw evidence from a variety of sources to answer the main question. Research papers that directly study learning theories as they are applied by museums both in-person and online will of course be vital, as the results from these can help inform analysis on other sources. Articles describing various online learning opportunities offered by museums will also be helpful in analyzing how they apply learning theories. Additionally, online museum communities both in social media and forums will be explored in order to more deeply understand the social aspect of online learning. Lastly, as these virtual learning experiences can be accessed anywhere, I will explore them myself and use my firsthand experience to judge how the activity allows me to interact with it. This data will then be analyzed from constructivist and social learning perspectives in order to evaluate how museums are applying these theories. For constructivist approaches, the focus will be placed on how the museum establishes ground-level context and understanding of a subject and encourages deeper internal discussion in the learner by, for

example, posing questions and offering different perspectives on a topic. How the learner is allowed to interact with the subject is also of interest (e.g. manipulating an artifact in VR). Evaluation of the application of social learning theory will pay attention to how learners are enabled to engage in social discourse with others in relation to the learning subject. Some examples of this might include granting access to internet forums and participating in the chat/comment sections of video streams. When possible, the efficacy of these application will also be discussed qualitatively, as the lack of an empirical consensus on how to assess these learning theories makes objective judgement practically impossible.

Conclusion

After completing my STS research, I hope to have a much better understanding of how museums are applying online learning emphasizing interactivity with both the material and other people. Through my technical project, I hope to be able to design and manufacture an interactive exhibit that will connect music theory and math while also being visually and audibly appealing to children. Ideally the data compiled and analyzed in this paper will inform future exhibit design, whose effectiveness can then be studied to be further refined. As our understanding of learning continues to grow, it can be applied to improve the education of future generations.

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