DESIGNING INTERACTIVE ACTIVITIES AT THE SWISS
SCIENCE CENTER TECHNORAMA

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Abstract

Science education has changed substantially due to a better understanding of how the subject is learned. Specifically, giving learners hands-on activities retains their attention on the topic. As a result, interactive science centers, like the Swiss Science Center Technorama, were developed to give people an opportunity to explore science. Technorama’s vision is to create a hands-on environment that encourages visitors’ self-exploration of the exhibits. To enhance the experience, the team developed an interactive activity comprised of challenges that encouraged visitors to interact with the exhibits in more depth. To determine its effectiveness, the team assessed the visitors’ interaction with the exhibits and with one another as well as the time they spent at the exhibits. The data gathered demonstrated an increase in these parameters, which illustrates the benefit of the challenge activity for Technorama.
Executive Summary

The Swiss Science Center Technorama is a hands-on science center located in Winterthur, Switzerland. With over 500 exhibits and over 200,000 visitors annually, Technorama attracts individuals from all over Switzerland and even other European countries. With such a large exhibition, visitors often think that they must interact with the exhibits quickly, so they can see the entire science center in one day. Thus, a problem that Technorama faces is that many visitors are not exploring the exhibits in enough depth to fully experience the science concepts and phenomena that are being presented. This project will address and attempt to fix this problem by implementing activities within a section of the science center that encourage visitors to explore the exhibits in more depth, even if it means they may not see the whole exhibition in one visit.

To address this problem best, the team identified and researched four topics that provided a background for the work to be done: science education, other science centers, interactive exhibits, and museum activities. These helped guide the decision making throughout the project’s implementation.

Over the past few decades, science education has changed greatly, both in terms of teaching methods and ways of learning. Exposing students to informal environments, such as a science center, when they are learning science keeps them focused on learning and engaged in the material. This is also true when elements of play are incorporated into science education. These elements are often experienced in science centers like Technorama, which create a more interactive environment for visitors to enhance their science experience. Another example is the Exploratorium in San Francisco. The science center developed multiple interactions and entry points for its exhibits, which allow visitors to actively participate and interact with them.

At museums like these, interactive exhibits must delicately balance telling visitors how to interact and allowing them to discover this themselves. The goal of these exhibits is to convey information to a visitor in an engaging manner. To attract visitors and keep them interested, an exhibit should be exciting and provide a little bit of guidance, so visitors will be more willing to experiment with it and see what can be learned. To keep their visitors engaged, many science centers also rely on worksheets that include interactive activities and guided tours. Although worksheets and guided activities are not something Technorama wishes to implement, these methods still helped the team develop its own activity for the science center.

During the seven weeks spent working at Technorama, the team was able to complete the overall project goal and objectives. Various Technorama staff members were interviewed about their opinions regarding visitors’ interaction with the exhibits in the Mechanicum section and improvements to the experience. Additionally, the team conducted observations to see how visitors interact with four exhibits in this section as well as with one another. Using the observations and interview data, the team brainstormed and developed an interactive activity comprised of challenges that were posted at the chosen exhibits, as can be seen in the picture below. The challenges varied in difficulty and were designed to help visitors notice the multiple ways they can
interact with the exhibits. After the first version of the activity was implemented, a series of development cycles followed, in which the team observed visitors’ interactions and made changes to the activity as needed. Once the final version of the activity was implemented, visitors were directly surveyed about their experience at the exhibits, and if they believed they fully explored them.

**Challenges Pasted to the Podium of an Exhibit**

Using the observations data collected during the implementations of the activity, the team also discovered some trends about visitors’ interactions and behavior at the exhibits. By comparing people who read the challenges and people who did not read the challenges, the team recognized that readers tend to spend more time at the exhibits and interact in more different ways than non-readers as illustrated in the graph below. Other data showed that readers tend to interact with the exhibits in more complex ways and complete actions that visitors who did not read may not have considered when they first encountered the exhibits. Additionally, there was a clear trend of visitors in groups interacting more with each other, both by talking to each other or by showing each other how to interact with the exhibits, in the presence of the activity. One consistent trend found is that across all the versions of the activity, children and teenagers tend to read and attempt the challenges much less than young adults, adults and families.
At the end of the project, the team left all materials used in the various versions of the interactive activity with its sponsor. These materials included the laminated papers on which the challenges were displayed at each exhibit, the posters made for the Mechanicum sections that notify visitors of the new implemented activity, the signs that indicate that there is a challenge at an exhibit, and the symbol designed to represent the team’s challenge activity.

The team also created a guide that explains a simple process to determine if an exhibit is suitable to be accompanied by challenges. This guide is meant to assist Technorama staff in the creation of new challenges in the science center as well. Lastly, the team provided some suggestions that the science center can use to expand the interactive activity developed to larger groups, specifically school groups.
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1. Introduction

The Swiss Science Center Technorama, pictured in Figure 1, is the largest out-of-school learning institution for the sciences in Switzerland. Technorama is “designed for self-directed discovery, comprehension and understanding” of different scientific phenomena and encourages exploration of science (Technorama, n.d-a). As one of the biggest science centers in the world, Technorama has many exhibits that visitors are eager to see. Trying to visit all exhibits, however, makes it challenging for visitors to experience science phenomena at a deeper level. Therefore, Technorama wishes to develop a method that would help visitors explore exhibits in more depth and encourage them to interact with one-another.

![Swiss Science Center Technorama](image)

**Figure 1: Swiss Science Center Technorama**

Since the science center emphasizes undirected exploration and discovery, there is little guidance provided for the public to help them spend time interacting with single exhibits, or exhibits of related topics, and share ideas with each other. The science center already attempted to address this issue by providing students with worksheets to help them understand the exhibits. However, this approach had an adverse effect since the worksheets reminded students of schoolwork and did not allow them to discover the exhibits freely, diminishing their interest in exploring the science center. Carrying a pen and paper prevented students from interacting with the hands-on exhibits. Being able to develop a solution to these dilemmas would allow Technorama to successfully implement their vision by helping visitors interact with one another and explore the exhibits in more depth.

Prior to arriving at the project site in Switzerland, the team conducted preliminary research to better understand how to approach and eventually propose a solution to the challenge that Technorama faces. Science education incorporates self-exploration and hands-on experiments that allow individuals to delve into the subject which science centers and museums play an integral part in. People who visit museums more frequently and for longer periods of time, retain the information taught much better than those who visit museums rarely and, or for a short amount of time (Falk et. al., 2016). This finding is applicable to science education in schools; as more students utilize out-of-school experiences, it is important for them to continue participating in classroom
activities that are linked to the science exhibits they observed in the science center. The activities completed after visiting a science center are important because they allow students to think about the exhibits again and apply what they learned (Anderson et al., 2000). Without these activities, it is easy for students to forget what they learned, and their experience will have little to no impact on their understanding of a topic. Although part of the mission of many science centers is to enable visitors to create memorable experiences, they also focus heavily on providing students with the ability to learn and experience new science concepts.

These findings provided necessary information about science education and the positive effects of hands-on learning, which helped the team develop interactive activities for the Swiss Science Center. They also focused on ways in which visitors interact with exhibits and how these interactions can be observed and evaluated. Additionally, the research included information about three science centers that are like Technorama and the activities they provide to visitors, which helped the team brainstorm its own ideas for the project.

While in Switzerland, the team’s goal was to design, implement and evaluate interactive activities that help visitors in the Swiss Science Center Technorama further explore the concepts presented by several exhibits. To accomplish this, the team observed the visitors’ interactions with the exhibits and one another and recorded the amount of time they spent at each exhibit, which helped establish a baseline for the research. It was important to understand the visitors’ current behavior, so the museum activities could be designed accordingly. To understand various perspectives, the team also surveyed managers and staff to collect their opinions on visitor interaction and experience at the science center.

The work the team did at Technorama was meant to have a positive impact on the visitors’ overall experience at the science center. Instead of attempting to see the whole museum in a day to interact with every exhibit, the activity will encourage visitors to spend more time interacting with fewer exhibits. In this way, they will take away more information about the underlying science concepts and feel less rushed as they go through the museum. The visitors can also share this experience with others, as the activity fosters communication. People who visit Technorama in groups will help each other complete the activities at the exhibits with demonstrations and discourse. This can help visitors feel a sense of gratification and accomplishment for discovering something new by delving deeper into the exhibits. The activities can also help develop a motivation to learn in visitors of all ages, especially kids who normally just come to play with the exhibits. This curiosity for self-discovery can also be applied in other aspects of everyday life.
2. Background

This chapter introduces the Swiss Science Center Technorama, explains how the visitor experience could be improved and discusses science education and the role interactive exhibits play in it. It describes research that has been conducted about other museums, the interactive elements they implemented, and notable characteristics of exhibits that can apply to the project. Additionally, the chapter discusses various interactive activities implemented in other education centers and how these can influence the team’s work.

2.1 Sponsor Description

The Swiss Science Center Technorama is a hands-on science museum in Zurich, Switzerland, that aims to give individuals the environment and tools necessary to learn more about science phenomena. Each year, the 7,000 square meter facility, with its 120 employees and over 500 unique exhibits, attracts more than 280,000 visitors from across Europe, 60,000 of whom are schoolchildren (Technorama, n.d.-a). The vision of Technorama is to give people the opportunity to appreciate and explore science in the best way possible. The science center believes that it “awakens in the public a curiosity, understanding and enthusiasm for scientific phenomena as well as a healthy questioning attitude” (Technorama, n.d.-a).

The science center is also geared towards providing teachers training in the principles of science education, so they can expose students to the subject while they are still young. Although these resources are available for everyone, Technorama focuses its outreach to primary schools, since that is when students are generally first exposed to science education. The unique experimental and laboratory resources provided by the center complement school curricula by allowing students to apply what they learned in the classroom in an interactive environment. Technorama is organized into categories of exhibits that correspond to specific fields of science, including Light and Vision, Mathemagics, Mechanicum, Current and Magnets, Water, Nature, Chaos, and The Sound of Wood (Technorama, n.d.-b). This gives visitors the ability to focus on specific areas of science each time they come to the museum, which makes visits somewhat structured and prevents them from being too overwhelming. This approach also encourages people to return to Technorama and explore different realms of science each time they visit to, eventually, develop a cohesive understanding of the subject.

Technorama’s history began as early as 1947 when an organization was established for the foundation of a technical museum in Switzerland. Potential exhibits, mostly from Winterthur, Zurich, and Baden, started to be collected. On June 26, 1969, a foundation was established under the name Technorama der Schweiz (Technorama of Switzerland), with the intention of setting up an exhibition that would permit the public to explore different scientific areas. In 1982, the exhibition opened as a conventional technological museum with a large amount of verbal material in the form of an audio-visual “superstructure”. In 1990, Remo Besio, the former director of the foundation, adopted a new model, inspired by the Exploratorium in San Francisco and the
Exploratory in Bristol, England. Using a collection of reports and evaluations from the American Association of Science and Technology Centers (ASTC), Frank Oppenheimer, an American physicist, and Richard Gregory, an English psychologist, developed the concept of Technorama (Technorama, n.d.-c). With the help of the German educator Hugo Kükelhaus, Technorama of Switzerland was converted from a classical technological museum into a science center with hands-on and stimulating exhibits. These changes were very popular, as reflected in the high number of visitors, shown in Figure 2. Similarly, Technorama also attracts visitors from every part of Switzerland, Germany and other countries as seen in Figure 3. In 2012, the science center was refurbished and expanded. The laboratory area was divided into seven laboratories: two for chemistry, two for biology, two for physics and one studio, which became a multifunctional workspace. In 2016, Technorama welcomed a record of 281,427 visitors, and, for the first time, the museum was open on Mondays year-round (Technorama, n.d.-c).

![Number of Visitors (since 2011)](image)

*Figure 2: Number of Technorama’s Visitors Annually from 2011 to 2017*
2.2 Science Education

The Swiss Science Center Technorama heavily focuses on giving students within Switzerland the opportunity to learn more about science and develop an interest in the subject. Therefore, it is very important to address the current state of science education, investigate effective ways of teaching science, and research factors that influence how students learn best.

2.2.1 Current State of Science Education

The way science is being taught, and the understanding of how students learn most effectively, has changed over the past decades. Most recently, researchers and educators found that providing students with an informal environment in which they can learn and experiment with science is an effective method of allowing them to grasp new concepts. This teaching method can also be applied to adults. Most notably, families with young children who are trying to learn and explore science phenomena are most impacted by this learning style. When a family attempts to explore science, all members ask each other questions, which stimulates the learning of all individuals involved (Kanhadilok and Watts, 2014-a). Given the inherent inquisitive nature of science exploration, this type of interaction can give groups the ability to connect through science regardless of age.

Along with informal approaches to science education, integrating a level of play into learning is also effective when trying to keep young adults and children engaged. Playfulness keeps people engaged in an activity and incorporating this into education will encourage participation and have a profound impact on what the participants gain from it (Kanhadilok and Watts, 2014-b). Over the past five to ten years, the number of students studying science at a high level and the desire for young people to learn science has been consistently decreasing (Braund and Reiss, 2006). Researchers Martin Braund and Michael Reiss believe that this is due to the uninteresting, irrelevant and outdated science curricula around the world that only grab the attention of students.
already interested in science and fail to encourage new students to study the subject (Braund and Reiss, 2006). They determined that these programs could be improved through out-of-school experiences. Current science laboratories in schools are very restrictive, and they do not motivate students to learn more. Out-of-school experiences, like visiting a museum or science center, give students a change in environment that is needed to engage and urge them to learn more about science at a higher level (Braund and Reiss, 2006). Given the current state of science education and how it is changing, the team will design interactive activities for the Swiss Science Center Technorama with these changing aspects in mind.

2.2.2 Educational Experience in Museums

Many areas of science education that are rapidly changing can be improved by incorporating visits to science centers and museums into science education curricula. A very important study regarding the connection between science museums and people’s understanding of science concepts was conducted using 6,089 people, in 17 communities, and throughout 13 countries (Falk et. al., 2016). This study was a unique international study that showed that the impact of science centers on science education is profound and widespread throughout the world. Nonetheless, the process of learning even a single concept in science can take a long time and cannot possibly happen in one day. People who visit museums more frequently and for longer periods of time retain the information taught much better than those who visit museums rarely and/or for a short amount of time (Falk et. al., 2016). This finding is applicable to science education in schools; as more students utilize out-of-school experiences, it is important for them to continue participating in classroom activities that are linked to the science exhibits they observed in the museum. The activities completed after visiting a science center are important because they allow students to think about the exhibits again and apply what they learned (Anderson et al., 2000). Without these activities, it is easy for students to forget what they learned, and their experience will have little to no impact on their understanding of a topic.

Museum-based learning is not the same at every museum. Professor Eugene Matusov and educator Barbara Rogoff identified four unique ways that museums, in general, approach educating their visitors. The first, and most obvious, method is transmission of information. This is the most common way for museums to teach their visitors, and it consists of a tour guide directly explaining a topic. The second method is solo discovery which occurs when an individual or small group guide themselves through the museum and learn primarily through observation. In this method, the responsibility to learn is placed on the learner. The third approach is a transfer of control over the curriculum, which is a combination of the two previous approaches. The educators first define the curriculum, activities and task. Afterwards, the learners are responsible for engaging and asking questions about the curriculum presented (Matusov and Rogoff, 1995). While this is a way to involve both educators and learners, it is only effective if there is engagement from the learners. The final and most effective approach to science education involves a community of learners (Matusov and Rogoff, 1995). In this approach, both the educator and learners are active in building and structuring the curriculum. The educators are responsible for guiding the process
while the learners are responsible for participating and managing their own learning. In this approach, it is common for learners who already have some knowledge on the topic being discussed to occasionally take the role of educator and teach the group. This final approach gives the class the ability to hold an in-depth discussion on a topic that can be facilitated by an expert. This can then be brought back to the classroom and expanded upon using post-visit activities that connect back to the visited exhibits.

Within Technorama, two of these types of learning are present; the most prominent one is *solo discovery*. When visitors come to Technorama, they are expected to experience the museum on their own or within the group they came with. The second, but less prominent learning style that is present in Technorama, is the *community of learners*. On each floor at Technorama, there are a few staff members who know the exhibits very well and can help someone who may be struggling. They will give them different ideas on how to interact with an exhibit without blatantly showing them what to do. However, due to the inability to have a staff member at each exhibit, the most common approach to learning at Technorama is *solo discovery*. In general, museums are a very effective method of teaching, and science centers specifically can help people understand very abstract and confusing concepts.

### 2.3 Other Science Centers

Unlike traditional science museums where scientific artifacts are displayed in collections for the public to see, science centers like Technorama place greater emphasis on a hands-on approach to science education. There are similar organizations around the world, some of which acted as inspirations for Technorama’s transition from a traditional science museum to an interactive science center. This section will present several notable science centers around the world and the programs they offer.

#### 2.3.1 Exploratorium

Founded by Frank Oppenheimer in 1969, the Exploratorium in San Francisco, California is one of the largest and most visited science centers in the world (Exploratorium, n.d.-b). Additionally, it is one of the two science centers that Technorama was modelled after (Technorama, n.d.-c). At the Exploratorium, there are around 650 interactive exhibits available for the public to see and these are divided into 6 galleries with the following themes:

- **Tinkering:** interactive exhibits about physical science: physics, engineering, etc.
- **Human Phenomena:** exhibits about human psychology, social behaviors and feelings
- **Seeing and Listening:** exhibits about light, vision, sounds, hearing
- **Living System:** exhibits on biology and other living organisms
- **Outdoor Exhibits:** exhibits on natural phenomena like wind, tides, etc.
- **Observatory:** exhibits about history, geography and ecology of the Bay Area (Exploratorium, n.d.-c)
Inside each gallery, the exhibits are further divided into sections. Each of these sections focuses on one small area of science: electricity, magnetism, psychology, etc. This type of grouping aims to provide visitors with different choices on the breadth of subjects they want to focus on, from a subject like physics to a very particular phenomenon like how magnetic fields are created. These exhibits are also designed in a way that encourages visitors’ engagement and holds their interests (Exploratorium, n.d.-c).

With the vast number of exhibits at the Exploratorium, a way of instructing visitors about optimizing their visit had to be determined. This was done through the Active Prolonged Engagement (APE) method, the result of a four-year project funded by the National Science Foundation. This project aims to change the way people think and approach interactive exhibits by turning them from “passive recipients of information to active participants in the exhibit experience” (Humphrey & Gutwill, 2005). The project developed 30 exhibitions under its model that proved to have a positive effect on visitors, helping them attain a more hands-on experience at the Exploratorium (Exploratorium, n.d.-a).

Various strategies were used in developing these APE exhibits. Developers studied phenomena with a variety of interactive and manipulatable components that yield different end results. They designed exhibits so that multiple individuals can interact with one simultaneously. This was accomplished by creating various entry points to the exhibit and providing activities for those who are not directly in control of it. The project developers also determined that visitors tend to seek answers and be more engaged when exhibits do not provide direct explanations. Therefore, the objectives of the activities at the Exploratorium are clearly stated in the exhibits’ titles and small hints are provided visually at each exhibit (Exploratorium, n.d.-a).

While this project was underway, observations were made on visitors’ interactions with the exhibits, and the interactions showed signs of positive engagements: “[Visitors] spend more time and seem more involved with [APE] exhibits than with other types of exhibits. They “ask their own questions, and use the exhibit to pursue answers, without relying fully on the authority of the museum” and they “talk to one another or give other indications that they are practicing scientific process skills such as inquiring, exploring, playing, observing, or contemplating” (Humphrey & Gutwill, 2005). Elements of APE can potentially be implemented into Technorama’s existing exhibits. The team’s activity can allow people who are not directly interacting with the exhibits to still learn something by observing others, as well as provide many different possibilities of interactions with the exhibit for visitors without directly explaining what to do. An activity like this will create more compelling sets of exhibits and greatly improve the quality of visitors’ interactions with them.

2.3.2 Boston Museum of Science

Another large-scale science museum the team researched was the Museum of Science in Boston. The museum was originally established as the New England Museum of Natural History, mainly devoted to collecting, researching and displaying natural specimens. In 1951, the natural history
museum was converted into a museum representing all areas of science, with both displays of scientific artifacts and interactive exhibits (Museum of Science, n.d.-d).

Along with its permanent exhibits and guided tours, the Museum of Science provides drop-in activities throughout the day. Visitors can participate in these programs during scheduled times and stay if they would like to. These programs vary daily and each of them focuses on a certain theme, subject or phenomenon. One of the most popular programs is the Investigation Station, a short session where children are encouraged to think like a scientist (Museum of Science, n.d.-c). With the guidance of museum staff, students have the chance to directly conduct experiments on a scientific phenomenon, ask questions, gather evidence and look for answers. Another interesting program is the Design Challenge, where children can learn the basics of different engineering disciplines and implement them to design solutions that solve real-life problems. Children are encouraged to work in groups and with an instructor to design, build and test their own ideas (Museum of Science, n.d.-a).

One unique program that the Museum of Science offers is the Overnight Program. Children and accompanying adults can register and take part in this program, which takes place from 6:30 P.M. to 11 A.M the following day. During the Overnight Program, visitors can participate in instructor-led experiments, watch scientific documentaries, and see a lightning or a planetarium show (Museum of Science, n.d.-e).

These programs have played an important part in improving the museum experience by creating an interactive play-and-learn environment where children can discuss ideas with their parents, instructors, or other children. This gives them a better understanding of what they learned during their visit and encourages social interaction. Programs like these can greatly benefit big science centers like Technorama, as organized activities focus visitors on a smaller section of the exhibitions, leading to better and deeper exploration of a subject matter.

2.3.3 Deutsches Museum

The Deutsches Museum (German Museum) in Munich, Germany is the world’s largest museum of science and technology. Opened in 1903, the historical museum has been through many phases of renovation and expansion. Currently, the Deutsches Museum has exhibitions and collections that span 50 different areas of science and technology (Deutsches Museum, n.d.-a).

The museum has its own education and research department that is responsible for developing different guided tours depending on the visitors’ demands. Due to the number of exhibits and science areas inside the museum, many tours on different subjects are available. One example of tours currently offered is the Inventor’s Trail, in which students learn about famous inventors and their creations. Original objects are displayed, and students can participate in interactive exhibits to learn how these objects work (Deutsches Museum, n.d.-b). Another tour is aimed at senior citizens, which is “designed to awaken and deepen their appreciation in science and technology”. During this tour, visitors can look at the history of technology and the advancements that have been made over time (Deutsches Museum, n.d.-b).
Preventing visitors from being overwhelmed by the scale of the science center and the number of exhibits is one of Technorama’s goals. The tours available at the Deutsches Museum are good inspirations which can help the team with the brainstorming process. Bigger groups of visitors can also book and tailor tours according to what they wish to see to explore the exhibits better and in a more focused way.

2.4 Interactive Exhibits

A good interactive exhibit draws the attention of viewers to engage them, and its content is entertaining enough to keep them interested. The exhibit lets visitors make discoveries about a certain topic on their own but gives a little bit of guidance to make that process occur faster and ensure that they fully understand a topic. The next section will describe some interactive exhibits that demonstrate these characteristics.

2.4.1 Successful Characteristics of Interactive Exhibits

Although there are many kinds of interactive exhibits, collectively, they share one unifying characteristic. These exhibits are built with the intent of teaching a lesson by allowing people to make discoveries for themselves, whether this may be uncovering items from a sandbox, wiring up a circuit, or playing a game. Visitors cannot simply learn the information that an exhibit tries to portray by simply approaching and observing it. They must be able to take an active role in learning by participating in activities related to the exhibits.

Being engaging and drawing visitors’ attention is also an important characteristic for an exhibit. Flashy technology, such as a large illuminated display, makes visitors want to approach the exhibit. However, if the exhibit employs too much “technological novelty” visitors will likely spend too much time playing with the exhibit as opposed to paying attention to the results of their interactions and learning valuable information from them (Sandifer, 2003).

A common way to determine which exhibits are the most interactive and appealing is by recording the amount of time visitors spend engaged in the exhibit. This is not a direct indicator that visitors are learning the lesson taught by the exhibit; instead, it shows that the exhibit has drawn and kept their attention (Boisvert, 1995). If visitors spend a few seconds looking at an exhibit and then walk away, it can be concluded that the exhibit was not interactive, but it did succeed in attracting one’s attention. If visitors spend a fair amount of time at the exhibit, then it can be determined that the exhibit is likely well designed (Boisvert, 1995). With more detailed observation, one can analyze exactly what an exhibit is successful at achieving. If visitors stand near an exhibit for quite a while simply pondering a topic, then the exhibit may not be necessarily interactive, but it does allow individuals to think about a certain idea. A truly successful exhibit makes an impact on the visitors’ learning (Boisvert, 1995). The team will use the amount of time spent by visitors at exhibits as one metric to measure the effectiveness of the activity implemented for Technorama.
2.4.2 Effect of Interactive Activities on Learning

Many studies, such as the ones described below, have shown that letting students perform experiments or participate in interactive activities greatly enhances their comprehension and interest in the subject being studied. Regardless of the subject matter, students who can perform hands-on experiments have a better experience than those who watch a teacher perform the tests or those who simply read a description of the experiments in a textbook. In a study conducted by Nina Holstermann, lectures and experiments performed by teachers were described by the students as “boring”, while independent lab experiments were considered “exciting”. In both situations, students are exposed to educational material and are learning, but experiments and interactive activities motivate them to pay more attention (Holstermann, 2009).

Some examples of activities that people can individually interact with and explore come from a museum in Limerick, Ireland. In the Hunt Museum, Luigiana Ciolfi, a researcher from Sheffield Hallam University, conducted a study; visitors were observed to determine how they interacted with exhibits that allowed them to inspect objects more closely than the traditional art-on-wall exhibits. One of the test exhibits in the study was the “Cabinet of Curiosities,” which was a glass-faced cabinet filled with drawers that visitors were free to open and inspect closely (Ciolfi, 2002). Visitors, however, were not allowed to touch the actual artworks found inside the drawers. This setup was slightly more interactive than a normal exhibit, which visitors only approach and look at. The “Cabinet of Curiosities” is different from an exhibit that can only be viewed and not interacted with since it encourages a sense of exploration and curiosity.

Another exhibit, aimed towards a younger audience, was composed of a set of large sandboxes in which objects were buried. The task was to discover the location of the hidden items, excavate them, and guess the time-period from which the objects originated. The children who wished to participate in the activity were not left entirely unattended; museum staff guided and taught them proper techniques to gently remove the sand from and around the objects. The children enjoyed receiving some form of instruction as well as the ability to pretend to be archaeologists on their own. This exhibit was received well by children, who learned, yet had plenty of fun (Ciolfi, 2002). The team can utilize some of the findings from this study in this project. Instead of having a staff member describe an activity for certain exhibits, the team could include simple instructions, such as a video or written aid, which would be easily implementable and illustrate how to complete a certain task. Visitors do not always know how to use an exhibit the first time they see it, and they may need additional assistance.

2.4.3 Teaching Visitors How to Approach Interactive Exhibits

Part of the team’s project goal is to help visitors explore the lessons presented in the exhibit they are observing. If they cannot understand how they are meant to approach exhibits, visitors will not be able to fully experience the concepts the exhibit covers, which is a problem that Technorama is experiencing. A previous attempt at helping visitors analyze and understand exhibits was known as the “Inquiry Games,” which was run by Professor Sue Allen and the director of research at the Exploratorium, Joshua Gutwill. This activity focused on two main portions of scientific inquiry:
proposing a question and interpreting the results of the experiment performed. If visitors are not actively thinking about the exhibit during their interaction with it, they might miss important details, or not fully investigate the concepts it shows. After visitors complete the activity at the exhibit, they can compare their original thoughts and questions about the information presented with the answers they found and other questions they proposed in the meantime (Allen & Gutwill, 2009). In the project, visitors can be helped by guiding their thought processes in some way before, during and after they explore an exhibit.

Worksheets may be one method of achieving this since a well-defined worksheet can structure how people think about the science concepts behind an exhibit. However, a worksheet can also be too open-ended if it only asks what visitors think and does not provide any guidance. This might result in visitors becoming confused and not wanting to continue completing the worksheet. However, if the worksheet gave hints and asked for specific answers to smaller questions, visitors would be more inclined to use it (Krombaß & Harms, 2008). Worksheets also occupy the formerly free-to-interact hands and can be inconvenient to the visitor. Perhaps the idea of paper worksheets could be implemented in a different format, such as on a mobile device, which can be quickly stowed in a pocket or within the exhibit itself. For more examples of interactive exhibits, the following sections discuss other museums and what activities they implemented.

2.5 Guided Activities

Museums and science centers have become increasingly popular attractions. For this reason, the individuals who manage them are continuously looking for more interactive and engaging ways to ensure that their visitors have a meaningful experience. Since this is also what Technorama wishes to achieve, researching approaches that have already been used will provide the team with a better understanding of how to design its own activities.

2.5.1 Museum Tours

Today’s technology-driven world has led to the incorporation of various devices into many aspects of daily life, including museum visits. Museums started to utilize mobile devices to guide visitors through vast arrays of exhibits. The National Museum of Natural Science in Taiwan, one of the largest in the country, welcomes over 3 million visitors per year (Chou, n.d.). Since no two visitors are alike, the museum uses a Semantic Web technology, which contains information about the museum’s exhibits and layout as well as the visitors’ interests and location. Museumgoers are exposed to this technology at the beginning of their visits when they are given a personal digital assistant (PDA), which they carry along during their tour. The PDA asks visitors several questions whose answers will be used in designing a customized tour of the museum. Based on interests, location, time available and previously seen exhibits, the device can also suggest additional exhibits for the user to see along with the exhibits’ ratings and locations (Chou, n.d.). The PDAs ensure that visitors are led on customized tours, ensuring that their museum experience is enhanced. With the opportunity to focus on topics of interest, they will likely enjoy the exhibits more. The devices can also suggest times that visitors can spend at each exhibit, which can also
encourage them to observe exhibits more closely. These ideas can also be implemented at Technorama, where visitors can be encouraged to spend more time and explore the science concept presented at several exhibits in more depth.

As observed at the National Museum of Natural Science in Taiwan, technology can be beneficial. Nonetheless, it can also have some downsides. Similarly, museum visits are also popular across Europe, where up to 52% of the population visits a museum at least once a year (Wessel, n.d.). Since museumgoers are constantly moving, the use of a small, portable, personal technology device can help enhance the experience of the visit. However, a disadvantage of this feature is the inability to display a great amount of information on a small screen. Additionally, such devices are generally made for one user, which may prevent interactions among visitors who arrived at the museum in a group. This lack of collaboration between individuals also inhibits the sharing of information, and thus decreases the sharing of knowledge. Mobile devices are also believed to distract visitors from fully observing the exhibits. However, instead of causing a distraction, the devices can supply visitors with additional information about the exhibits that may not be present on the displays. With the ability to connect to the internet, mobile devices have unlimited access to information that may interest the visitor. The biggest challenge of this feature though is organizing the available information and verifying its validity. Though Technorama does not wish to create a customized tour for its visitors, the team can take these findings about incorporating technology into the museum experience into consideration during the design phase of the project.

2.5.2 Demonstrations

Many museums have shifted towards incorporating self-guided tours for their visitors. However, others have tried a different approach by using stories narrated by staff members to promote visitor engagement. Stories are believed to provide museumgoers with a new perspective of the exhibits and it encourages them to develop their own interpretations and feelings (Burdelski, 2016). At many museums, stories are told through audio recording and self-guided tours. However, studies suggest that human inclusion also enables interactions. At a Japanese American museum, staff members share “we-focused” and “I-focused” stories to the visitors (Burdelski, 2016). These narratives focused on the personal stories of Japanese Americans and families who were relocated and incarcerated during World War II. The stories gave visitors a unique perspective on Japanese American history and allowed them to actively participate in the tours by asking the storytellers questions. They also enabled individuals to appreciate experiences described by the staff, thereby helping them gain a better understanding of history.

With a similar goal in mind, the Oregon Museum of Science also decided to use its staff to improve the museum experience. However, instead of being storytellers, staff members were asked to assist with interactive activities and suggest goals that promote critical thinking. Research concluded that visitors generally enjoy engaging with museum staff and that the presence of staff increased their satisfaction and time spent at exhibits (Pattison, 2013). Although some studies suggest that staff members may interfere with a visitor's exploration of an exhibit, it was found
that staff-visitor interactions with adult groups were longer and included more beneficial conversations for the adults (Pattison, 2013). This is because staff members were able to integrate visitor interest and prior knowledge into discussions, which prompted families, specifically, to engage in more conversations in which they shared new information with one another (Pattison, 2013). Although staff mediated exhibits and activities are not something that Technorama specifically wishes to implement, these studies highlight the positive impact of collaboration on the museum experience. When designing interactive activities for the science center, the team can incorporate group discussions that can help visitors delve deeper into the exhibits they are interacting with.

2.5.3 Designing Guided Tours

With the necessity for some form of guidance through museums exhibits established, the subsequent task is to determine how visitors will be guided through their tours. Eager museumgoers often wish to see all exhibits in a museum. Thus, they tend to become overwhelmed and tired as they see more displays. In addition, popular exhibits tend to attract the attention of many visitors, leading to hyper-congestion. To solve these issues, researchers thought of designing various paths which visitors can follow that are tailored to their interests. To establish these paths, a proximity sensor system was installed throughout a large-scale museum in Italy. These proximity devices were used to display the visitors’ location in the museum and the time spent at each exhibit (Germak, 2013). The data collected was used to detect popular areas where hyper-congestion may be an issue and to observe the types of exhibits most commonly visited. Additionally, a questionnaire was distributed to visitors, asking about their personal interest towards a museum collection, understanding of an exhibit display and overall satisfaction. The museum intended to use the findings to establish museum pathways and specific tours that can be suited to different visitors depending on their interests (Germak, 2013). Although this approach used an advanced technological approach to design self-guided paths, the ideology behind the methods used could be applied to the team’s project at Technorama.

A similar study focused on the use of interaction geography to interpret the visitors’ interactions and conversations with each other and to analyze their movement at a renowned museum in southern United States (Shapiro, Hall & Owens, 2017). With the use of interaction geography, the authors observed that galleries, which are often arranged in a linear fashion, do not allow for wide ranges of movement. On the other hand, exhibits located in open spaces encourage movement and interactions between museumgoers (Shapiro, Hall, & Owens, 2017). This method also enabled the authors to study the often-sporadic movement of children. While many might infer that a child’s quick, random path throughout the museum indicates a lack of focus, personal interviews with the visitors indicated that many children often move from place to place because they have a question about a topic of interest to them that needs an immediate answer or because they are eager to share what they discovered (Shapiro, Hall, & Owens, 2017). Since Technorama’s emphasis is on undirected exploration, the data collection methods presented can be used when
the team observes visitors interacting with the exhibits; the team can determine any trends in which visitors approach exhibits or if certain exhibits are more interactive and popular.

2.5.4 Foxtrail Tour

Although not offered in museums, a guided tour currently available in Switzerland is the Foxtrail tour, which is a unique treasure hunt offered in 10 different destinations. In every location, there are various trails that individuals can follow to chase “the Fox”, an imaginary character that created the paths. Each of the Fox’s paths incorporates different tasks and messages, which need to be solved to receive a clue that will provide directions to the next destination (Foxtrail, n.d.). Groups complete these treasure hunts once they are provided with the necessary documents, tickets, a mobile phone and the initial instructions for arriving at the assigned trail. Teams need to rely on collaboration, ingenuity and skills to finish the tour, and since all trails are unique, no clues and messages are identical (Foxtrail, n.d.). This experience helps develop team-building skills and creates closer relationships among team members. Given its popularity in Switzerland, it is likely that the public is familiar with the structure of the Foxtrail tour. The implementation of a similar type of activity in the Swiss Science Center could be beneficial; the Foxtrail tour encourages teamwork and is an engaging and enjoyable way for individuals to visit and explore several well-known landmarks.

2.5.5 Interactive Museum Activities

Various museums and science centers already offer self-guided activities that help visitors enhance their museum experience. The Museum of Fine Arts in Boston offers a variety of interactive worksheets for children and families with activities pertaining to different exhibit collections. For instance, visitors are provided with directions to the Art of the Americas Wing as well as galleries within it. They are also given quick facts about the exhibits in each gallery followed by questions that can be answered after observing the exhibits. The worksheet includes interactive activities for children to complete during the visit, such as creating their own designs after seeing those displayed in the gallery. Likewise, a post-visit activity is also included, which is designed to be completed at home (Museum of Fine Arts, n.d.).

The Connecticut Science Center also provides worksheets that complement their exhibits to help teachers convey important lessons to kids of different ages. One worksheet that targets children in kindergarten asks them to complete tasks, draw what they observe and write additional questions they might have. This worksheet focuses on tornadoes; the exhibit has kids drop balls into a water vortex and observe how quickly they are sucked into the middle of the vortex. The next part of the exhibit has them step into a “Tornado Booth” that blows air at a high velocity. The children can experience how the wind blows their hair and clothes, and the worksheet instructs them to do this activity in pairs, so they can discuss and draw what they experience (Connecticut Science Center, n.d.).

The Museum of Science in Boston provides activity sheets for field trips that educators and chaperones can use or customize to their liking. Some examples of field trips that the museum
provides are Animal Adaptation, Dinosaurs and Fossils, and the Earth in the Solar System. Each field trip aims to focus students on a specific science theme. Each activity sheet has a map highlighting where the relevant exhibits are located on the museum’s floor plan. After finishing each field trip, students will receive a worksheet where they can write down three concepts, experiences or exhibits that they enjoy, draw or describe things that they learn about the field trip or that they found interesting, and write one thing that they want to learn more about. Depending on the type of field trip, there are also design challenges, group discussions and play-learning, as well as other types of activities (Museum of Science, n.d.-b).

Similarly, the London Museum of Science has many different types of activities that utilize their science exhibits. Their activities reach all age levels and their format ranges from paper documents to games that teach science concepts. Their museum activities, like the Electrifying Electricity Trail and the Exploring Space Gallery Introduction, give visitors a qualitative learning experience regarding science. The Electrifying Electricity Trail is a list of exhibits with corresponding activities which give visitors an in-depth experience with electricity (Science Museum Group, n.d.-a). The Exploring Space Gallery is a video tour linked with an exhibit which gives visitors an understanding of space which is something that may be difficult to grasp yet is presented in a way that people can understand (Science Group Museum, n.d.-b).

These activities give a reference to see how other successful museums are run and how the project’s activities can be formatted. Although providing visitors with worksheets has been one of Technorama’s concerns, the team can still reference the interactive activities outlined in the various worksheets provided at the museums mentioned. When brainstorming ideas for the project, the team can utilize concepts from these worksheets to create an activity for Technorama that will help visitors self-explore the exhibits in more depth and interact with one another. These aspects can be incorporated in forms other than worksheets, which will not prevent Technorama’s visitors from interacting with the exhibits or force them to carry papers and writing utensils.

After conducting this preliminary research, the team gained a better understanding of the way science education is taught and the importance of interactive components in learning environments. Additionally, studying museums and science centers like the Swiss Science Center Technorama as well as discovering how visitors can be engaged and intrigued by interactive exhibits will allow the team to learn more about how museumgoers act. Lastly, becoming familiar with interactive activities that have already been implemented at other museums and science centers enabled the team to develop a way to gather the data needed for this project and brainstorm ideas for some interactive activities that could be implemented at Technorama.

### 2.6 Summary of Background

Technorama focuses a lot of time on tailoring it exhibits to school groups and science education. Given this, the team thought it would be valuable to have an in-depth understanding of the current state of science education and how science is taught, specifically, in museums. Over recent decades, science education has changed greatly, primarily due to the better understanding of how
students learn science. Traditional lecture-style teaching is often considered boring and struggles to keep learners attentive and focused. Rather, researchers and educators have found that putting students in informal environments when teaching science keeps them engaged and helps them learn the content. A larger part of learning science is being able to touch, feel and experience the different topics; a lecture style of teaching doesn’t accomplish this. Also, incorporating an element of play keeps people not only focused on the topic at hand but engaged and interested, sometimes without them even realizing it.

One way in which an educator can incorporate both an informal environment and an element of play into their teaching is by utilizing science centers, like Technorama. Bringing a class here makes the students excited to learn and will keep them engaged with what they are learning more effectively than a school classroom or lab. However, visiting the science center is not where the learning stops. For the visit to be useful, the teacher must connect his or her classroom teaching back to the museum so that the concepts are remembered.

Looking at different science centers and science museums around the world gave the team a good perspective of what activities they offer to visitors. These activities will help the team brainstorm its own activity that aligns with Technorama’s visions. For instance, the Exploratorium in San Francisco developed the concept of Active Prolonged Engagement (APE), giving different ways for visitors to interact with an exhibit and actively receive information. By implementing APE into their exhibits, the Exploratorium creates an engaging and interactive experience for its exhibits and encourages communication between visitors, helping them learn not only from the science center itself but also from each other. Both the Boston Museum of Science and the Deutsches Museum have their own versions of activities that can help visitors explore and understand the concepts on a deeper level. Boston Museum of Science provides drop-in activities throughout the day which give visitors the flexibility to explore a subject in-depth whenever they want. Deutsches Museum provides visitors guided tours through part of the large exhibition that can be tailored to the visitors liking. It is very important for these science museums and science centers to give visitors freedom of choice instead of a rigid, classroom-like guidance.

The interactive exhibits section details qualities of exhibits the team would like to incorporate into the activity, and describes some example exhibits from other museums. A good interactive exhibit teaches the visitors a lesson by allowing them to experiment by themselves. If the exhibit tries to explain the lesson from start to finish, the visitor will become bored. Being able to participate in the exhibit is what keeps them interested and attentive. For science teachers, it is better to arrange an experiment that students can complete themselves, instead of the teacher performing the experiment for them, in front of them. This way the student makes the discovery themselves which sticks a lot better than just watching someone else’s discovery. Another important quality to have in an exhibit is the ability to draw in visitors. They can accomplish this by being flashy, but if they are too flashy then that can distract from the learning process.

Another key to ensuring a good experience at an interactive exhibit is guiding visitor thought and actions at the exhibit. If visitors approach an exhibit that has no instructions, they may
not fully explore it or learn everything it has to offer. If visitors are guided in certain directions this can shorten the amount of time they spend simply trying to discover how the exhibit works. If some questions were proposed to them, they can immediately begin thinking about answering those questions.

To better understand how a museum activity can be developed, the team researched ways in which other museums are helping their visitors interact with exhibits. Using technology to create more engaging museum experiences has become a popular tactic since technology plays a major role in everyday life. Museums can use personal assistant devices (PDAs) to gather information about visitors and create tours tailored to their liking.

Like the use of technology, museum staff can also help visitors have a more engaging museum visit. Their knowledge about the museum and its exhibits can help visitors gain a more meaningful understanding about what they are seeing during their visit. In addition to incorporating technology and the help of staff members, many museums provide younger visitors with activity sheets that they can use to explore the exhibits in more depth.

Although used in outdoor settings to help individuals explore various sites, a Foxtrail tour is also an engaging activity that encourages teamwork and collaboration. These aspects, along with the excitement of completing a scavenger hunt, are characteristics which can be applied to an activity in a museum setting.
3. Methodology

The goal of the project is to design, implement and evaluate interactive activities in the Swiss Science Center Technorama that will encourage visitors to explore exhibits in more depth and interact with one another. To accomplish this goal, the team developed the following objectives:

- **Objective 1:** Assess how visitors interact with exhibits as well as each other and survey them about their experience exploring the exhibits.
- **Objective 2:** Brainstorm and develop activities for the Mechanicum section that encourage visitors to explore the exhibits and interact with other individuals.
- **Objective 3:** Implement the developed interactive activities.
- **Objective 4:** Evaluate the effectiveness of the implemented activities.

This section will provide a detailed outline of the team’s plan to accomplish these objectives. The implementation of this plan and the interactive activities will be discussed in Section 4, and the data collected during the implementation phase will be shown and analyzed in Section 5.

3.1 Objective 1: Observing Visitors’ Interactions and Assessing Museum Experience

To gain an understanding of how individuals spend their time during a museum visit, the team recorded how visitors interact with certain exhibits in Technorama’s Mechanicum section. The project sponsor, Dr. Armin Duff, suggested focusing on this section since it contains many exhibits with interactive components that are generally well known among visitors. The team focused on the following exhibits: Ball in a Bowl, Rodeo Gyroscope, Rope Squirter, and Pendulum Cradle. These exhibits were chosen because there are many ways in which individuals can interact with them. Likewise, some of them are simple to understand right away, while others require additional guidance until a visitor can fully know how the exhibit functions. This was a beneficial combination for the interactive activity since the goal was to help visitors explore exhibits in more depth.

Using the Google Form survey (Appendix A), each team member recorded visitors’ interactions with the exhibit and one another at one of the exhibits selected. Since the concept of engagement can be quite abstract, the team specifically looked for hands-on interactions with the exhibits, such as pushing buttons to start a process, moving objects, observing and indicating to a visual aid (Walliman, 2006). Once this initial data was collected, the responses were transferred to a spreadsheet created on Google Drive where the information was stored, saved and analyzed.

Observing both individuals and groups was efficient and beneficial for the project because it allowed the team to notice how a variety of visitors interact with each other at exhibits, since encouraging visitors’ interaction with each other is another goal of the implemented activities. There is no specific demographic group that the activity is geared towards, so gathering data from
all types of visitors was helpful. Having one team member focus on a specific exhibit also enabled the data collection portion of the project to be as efficient as possible.

To successfully design and eventually evaluate activities that helped visitors interact with the exhibits for a longer period and explore the scientific concepts they teach, the team surveyed Technorama’s visitors about their experience interacting with the four exhibits listed previously. To accomplish this, a Google Forms survey (Appendix B) was created. The survey was finalized after the activity was developed to ensure that the impact of the activity is clear, and the questions are relevant to it. That way, the pre-activity survey results could be comparable to the post-activity survey results. This survey was translated into German and displayed on tablets.

The team also conducted face-to-face interviews with Technorama’s staff to gauge their opinions on how visitors explore the science center. These were standardized interviews since they were based on structured questions (Appendix C). Asking interviewees the same set of questions was beneficial because the answers were comparable (Berg, 2007). Interviews may encourage the staff members to share more information than they would in a self-reporting handwritten survey. Most of the staff at Technorama speaks English, which allowed interviews to be conducted without a translator.

### 3.2 Objective 2: Brainstorming and Developing Interactive Activities

After conducting preliminary observations and interviews, the team started the process of brainstorming and developing multiple interactive activities to consider implementing. To brainstorm effective activities, the team first addressed and evaluated all the interview data and observations collected in the first objective. The team focused on developing activities primarily for the four exhibits selected from the Mechanicum section of the museum. However, the team also created a basic framework for the activities that will allow Technorama to expand the activity idea to different sections of the museum after the project is completed.

When brainstorming, the team either developed new ideas that had not been considered before or combined some of the ideas researched to create the best solution for Technorama. The team spent one week brainstorming possible activities and created three to five activities that could be implemented at the science center. The team followed a few guidelines to have successful brainstorming sessions. The first was to focus on the number of ideas rather than the quality. If quality ideas were expected, some team members may have felt that an idea they had was not good enough and thus not share it. However, focusing on quantity rather than the quality eliminated that problem. The second guideline was that no ideas were to be criticized and all ideas were welcome. Ideas that seemed infeasible at first were very beneficial because they helped other people think of feasible ideas that would not have been thought of otherwise. Finally, the team expanded on previous ideas and combined multiple good ideas into a great one (Feinberg & Nemeth, 2008).

Before arriving in Switzerland, the team brainstormed several activities (Appendix D) that could be implemented. After visiting the museum, a few of these activities were further developed so they became more concrete. The team then compared what each activity had to offer and
addressed the areas where they can be improved. Narrowing down these activities with an unbiased approach was important so that the options that were best suited for Technorama were selected, and not the activities the team liked best. To do this, the goals and objectives of the project were referenced to guide the decision-making process in selecting an activity. The final step of this process was to discuss the final activity with the staff at Technorama. Given the staff’s feedback, the team made a few minor alterations to the final activity to better fit in with the environment of the exhibitions at the science center.

3.3 Objective 3: Implementing the Developed Activities

After brainstorming several ideas for possible activities, the team selected one interactive activity and started the process of implementing. A detailed week-by-week schedule that specified when the activity was going to be introduced, and roughly when improvements and changes were going to be made, was established. As mentioned in Objective 1, suitable survey questions were created to compare the visitors’ experience before and after implementing the activities. Based on the information received, the team made necessary changes and improvements to the activity. Once the necessary changes and improvements were made, the next version of the activity would be implemented. This prototyping process lasted for approximately two weeks. The goal was to have three different iterations of the activity. If the team would have noticed that the activity is initially not well received by those participating in it, data collection for an unsuccessful activity would have been halted. Instead, the collected data would have been used to determine what improvements could be made so that the activity benefited and enhanced visitors’ museum experience.

This process allowed the group to present Technorama with one well-designed and well-tested activity that can be used and expanded on by the science center. Prior to implementing any activity, Technorama’s staff was asked to help establish the schedule mentioned previously to ensure that the implementation process did not interfere with the operation of the science center. Technorama’s staff were informed about the interactive activity so they could help visitors interact with the exhibits if needed. After the activity was implemented, the team started evaluating its effectiveness.

3.4 Objective 4: Evaluation of Implemented Activities

After implementing each version of the interactive activity, the team evaluated it to see if it achieved the goal of the project. The data collected was analyzed to determine if the visitors’ museum experience improved. As performed in Objective 1, data about visitors and how they interact with exhibits was recorded again. The same methods outlined previously were used to collect this information: the team observed visitors as they visit the Mechanicum section and participate in the implemented activity using. An updated observation form (Appendix E) was used that included some questions about the implemented activity. Additionally, visitors were asked to complete an anonymous survey (Appendix F) about their museum experience when the activity was present.
Once this data was collected, it needed to be analyzed. The team separated the responses from each question into two categories: one with the data before the activity was implemented and one with data after. Unfortunately, the team was not able to survey the same visitors twice over the course of the project, so the visitors compared were different. However, this did not cause major issues when analyzing the data.

Finally, once all data was collected, the team organized it in a way that displayed any trend or relationship that might exist. Over the course of the project, the team did not collect any personal data through the surveys and interviews conducted. The surveys did not ask for a name, phone number, or any other information that could identify the subject. The visitors’ responses to the questions on the survey also did not contain any information that could have been used to identify them since the questions did not ask for any personal details.
4. Implementation

This section describes the process of designing and implementing activities in the Mechanicum section of Technorama. It includes information about interviews with Technorama staff, the brainstorming sessions conducted to develop activities and the surveys that were used to collect information about the visitors’ interactions and experiences at several exhibits.

4.1 Interviews and Brainstorming

To develop the most effective activity for Technorama, the team relied on the responses received from Technorama’s staff in several interviews. This provided insight on the perspective of individuals who have worked at Technorama for longer periods of time or who have seen visitors’ interacting with the exhibits daily. The interviews (Appendix C) consisted of several questions mainly focusing on the exhibits that attract visitors and keep them engaged and the ones that have difficulty retaining their attention. To obtain a comprehensive idea about the exhibits, individuals in different positions at Technorama were interviewed. Once the interviews were completed, the team reviewed the responses gathered and noted major takeaways and similarities in the staff’s answers. This enabled the team to design activities that helped visitors spend more time at a specific exhibit to fully explore the scientific phenomena presented.

4.2 Data Collection Methods

To determine the type of effect the interactive activity had on visitors, the team decided to observe visitors while they interacted with exhibits and survey them to gather their opinions after the interactions. The initial set of surveys and observations acted as a control since the data was gathered before the activity was implemented for the first time. With each version of the activity, the team conducted a new set of observations to detect any changes and find ways in which the activity could have been improved. After the final version of the activity is implemented, the team conducted both the surveys and observations again, so the data can be compared directly. These various data sets helped illustrate major changes in how visitors interact with the exhibits.

4.2.1 Observations

To record observations of visitors at the exhibits in an efficient and organized manner, the team utilized a Google form (Appendix A). In the observation form, some questions focused on the demographics of the visitors: their approximate age, whether they are visiting alone or in a group and what kind of group they are visiting in. Other questions focused on the visitors’ interactions at the exhibits. After personally interacting with the exhibits, the team chose a few different common and uncommon interactions that visitors can try at each exhibit and included them in the Observations Form. When conducting observations (Figure 4), the team recorded which interactions the visitors completed. The amount of time visitors spent at the exhibit and whether they interacted with others or not was also recorded.
The amount of time spent at each exhibit and the types of interactions visitors have with the exhibits and with each other helped the team design an effective activity that can encourage individuals to explore the exhibits in more depth. Additionally, by observing how visitors communicate with one another, the team was able to develop activities that will encourage discussions about the exhibits and interaction among individuals. Thirty observations were recorded for each exhibit, for a total of 120 observations. All observations made were automatically recorded in a Google spreadsheet, where the team was able to extract and evaluate data. These same observations were carried out after each version of the activity was implemented.

While the various versions of the activity were implemented, the team continued to observe visitors interacting with the exhibits. The visitor observation form mentioned previously was used again to determine if visitors spent more time at the exhibits, if they interact with those around them more and if they spend more time exploring the exhibit. An additional three questions, seen in Appendix E, were included in the observation survey so the team could record if visitors noticed and tried the activity and if they appeared to enjoy it. This data was compared to the data gathered prior to the implementation of the activity to see if there were any changes in the visitors’ interactions with the exhibits and with each other.

4.2.2 Surveys

To collect the visitors’ opinions about the exhibits, the team used a Google survey (Appendix B). Visitors were surveyed before the implementation of the activity and after the implementation of the final version of the activity. In the survey, visitors were asked if they enjoyed the exhibit, if they understood it, and if they thought they had done everything the exhibit has to offer. By asking
these questions, the team hoped to see a general trend between the pre and post activity surveys, in that visitors should enjoy the exhibits more because they have completed the activity that invited them to explore the exhibits in more depth.

While conducting the surveys, the team wore Technorama shirts so that visitors were aware of the association with the science center. Directly after visitors finished interacting with an exhibit, two team members asked them if they would like to complete the anonymous survey about the respective exhibit, which was displayed on a tablet. The team chose to present visitors with the survey after they completed interacting with an exhibit so that the visitors were more likely to remember their opinions about the exhibit.

Initially, the team planned to survey visitors about their experience after each version of the activity was implemented. However, due to a language barrier and a lack of visitor interest in answering these questions, the team decided that it would be most efficient and feasible to only conduct these surveys once the final version of the activity is implemented. Thus, after visitors completed the final activity version that was implemented, they were asked if they would like to participate in an anonymous survey (Appendix F) about their experience completing the activity. The first three questions in this survey were identical to the questions asked in the visitor survey mentioned in Section 4.3.1. The same questions were asked so that the team can easily compare the visitors’ experience interacting with the exhibit. The team hoped to see that the visitors’ enjoyed the exhibits more, clearly knew what they could do at each exhibit, and were able to interact with the exhibit in more depth. Two additional questions, seen in Appendix F, that focus specifically on the team’s activity were included so that the visitors’ experience interacting with the activity implemented was helpful.

To obtain more survey responses, the team decided to invite other groups completing their Interactive Qualifying Projects (IQPs) in Switzerland to Technorama. These groups were treated identically to the other Technorama visitors: they were observed as they interacted with the exhibits in the Mechanicum section and then they were asked to complete the two surveys that asked them to reflect on their experience at the exhibits with and without the activity present. Three groups (10 individuals) were able to visit Technorama.

### 4.3 Implementation of Activities

The activity that the team implemented consisted of a series of challenges for four exhibits selected from the Mechanicum section: Ball in Bowl, Rodeo Gyroscope, Rope Squirter and Pendulum Cradle. At each exhibit, there were two to three challenges of varying difficulties (easy, medium, and hard) that encouraged visitors to interact with the exhibit and one another in new ways. This section will describe the process of developing the challenges and the multiple versions of the implemented activity.
4.3.1 Challenges

To create the challenges for each exhibit, the team interacted with the four exhibits used in the activity and observed how visitors interact with them as well. When observing visitors, the team noticed that most visitors tend to interact with the exhibits in simple ways; they either read the instructions and follow the directions listed, or they do not read the instructions and interact with the exhibit as they deemed appropriate. By personally exploring the exhibits in depth, the team was able to spend time thinking of innovative ways to interact with them so that the challenges can present possibilities of interaction that are not mentioned in the instructions.

After interacting with the exhibits, the team discussed ways in which the challenges should be presented to the visitors. Since Technorama wishes to allow its visitors to freely explore the museum and not provide them with too much guidance and directions, it was decided that the challenges should be worded as questions. This way, visitors have the choice of reading them if they choose to. To ensure that the challenges were understandable, the team asked some Technorama staff members to attempt them. These individuals stated that they enjoyed completing the challenges and provided some suggestions that helped ensure that the wording of the questions is clear. Once the wording was changed, the same staff members were asked to read the questions again and provide any additional feedback. All individuals stated that the questions were understandable.

The challenges, written as questions, were designed to show visitors the possible ways they can interact with the exhibits without directly instructing them to complete a series of tasks. When visitors read the questions, they would hopefully become eager to answer them. If the visitors were at the exhibit in a group, the individuals present would likely want to work together to answer those questions. Likewise, if one visitor from a group can complete the challenges, he or she would feel self-gratification and be inclined to share their newfound knowledge with others. The challenges were translated into German. The team decided that it is not necessary to translate the activities into more languages (French and Italian) so that the challenge displays does not become too lengthy and difficult to read. Additionally, German and English covered most of the demographics that came to the science center. Prior to implementing the first version of the activity, the team informed Technorama staff members about all changes made to the exhibits in the Mechanicum section. Below are the challenges for the four exhibits followed by the four versions of the activity. In the implementation of the different versions, the questions describing the challenges were not modified since the team and Technorama staff agreed that they were clearly written. Changes were made only to the display of the challenges.
Challenges

Easy: Can you get the small ball to rotate as fast as you can parallel to the ground?

Medium: Can you get the small ball to rotate without you touching the bowl?

Hard: Can you get the small ball to rotate diagonally and as close to vertically as possible inside the bowl?
**Figure 6: Rodeo Gyroscope Exhibit**

**Challenges**

Easy: Can you get the exhibit to rotate without sitting on the chair

Hard: Can you move your partner who is sitting on the seat up and down, without touching your partner or the seat? Your partner must sit still.
Challenges

Easy: Can you make the balls on the left and the right swing simultaneously?

Medium: Can you make the balls swing in such a way that the middle ball is always in motion?

Hard: What would happen if you release a different number of balls from the two sides simultaneously?
Figure 8: Rope Squirter Exhibit

Challenges

Easy: Can you get the rope inside the ring using your hand? Hint: You are allowed to grab the rope.

Medium: Can you get the rope inside of the ring using the rod?

Hard: Can you get the rope inside of the ring by only using the ring?
4.3.2 Version One of Challenge Activity

In the initial version of the activity, the challenges were printed, laminated, and posted on the existing podium next to each exhibit, replacing the current set of instructions. The display of the challenges on an exhibit’s podium can be seen in Figure 9. The challenges on the other three exhibits were displayed in this same manner. The team believed that placing the challenges on the podiums would be fitting since visitors tend to look for instructions if they are unsure about an exhibit. Although the exhibit instructions on the podium were hidden, there were still hand-held copies of the instructions present at each exhibit, so visitors could read those too if needed.

![Figure 9: Placement of Challenges on Exhibit Podium](image)

Once data from the first version of the activity was gathered and analyzed, the team brainstormed ways to improve the activity. After making the necessary changes to the first version of the activity, the second version was implemented, and the same process was followed. A total of four versions, described below, were created.

4.3.3 Version Two of Challenge Activity

While conducting observations for the first version of the activity, the team noticed that many visitors would simply approach the exhibits and begin interacting with it; they did not read the information on the podiums, and therefore did not read the challenges. The team did not consider this as a possible issue until the data collected during the visitor observations reflected that many visitors did not read the challenges. To solve this, the team decided to display the same challenges on a larger piece of paper and hang them above the exhibits so visitors would be more likely to notice them. An example of the setup, which was kept the same for all four exhibits, can be referenced in Figure 10. Additionally, with this change, visitors could interact with the exhibits and read the challenges at the same time instead of taking extra time to read before completing the activity. The papers above the exhibits were also laminated to ensure they are durable, and the
papers used to cover the instructions from the first version of the activity also remained on the podiums.

![Figure 10: Placement of Challenges Above an Exhibit](image)

### 4.3.4 Version Three of Challenge Activity

After observing visitors interact with the second version of the activity, the team realized that many people noticed the hanging challenges but ended up reading the ones that the team kept on the podium. This could have been because the Mechanicum section is not well lit and thus the hanging paper might have been difficult to see. However, the lighting on the podium was much better, making the challenges placed there easier to read. Thus, the team decided to replace the challenges above the exhibits with a sign indicating that the certain exhibit includes challenges. An example of the setup can be seen in **Figure 11**. The same organization was used for all four exhibits.

![Figure 11: Placement of Sign Indicating the Presence of Challenges at an Exhibit](image)
To attract more visitors to participate in the activity, the team created posters, seen in Figure 12, to hang at the two entrances of the Mechanicum section. The placement of these posters at the entrances can be seen in Figures 15 and 16 in Section 4.3.4. These posters notified visitors that there are challenges in this section and encouraged them to look for the exhibits that have them.

![Figure 12: Poster Indicating the Presence of Challenge Activity in the Mechanicum Section](image)

4.3.5 Version Four of Challenge Activity

The alterations of the activity between version three and version four were primarily aesthetics. The team created a logo, illustrated in Figure 13, which represented the challenge activity and replaced the hanging sign that indicated the respective exhibit included a set of challenges.

![Figure 13: Logo Indicating the Presence of Challenge Activity at Exhibit](image)
The logo was affixed to a cord hanging above the podium at each exhibit, as shown in Figure 14, to notify the visitors that there is a challenge at the specific exhibit. The logo reduced the number of words at the exhibit which eliminated the need for further translations.

![Figure 14: Placement of Logo Above Podium at Exhibit](image)

In the fourth version of the activity, the team also changed the hanging posters at the two entrances to the Mechanicum section to be more noticeable and easier to read, as seen in Figure 15. The location of these posters at the section’s entrances can also be seen in Figures 16 and 17. Their placement remained consistent between the third and fourth version of the activity.

![Figure 15: Poster Indicating the Presence of Challenge Activity at Exhibit](image)
Figure 16: Poster Indicating the Presence of Challenge Activity at Main Entrance

Figure 17: Poster Indicating the Presence of Challenge Activity at Back Entrance
4.4 Deliverables

The deliverables for this project included:

- The final version of the challenge activity
- A guide that explains how to select exhibits that will benefit from the challenges
- A list of suggestions to make the challenge activity suitable for school groups
- The Interactive Qualifying Project final report

The activity consisted of challenges, ranging from easy to hard, for four of the exhibits in the Mechanicum section of Technorama (described in Section 4.2). These challenges were displayed next to their respective exhibits which will give the visitors the option to complete them if they wish. After completing a few versions of these challenges, the team provided Technorama with recommendations on how to successfully expand these to the rest of the science center. These were presented in a short guide (Appendix I) describing how to select exhibits that would benefit from the integration of challenges. The team also wrote a set of suggestions, which further described in Section 6.1.2 of the report, about effective ways to connect the challenges to a school group lesson. The final deliverable of the project is this report, which provides an in-depth documentation of the team’s work.
5. Results and Data Analysis

This section describes the two forms of data collected over the course of this project: interviews with Technorama’s staff and the observations of visitors. The interview information describes the perspectives of the science center’s staff regarding exhibits and visitor interactions in the Mechanicum. The visitor observations are analyzed to illustrate relationships observed in the visitors’ interactions with the exhibits before and after the team’s activity was implemented.

5.1 Interviews

To obtain multiple perspectives about visitors’ interactions and behaviors in the Mechanicum section of Technorama, the team conducted interviews with several different staff members. These asked the staff members questions about the exhibits in this section as well as the visitors’ interactions and experiences and ways in which the latter can be improved. The transcripts for the interviews can be referenced in Appendix H.

Initially, interviewees were asked which exhibits had trouble retaining the visitors’ attention in the Mechanicum section and to explain their reasoning behind their opinions. Instead of simply listing the names of these exhibits, staff members described the characteristics of such exhibits. This was most beneficial since these characteristics can be used to detect exhibits across the entire science center. Interviewees mentioned that exhibits that do not display an astonishing phenomenon have difficulty in keeping visitors interested and intrigued. Visitors wish to observe an unexpected and impressive effect at the exhibits that they visit. If such an effect does not occur, or if too much time passes before it occurs, visitors are likely to lose interest in the exhibit and proceed to the next. One of the interviewees stated that an exhibit has only a few seconds to grab someone’s attention.

Exhibits that are too complex to understand or interact with, such as the Double Gyroscope pictured in Figure 18, may also have difficulty retaining visitors’ attention. This exhibit is a perfect teaching tool, as a visitor can make simple adjustments and see how the gyroscope reacts. However, the Double Gyroscope does not have a big element of play in it, like the Rodeo Gyroscope (Figure 6) that can be ridden on. Additionally, if an exhibit has many buttons to push or knobs to turn, visitors will likely have a hard time understanding how to interact with it and will not explore it further. Similarly, some exhibits are meant to be too difficult for the average museumgoer to understand. If visitors cannot make a connection between what they see at an exhibit and everyday life, they might lose interest in that exhibit, especially if they do not wish to read the explanation describing what the exhibit is meant to portray. On the other hand, exhibits that are too simple and not interactive will also have trouble keeping visitors engaged. Although such exhibits are generally more visually appealing, the lack of physical interaction does not allow visitors to spend much time exploring these exhibits.
After speaking about the exhibits that are not as engaging, the team also asked Technorama staff about the exhibits that best attract visitors. Regarding this question, staff members mentioned that exhibits with unexpected results are often the ones that visitors enjoy most; visitors want to experience a new phenomenon and have a memorable experience. On the other hand, exhibits that illustrate phenomena that can occur in everyday life are also well-liked because they are very relatable. Also, they stated that visitors tend to enjoy exhibits that do not rely on lengthy instructions that explain the interactive possibilities. Additionally, exhibits with multiple possibilities of interaction, specifically those where individuals can see others interact, are also greatly enjoyed by visitors.
Table 1: Characteristics of Exhibits from Interview Responses

<table>
<thead>
<tr>
<th>Exhibits that retain visitors’ attention</th>
<th>Display an unexpected result</th>
<th>Present a science concept that is relatable and observed in everyday life</th>
<th>Instructions are concise and easy to understand</th>
<th>Phenomena displayed is observed quickly</th>
<th>Multiple ways of interacting with the exhibit and seeing others interact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhibits that do not retain visitors’ attention</td>
<td>Do not display astonishing phenomena</td>
<td>Science concept presented is too complex</td>
<td>Instructions are difficult to understand</td>
<td>Phenomena takes time to display itself</td>
<td>Interaction is too simple or unexciting</td>
</tr>
</tbody>
</table>

To help the team find ways to encourage visitors to interact with one another more at exhibits, the staff members were also asked if they knew what visitors talk about on their visits to the museum. Many interviewees stated that the topics of conversation vary depending on age and type of visitors. Nonetheless, they also mentioned that visitors often make remarks about the exhibits, especially if they observed something unexpected. Some visitors ask for help if they do not understand the exhibit. Usually, adults will try to explain to kids why a certain phenomenon occurred. Generally, visitors tend to simply show one another how to interact with the exhibits instead of verbally explaining the possibilities of exploration.

Visitors’ conversations at exhibits consist of:

- Remarks about the phenomena at the exhibits
- Parents explaining to children why a certain phenomenon occurred
- Questions and replies about interacting with the exhibit

At the end of the interview, the team asked Technorama staff if they have any suggestions that will help encourage visitors to spend more time exploring exhibits. One staff member mentioned the importance of unguided exploration in the activities designed and implemented for Technorama. Other staff members suggested the idea of designing some questions or challenges that help visitors think more about an exhibit. The suggestion of limiting text at the exhibits was also mentioned since visitors are not usually interested in reading a long explanation about the exhibit interactions.
Technorama staff suggestions to help encourage visitor interaction

- Unguided exploration of exhibits
- Questions or challenges to prompt visitors to think about more interactions with the exhibits
- Brief instructions

5.2 Visitor Surveys

To ensure that the final version of the activity would be enjoyable and beneficial for the visitors, the team also wanted to collect the visitors’ opinions about the exhibits and challenges. The initial approach was to survey visitors before an activity was implemented as well as after each activity version was implemented. However, after attempting to collect the first set of responses, and experiencing how difficult it was, the team opted to only collect responses before an activity was implemented and after the last version was implemented. Twelve visitor responses were collected, three from each exhibit, for each round of surveying. Responses from the surveys were averaged together to create a larger sample size to analyze. However, this data was not used to make critical decisions because the sample size was not large enough.

The pre and post activity surveys had three questions in common. Visitors were asked to rate how much they enjoyed each exhibit on a scale of 1 to 5, with 1 being strongly disliked and 5 being strongly liked. Also, visitors were asked how clear their understanding of the possible interactions at the exhibits was on a scale from 1 to 5, with 1 being very unclear and 5 very clear. As shown in the table below, visitors enjoyed the exhibits whether the activity was present or not. There seems to be a small increase in how clear visitors thought the exhibits’ possible interactions were, which is explained by the presence of the challenges that describe multiple outcomes the visitors can create. Additionally, most visitors thought that there was not much more they could have done at the exhibits whether the challenges were present or not. This may be because those who interacted with the exhibits without the challenges present most explored the exhibits as best as they thought possible. Similarly, those who completed the challenges did explore the exhibits more, so it is also expected for them to believe that there is not more that can be done at the exhibit.

<table>
<thead>
<tr>
<th></th>
<th>Average Exhibit Enjoyment (1-5)</th>
<th>Average Exhibit Clarity (1-5)</th>
<th>Do you think you could have done more at the exhibit? (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-activity</td>
<td>4.4</td>
<td>3.9</td>
<td>11 No, 1 Yes</td>
</tr>
<tr>
<td>Post-activity</td>
<td>4.5</td>
<td>4.25</td>
<td>10 No, 2 Yes</td>
</tr>
</tbody>
</table>
The post-activity survey included two questions that the first survey did not have. Visitors were asked if they enjoyed the challenges on a scale of 1 to 5, with 1 being strongly disliked and 5 being strongly liked. They were also asked how much the challenges helped them interact with the exhibit on a scale of 1 to 5, with 1 being not a lot and 5 being a lot. Originally, if the team surveyed visitors after each revision of the activity, these questions could be compared to each other to see if a certain activity revision was better according to the opinion of visitors.

Table 3: Technorama Visitors’ Opinions about Challenges

<table>
<thead>
<tr>
<th>Average Challenge Enjoyment (1-5)</th>
<th>Did challenges help you interact with the exhibit? (1-5) (Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Since visitors did not show interest in completing the surveys presented, the team decided to contact other Interactive Qualifying Project (IQP) groups and ask if they would be willing to test the challenge activity and complete the surveys provided. Three groups (10 individuals in total) completed the survey which created a reliable dataset in which each person interacted with the exhibit without challenges, then read the challenges and interacted with the exhibit again. Each person completed a survey after interacting with the exhibit without the challenges. Next, he or she completed another survey after interacting with the exhibit with the challenges present. The quick turnaround of visitors and their prior knowledge of the activities means the data is slightly biased. However, the team thought this would be the best way to measure how much impact reading the challenges had because it is nearly impossible to know how much of the challenges each visitor reads.

The data gathered from the surveys the IQP students completed illustrates that their opinions were similar to those of Technorama’s visitors. The IQP students enjoyed the exhibits more and thought that the challenges improved clarity on how to interact with the exhibits. This follows the same trend as the one shown by Technorama visitors’ responses. However, the IQP students’ responses to the final question were different from the responses of Technorama visitors. The IQP students thought they could have done more before trying the challenge activity. After completing the challenges, they were satisfied with how much they had done at the exhibits. The IQP students also enjoyed the challenges and believed that these helped them interact with the exhibit more than Technorama’s visitor. This could be explained by their prior knowledge of the existence of challenges that would tell them new ways to interact with the exhibits.
Table 4: IQP Students Survey Responses

<table>
<thead>
<tr>
<th></th>
<th>Average Exhibit Enjoyment (1-5)</th>
<th>Average Exhibit Clarity (1-5)</th>
<th>Do you think you could have done more at the exhibit? (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-activity</td>
<td>4.1</td>
<td>3.9</td>
<td>33 Yes, 7 No</td>
</tr>
<tr>
<td>Post-activity</td>
<td>4.6</td>
<td>4.5</td>
<td>10 Yes, 30 No</td>
</tr>
</tbody>
</table>

Table 5: IQP Students’ Opinions about Challenges

<table>
<thead>
<tr>
<th>Average Challenge Enjoyment (1-5)</th>
<th>Did challenges help you interact with the exhibit? (1-5) (Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>4.4</td>
</tr>
</tbody>
</table>

5.3 Visitor Demographic Distribution

While the team conducted visitor observations for the different versions of the challenge activity, the visitor demographics at Technorama varied quite drastically. The distribution of the types of visitors observed was inconsistent across the five observations sessions completed as it can be seen in Figure 19. For instance, when no activity was implemented, a large portion of visitors observed were families. However, after implementing Version 4 of the activity, many of the visitors observed were teenagers. This made it difficult to compare the visitors’ interactions when no activity was present to when the last version was implemented.

Each type of group interacts with the exhibits very differently. Groups of young school kids were more likely to come and play with the exhibits quickly and then simply proceed to another exhibit, while a pair of adults were more likely read the instructions and interact with the exhibit more thoughtfully. Because the type of groups varied, the interactions with the exhibits for each observation period were skewed depending on which group made up most of the visitors the team observed in each set of observations. If a lot of school kids were present at the science center, most interactions completed would be easier and less complex. However, if a lot of adults were present when the observations were conducted for a certain version, most of the interactions would be more difficult and complex.
5.4 Results of Visitor Observations

To determine the effect that the challenge activity, the team created graphs that compare several aspects of the visitors’ interactions with the exhibits and one another with and without the presence of the activity. Since the data collected was prone to some error, error bars were included in the graphs. Likewise, to determine the effect that the challenge activity had, the team performed some statistical tests which will be outlined in this section.

5.4.1 Sampling Error

When collecting data, it is often very hard to do so for an entire population; rather, researchers often collect data for a smaller sample of the population and use that to make inferences about the entire population. This idea was evident in this project when observing visitor interactions at exhibits. It would be impossible for the team to gather data for every Technorama visitor, so they collected data for a smaller portion of the visitors to represent the entirety of the visitors. Given that the team only analyzed data for a portion of all visitors, the data collected does not perfectly represent all visitors at Technorama.

Therefore, the team calculated the error for each of the data sets analyzed. For non-continuous data (such as interactions completed at exhibits) a sampling error was calculated. Sampling error only considers a percentage of people who do a given task and the sample size recorded. The equation for sampling error is

$$Z \sqrt{\frac{p(1-p)}{n}}$$

where $p$ is the sample mean (represented as a decimal), $n$ is the sample size and $Z$ is the $z$-value for the corresponding confidence interval (Rumsey, n.d.). An example calculation by the team is as follows.

This is an example for calculating the standard error for the percentage of groups who interacted with each other. From the observations, the percentage of groups who interacted with
each other (sample mean) was calculated to be 81% (p=.81). This average was calculated from a sample size of 202 visitors (n=202). The team calculated the error using a confidence level of 95% thus a z-value of 1.96 was used. Using these values and the equation for sampling error, the sampling error for the percentage of groups who interacted with each other is ±5.4%. Hence, the percentage of groups that interacted with each other was 81% with a 95% confidence interval of 75.6% to 86.4%.

5.4.2 Chi-square Test

The Chi-square test is a non-parametric test used to determine statistical significance between two categorical variables. A categorical variable is a type of variable that can only take on one of a few fixed values; two examples include ice cream flavors and breeds of dogs. The null hypothesis of the Chi-square test states that the two variables compared are independent whereas the alternative hypothesis states that the variables are not independent (McHugh, 2013).

This test must meet the following assumptions:

1. The data used cannot be continuous (such as height, time, length); it must be represented in counts.
2. The categories of the variables must be mutually exclusive (a subject can only be part of one category)
3. The variables must be independent.
4. The expected values of the cells must be 5 or greater.

To calculate the chi-square statistic, the data used must be displayed in a table that includes the independent and dependent variable. Once the tables are created, the first step is to calculate the “marginals”, which are the sum of each row and column. Then, the expected values of each cell must be calculated by multiplying the row and column marginals for the respective cell and dividing by the sample size (McHugh, 2013). The equation for the expected value of a cell is given below.

\[ E = \frac{M_R \times M_C}{n} \]

Afterwards, the chi-square statistic is calculated by summing the squares of the differences between the observed value and the expected value, divided by the expected value. To equation for the chi-square statistic is given below.

\[ \sum \chi^2_{i-j} = \frac{(O - E)^2}{E} \]

To determine the level of significance, the degrees of freedom (df) must be calculated as well using the formula: (Number of rows - 1) x (Number of columns - 1). For the team’s data, all tables will have 1 df and they will be evaluating their data at a significance level of 95%. Thus, for the data to be significant, the Chi-square statistic must be greater than 3.84 (McHugh, 2013). The Chi-
square test is the only test the team used when testing for statistical significance and the results that were found to be statistically significant are indicated by an asterisk (*) in their respective graphs. An example calculation by the team is as follows.

5.4.3 Chi-Square Test Example

One of the exhibits that the team implemented challenges at was the Rope Squirter. At this exhibit, visitors can interact with a moving rope and see how different actions affect its motion. This example will test to see if there is a significant correlation between reading the posted challenges and if a visitor touches the rope with his or her hand.

**Null Hypothesis:** Whether a visitor reads the challenges has no effect on their likelihood to touch the rope with their hand

**Alternative Hypothesis:** If a visitor reads the challenges they are more likely to touch the rope with their hand.

**Table 6: Observed Values of Visitors Who Touched the Rope with Their Hand**

<table>
<thead>
<tr>
<th></th>
<th>Number of visitors who touched the rope with their hand</th>
<th>Number of visitors who did not touch the rope with their hand</th>
<th>Row Marginals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read Challenges</td>
<td>56</td>
<td>2</td>
<td>58</td>
</tr>
<tr>
<td>Did not read</td>
<td>43</td>
<td>19</td>
<td>62</td>
</tr>
<tr>
<td>challenges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Column Marginals</strong></td>
<td></td>
<td></td>
<td>n=120</td>
</tr>
<tr>
<td></td>
<td>99</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

**Table 7: Expected Value of Number of Visitors Who Touch the Rope with Their Hand**

<table>
<thead>
<tr>
<th></th>
<th>Number of visitors who touched the rope with their hand</th>
<th>Number of visitors who did not touch the rope with their hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read Challenges</td>
<td>47.85</td>
<td>10.15</td>
</tr>
<tr>
<td>Did not read</td>
<td>51.15</td>
<td>10.85</td>
</tr>
<tr>
<td>challenges</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The expected value for each cell was calculated using the formula \( E = \frac{M_R \times M_C}{n} \) where \( M_R \) is the Row Marginal, \( M_C \) is the Column Marginal and \( n \) is the sample size. These values can be found in Table 6.
### Table 8: Cell Chi-Square Values

<table>
<thead>
<tr>
<th></th>
<th>Number of visitors who touched the rope with their hand</th>
<th>Number of visitors who did not touch the rope with their hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read Challenges</td>
<td>1.39</td>
<td>6.54</td>
</tr>
<tr>
<td>Did not read challenges</td>
<td>1.30</td>
<td>6.12</td>
</tr>
</tbody>
</table>

The cell Chi-Squared value for each cell was calculated using the equation

\[ \chi^2 = \frac{(O - E)^2}{E} \]

where \( \chi^2 \) is the cell Chi-Squared value, \( O \) is the observed value of that cell, \( E \) is the expected value of that cell, and \( n \) is the total sample size. These values can be found in either Table 6 or Table 7. The Chi-Square value was then calculated by adding all the cell Chi-Square values and \( \chi^2 = 15.35 \).

Given that the degrees of freedom for this example is equal to 1 (\( df = 1 \)), for the null hypothesis to be rejected at a 95% confidence level the chi-square statistic must be greater than 3.84. Since \( \chi^2 = 15.35 \) is greater than 3.84, the null hypothesis was rejected, and the alternative hypothesis was accepted. Thus, it can be stated at a significance level of 95% that whether a visitor reads the posted challenges has a significant effect on the likelihood of them touching the rope with their hand at the Rope Squirter exhibit.

### 5.5 Time Spent at Exhibits

One of the goals for the project was to increase the time that visitors spent at each exhibit and encourage them to explore each exhibit in more depth. The graph in Figure 20 compares the time spent by visitors who read the challenges and visitors who did not read the challenges at each of the four selected exhibits throughout all versions of the activity. The team decided to combine the data from all versions of the activity in to obtain a larger sample size and to observe the effect that the challenges had on the visitors. The x-axis represents the time ranges visitors spent at each exhibit and the y-axis represents the percentage of visitors who spent that amount of time there.

The graph in Figure 21 uses the same data as in Figure 20, however an average for each exhibit was calculated using the midpoint of each time range. This gave the team more information on how the challenges effected time spent at the specific exhibits. After reading the challenges, more people spend a greater amount of time at the exhibits.
**Figure 20: Time Spent at Exhibits**

(The * indicates statistical significance, P < 0.05, by the Chi-square test. Error bars indicate 95% confidence limit by binomial sampling error)

**Figure 21: Average Time Spent at Each Exhibits**

(Error bars indicate 95% confidence limit by binomial sampling error)
5.6 Group Interactions at Exhibits

Another aspect of the project’s main goal was to increase the visitor’s interaction with one another when they visit exhibits. The graph in Figure 22 represents the group interactions the team observed at the exhibits during the four versions of the activity implemented. The group represented by the orange bars illustrates all group of visitors, across four versions of the activity, who have read the challenges at any of the four exhibits at which challenges were posted. The group represented by the blue bars illustrates all group of visitors, across four versions of the activity, who have not read the challenges at any of the four exhibits at which challenges were posted. As stated previously, since the challenges remained the same throughout the various versions of the activity, data from all four versions was compiled to increase the sample size.

The following bar graph illustrates a trend that the groups who read the challenges interacted more than the groups who did not read them. The first bar simply illustrates the groups who interacted, whether that may be by talking, showing each other how to interact with the exhibit, or doing both. The second set of bars represents the groups who talked, once again illustrating that the percentage of those who talked was greater among those who read the challenges. Lastly, the rightmost bars represent the groups whose individuals showed each other how to interact. The percentage of those who read the challenges was also greater in the groups who read the challenges.

![Interactions of Groups](image)

Figure 22: Interactions Between Visitors in Groups

(The * indicates statistical significance, P < 0.05, by the Chi-square test. Error bars indicate 95% confidence limit by binominal sampling error)
5.7 Individual Exhibit Interactions

To assess the effectiveness of the challenge activity, the team also created individual graphs, shown in Figures 23 through 26, representing the visitors’ interactions at each of the four exhibits selected: Ball in Bowl, Rodeo Gyroscope, Rope Squirter and Pendulum Cradle. In the graphs below, from left to right, the interactions are displayed from the easiest to the more challenging ones. The groups compared are visitors who read the challenges and the visitors who did not read the challenges. Data was gathered from all four versions of the activity and included individuals, groups, and families in the samples. A similar trend was observed in three of the four exhibits: the harder challenges were completed more by those who read the challenges created by the team.

At the Pendulum Cradle, the harder interactions with the exhibit were completed more by those who read the challenges. This increase was significant, which illustrates that visitors explored this exhibit in more depth after being presented with the challenges. Regarding the Rope Squirter, those who did not read the challenges did not complete the difficult interactions at all. This exhibit is not as clear as others; generally, visitors do not readily know how they can interact with it.

However, the challenges posted benefited some of the exhibits more than others. As seen in the graphs for the Ball in a Bowl and Rodeo Gyroscope, the differences in percentages between those who read and completed the more difficult interactions and those who did not read were not as high as the differences in the Pendulum Cradle and the Rope Squirter. The harder interactions are not impossible without the challenges, which is a possible reason for this observation. Likewise, it may be easier for visitors to know how to interact with certain exhibits more easily than others. If one an individual spends a longer period exploring the exhibits, it is likely that they can discover how to complete some of the harder challenges, without any additional help.

Another trend observed was that for the Ball in a Bowl, Rodeo Gyroscope and Rope Squirter, some of the simple interactions were completed less by those who read the challenges. Specifically, for the Rodeo Gyroscope, this decrease in the completion of the simple interaction by those who read the challenges was significant. A possible reason for this is that the visitors who read the challenges were eager to complete the challenges and therefore may not have completed the basic interactions.

At the Ball in a Bowl, there is a slight increasing trend that shows those who read the challenges completed the harder interactions more than those who did not read them. However, this increase is not statistically significant. This may have occurred because there is only one way for visitors to interact with the Ball in a Bowl: by shaking the bowl to get the inner ball to rotate. As a result, some visitors, regardless of whether or not they read the challenges, could have completed the easy and hard interactions without guidance.
Figure 23: Interactions of Visitors at Exhibit (Pendulum Cradle)
(The * indicates statistical significance, \( P < 0.05 \), by the Chi-square test. Error bars indicate 95% confidence limit by binomial sampling error)

Figure 24: Interactions of Visitors at Exhibit (Rope Squirter)
(The * indicates statistical significance, \( P < 0.05 \), by the Chi-square test. Error bars indicate 95% confidence limit by binomial sampling error)
**Figure 25: Interactions of Visitors at Exhibit (Rodeo Gyroscope)**

(The * indicates statistical significance, P < 0.05, by the Chi-square test. Error bars indicate 95% confidence limit by binomial sampling error)

**Figure 26: Interactions of Visitors at Exhibit (Ball in a Bowl)**

(Error bars indicate 95% confidence limit by binomial sampling error)
5.8 Reading Challenges

Another trend that was immediately apparent to the team was that there were many visitors at Technorama who were mainly interested in just playing with the exhibits. As illustrated in Figure 27, children would usually rush towards the exhibits that looked the most exciting, play with them for a short period of time, generally less than 30 seconds, and simply make their way to attention-grabbing exhibit. If children were visiting in a small group of friends, they would often crowd around the exhibit, spending a lot of time taking turns completing the same interactions with the exhibit. This affected the data collected, as having a lot of children who did not read the challenges did not help the team determine their effects because they were not read. Older groups, including families, were much more likely to read the challenges. The adults in families would read the challenges and help their kids solve them. Clearly, the challenges did not appeal as much to the younger demographic; perhaps when converted into a group activity for school groups, the teacher can make the challenge activity more appealing for children by organizing them and encouraging them to complete it.

![Visitors who Read and Attempted the Challenges](image)

*Figure 27: Percentage of Visitors Who Read and Attempted the Challenges and their Age*  
(Error bars indicate 95% confidence limit by binomial sampling error)*
6. Recommendations and Conclusions

The following section describes the conclusions reached after the completion of the challenge activity. It also includes recommendations for Technorama that are meant to assist the staff in continuing the work completed during this project. Lastly, the section includes a list of suggestions that can help Technorama staff make the challenge activity a more suitable to school groups.

6.1 Recommendations

This section includes recommendations of how Technorama can continue to develop the work that has been completed by the team. These suggestions include:

- Make the challenge displays more visually appealing
- Survey more visitors, and use the data to make small changes to challenges and display
- Modify challenges to be appropriate for school groups

6.1.1 Improving Current Challenge Activity

Since the challenges were successful in retaining visitors’ attention, helping them spend more time at the exhibits, and encouraging them to interact more with the exhibits as well as with other visitors, the team believes that Technorama can expand this activity to other exhibits in the Mechanicum section as well as the rest of the science center. However, during the implementation of the activity, it was seen that some exhibits benefit from the implemented challenge activity more than others. An appropriate exhibit to add challenges to is one that offers visitors multiple ways of interactions to see an exciting phenomenon. This would retain the visitors’ attention and keep them interested in exploring the exhibit further. Additionally, the interactions at such exhibits should not be obvious, as to allow visitors to discover what they can do.

As seen from our data, an exhibit that benefits from the challenges is the Rope Squirter (Figure 8). This exhibit is very visually interesting; the rope moves fast in unusual ways and displays a very interesting phenomenon. The Rope Squirter is also very physically interactive and dynamic, as visitors can touch most parts of the exhibit that each cause something new to happen. In addition, it is usually not very clear what visitors can do with this exhibit, which is why the challenges were effective. Visitors may not stay at the Rope Squirter for a long time trying to figure out complex actions; this takes some thought and planning because it is so open-ended. Once the challenges were implemented, visitors were given a direction to further explore in with the exhibit.

The team selected two additional exhibits that they felt would benefit from the challenges, which are described below. The team also created example challenges for these exhibits. The Rotating Chair with Electric Double Gyroscope (Figure 28) allows full manipulation of all elements of the exhibit by visitors. The chair rotates freely, and the visitors can control both the speed and direction of each flywheel in the gyroscope they hold. They can manipulate the
gyroscope in space and experience the reactionary torque it produces. With a combination of high flywheel speed and specific manipulation of the gyroscope, visitors can sit in the chair and rotate in both directions, at varying speed. There are multiple outcomes based on what the visitor chooses to do.

The Turntable (Figure 29) is also a very open-ended exhibit. Visitors sit down at a table with a large spinning surface in the middle. Many round objects are provided that can be placed on the table, where they will roll in equilibrium. Based on how the visitor sets them down, these objects can be made to travel from one end of the spinning surface to the other under their own power. Visitors can also place one object inside another and get both to rotate. Because there are so many options, visitors can discover different possibilities with the exhibit.

![Figure 28: Rotating Chair with Electric Double Gyroscope](image)

Challenges

Easy: Can you use the electric gyroscope to spin in the chair?

Medium: Can you spin at two different speeds only using the gyroscope?

Hard: Can you get yourself to not spin while holding the gyroscope vertically?
Figure 29: Turntable

Challenges

Easy: Can you get a cue ball to spin inside of a spinning wheel?

Medium: Can you get a thin wheel to roll?

Hard: Can you get a rollerblade wheel spinning inside a small wheel which also spins inside a big wheel?

Many exhibits at Technorama cannot facilitate deep exploration. These exhibits are very simple, and their main premise is to show a single science phenomenon. Many have a single knob to vary the strength of a certain effect and do not allow any further exploration. Visitors may not be able to touch the inner workings of the exhibit to alter its behavior.

The collected data shows that Ball in a Bowl (Figure 5) is an exhibit that does not significantly benefit from the addition of challenges. This exhibit is usually the first one that many people see when they enter the Mechanicum section and, since the section is so large, they try to interact with the Ball in a Bowl as quickly as possible and ensure that they have enough time to see the remaining exhibits. Also, this is a straightforward exhibit so many people might think they already know what to do and end up not reading the challenges. This can cause the exhibit to lose the visitors’ attention quickly, and thus make the challenges less effective.

Another way that Technorama can implement the developed activity is to use challenges as part of a bigger activity, which can possibly be aimed at school groups. The data analysis presented in Section 5.7 showed that younger visitors, such as children and teenagers tend to not read the challenges. To make the challenges more attractive for younger audiences, the team recommends changing the general appearance of the papers on which the challenges are displayed, by making them more visually appealing and eye-catching. Displaying the challenges with pictures instead of written questions might also attract the attention of these younger audiences more.

Due to a language barrier and little time available, the team did not obtain a desired number of responses for the visitors’ survey. However, Technorama can utilize these surveys to gather
more feedback in the future. Although the team was not extremely successful in obtaining many survey responses, with more time and resource, the science center could collect more responses. The science center can display the surveys on iPads near the exhibits they wish to collect data for. Since the surveys are very brief, it would not take a long for visitors to answer them. The surveys are worthwhile because they would enable Technorama to gather feedback from the visitors, which can help improve the interactive activity implemented.

6.1.2 Expanding Challenges Activity to School Groups

Technorama’s interactive elements and ability to display science concepts in an exciting and entertaining way attract numerous school groups to the science center. The team’s sponsor, who is responsible for the didactics of Technorama, wishes to present the activity developed during this project to future school groups. Therefore, the team decided to provide several suggestions that can help Technorama’s staff modify the activity implemented so that it becomes suitable for larger groups.

While conducting visitor observations at the science center, the team noticed students in many of the school groups that came carried worksheets, though it is unknown whether these were provided by Technorama or their instructor. Since school groups generally place more emphasis on learning from the exhibits in the science center, the team believed it would be beneficial to incorporate an element of learning in the challenge activity.

If Technorama chooses to add challenges to other exhibits, they can ask teachers what main science concepts students are being taught in school and then provide a list of exhibits, accompanied by challenges, that correspond to them. During the visit, students can interact with these specific exhibits, complete the challenges and explain why a certain phenomenon happened using their prior classroom knowledge. Depending on the age of the student group, Technorama staff can provide questions of varying difficulty and complexity levels.

These questions can easily be displayed in the form of a worksheet. However, since Technorama wishes to find other ways of keeping visitors engaged, the staff can also set up iPad stands near the exhibits that display the questions. Each student can be given a code that corresponds to his or her name, which will indicate the individual who answered the questions. At the end of the visit, the teacher can be provided with all the students’ responses.

Often, when students visited the science center in school groups, they carried cameras or phones to photograph or video record the interactions at the exhibit. Another way to make the challenge activity applicable to a school group is to divide the large group into groups of three to four students, each with a designated group leader. After the group collaborates to discover how to complete all the challenges, the group leader can photograph or videotape other members successfully completing or even just attempting, the challenges. After visiting all exhibits with challenges, the group can show the videos to their teacher and they can receive a reward for their work. This suggestion would be most suitable for teenagers (13-18 years old) since one student in each group would need a camera or a phone.
For school groups composed of younger students, the challenges at the exhibits can be presented in forms of pictures so they can be understood. The teacher or adult is responsible for the group can observe the students and reward those who are able to complete a challenge with a small prize, whether this is a sticker or another type of small reward. For this type of group, the team suggests that the number of challenges at the exhibits are limited since younger students tend to become distracted more easily at times.

Lastly, the students can also participate in a small competition; the group can be divided into smaller teams to see which one can complete the most challenges or complete the challenges in the shortest amount of time. Since honesty may be an issue that arises with this suggestion, a teacher, or another student can be assigned to watch two teams compete and ensure that all participants are acting fairly. After completing the challenges presented by Technorama, the students can also be encouraged to create additional challenges for the exhibits and have their peers attempt them. This can help them further explore the exhibit and discover innovative ways to interact with it.

6.2 Conclusions

The team was very pleased to see the positive trends in the data that correspond with Technorama’s goals. The data shown in the previous section illustrates that the visitors who read the challenges spent more time at each of the four exhibits and interacted with the exhibits in more ways than those who did not read the challenges. After these activities were implemented, visitors in groups also interacted with each other more, both by means of talking to each other and by showing each other how to interact with the exhibits. The survey responses from Technorama visitors as well as other IQP students also show that those who attempted the challenges enjoyed having them at the exhibits. Furthermore, they believed that the challenges helped them explore the exhibits in more depth.

The challenge activity benefited the visitors’ experience and helped them explore the exhibits in more depth. However, not all exhibits benefited from the challenges, and the team provided characteristics of exhibits that would enhance the visitors’ experience if challenges were added to them. Exhibits that allow visitors to interact with them in multiple ways, such as the Turntable and the Rotating Chair with Electric Double Gyroscope, are more suitable for the addition of challenges. On the other hand, exhibits that only have one method of interaction, such as the Double Gyroscope and the Ball in a Bowl are not as suitable since it is easier to discover how to interact with them.

The team enjoyed participating in furthering Technorama’s mission. Working on this project allowed the team to collaborate and create innovative ideas that were used in a real-world work setting, which was an invaluable experience. The activity developed had a positive impact on Technorama; the team believes that the results demonstrate a way to facilitate accomplishment of that mission and hope they are of some value. With the recommendations provided, the science center can ideally continue to improve the overall visitor experience.
7. References


Appendices

This section includes all additional materials that the team used throughout the project that have not been included in the main body of the report, such as the visitor observation form and the visitors' surveys, the forms used to collect observations, interview questions and transcripts, signs used for the challenge activity, pictures of the activity signs in the Mechanicum section of Technorama. The appendices also include the guide that the team created for the Technorama to help its staff add challenges to other exhibits and the raw data collected during the visitor observations.
Appendix A: Pre-Activity Visitor Observation Survey

Type of visitor? *
- Individual
- Group

Group

Type of group? *
- Family
- Friends
- Pair

Age

Approximate age of visitor? *
- Child
- Teenager
- Young Adult
- Adult
Which exhibit are you at? *

- Ball in a Bowl
- Rodeo Gyroscope
- Rope Squirter
- Pendulum Cradle
Ball in a Bowl

What did they do? *

☐ Get the small ball to rotate as fast as you can parallel to the ground

☐ Get the small ball to rotate without you touching the bowl

☐ Get the small ball to rotate diagonally and as close to vertically as possible inside the bowl

☐ Get ball to rotate (not super fast)

☐ Other: ____________________________

Rodeo Gyroscope

What did they do? *

☐ Sit on chair and move up and down

☐ Spin the exhibit

☐ Get the exhibit to rotate without sitting on the chair

☐ Move your partner who is sitting on the seat up and down, without touching them

☐ Other: ____________________________
Rope Squirter

What did they do? *

☐ Move the lever

☐ Touch rope with hand

☐ Touch rope with other objects

☐ Get the rope inside the ring using your hand

☐ Get the rope inside of the ring using the rod

☐ Get the rope inside of the ring by only using the ring

☐ Other: ______________________________________

Pendulum Cradle

What did they do? *

☐ Released any number of balls

☐ Release balls from both ends at the same time

☐ Make the balls swing in such a way that the middle ball is always in motion

☐ Release different number of balls from both ends

☐ Other: ______________________________________
Interaction

How did they interact with others? *

☐ They didn't

☐ Showed others how to interact with exhibit

☐ Talked with others

☐ Other: __________

Time

How much time did they spend at the exhibit? *

☐ Less than 30 sec

☐ 30 sec - 1 min

☐ 1-2 min

☐ 2-3 min

☐ 3+

☐ Other: __________
Appendix B: Pre-Activity Visitor Experience Survey

Which exhibit did you visit? *

- □ Rope Squirter
- □ Ball in Bowl
- □ Pendulum Cradle
- □ Rodeo Gyroscope
Exhibit Experience

We are a group of students from the US, working with Technorama to create activities to help you explore the exhibits. Our survey will help us better understand the ideal activity to achieve that goal. Any information that you share in this survey will remain confidential, and you can quit the survey at any time which will discard the information you have entered.

On a scale of 1-5, how much did you enjoy the exhibit? *

1 2 3 4 5

Strongly disliked 😞

Strongly liked 😊

On a scale of 1-5, was it clear what you can do with the exhibit? *

1 2 3 4 5

Very unclear 😞

Very clear 😊

Do you think you could have done more with the exhibit? *

☐ Yes

☐ No
Appendix C: Interview Questions for Technorama Staff

We are a group of students from Worcester Polytechnic Institute in Massachusetts, USA. We are working with the Swiss Science Center Technorama to design and implement museum activities that will guide visitors through the science center and encourage them to spend more time exploring the exhibits as well as communicating with one another. The following interview is meant to gather information that will help the team better understand how we can improve visitors’ museum experience. Any information that you share in this survey will remain confidential. Additionally, you have the ability to choose to stop this interview at any time and all information you shared will not be recorded.

1. Which exhibits have trouble retaining the visitors’ attention? Why do you think so?

2. What do you usually hear visitors talk about at the exhibits?

3. Which exhibits do you consider best in the Mechanicum section? Why do you think so?

4. How do you suggest visitors can be encouraged to spend more time at an exhibit and explore the science concepts presented?
Appendix D: Activities Brainstormed Before Arriving to Switzerland

Scavenger hunt:

This activity can be tailored to fit into any of the areas at the science museum. For this project, the area of focus will be the Mechanicum section of Technorama. The purpose of the scavenger hunt would be to guide children or families through this specific science area. Before children (and parents if they would like to participate) enter the group of exhibits, a staff member (or one of the team members) will provide them with a lanyard that has a flashlight, a magnifying glass, a ruler and a stopwatch attached to it. By using a lanyard, children will not have their hands occupied, and they will be able to freely interact with the exhibits. The staff member will explain the activity and indicate the starting point (the first exhibit). At this location, there will be a visual display that asks visitors a question that will be answered through an interaction with the exhibit. The questions would be open-ended so that they encourage visitors to explore the exhibits, use some of the objects they were given, such as the measuring tape or stopwatch and ask further questions themselves. Following the question, there will be a set of directions that will help guide visitors to the next exhibit. The set of directions will incorporate the answer to the initial question asked. This way, visitors are interacting and spending time at the exhibit as opposed to simply looking for the clues. These directions can also encourage visitor interactions by including phrases like “ask a parent to help you find...” or “along with a friend, look for...” Some of the subsequent clues will be placed in locations that are not so obvious. This will encourage children to use the magnifying glass and flashlight they were provided to act like true detectives. The next clues that they find will have a similar layout to the one initially described. When children reach the end of the scavenger hunt and discovered all the clues, they could be given a detective's badge as an accomplishment for being a true detective and finding all the clues.

Juicy Question:

To coax visitors to think further than what the exhibit presents outright, one must get them to ask questions that can only be answered by interacting with the exhibit in an unusual way. Sample questions and instructions for the activity can be posted on the exhibit to allow visitors to participate without the help of a staff member. Visitors are to examine the exhibit and then pose their own predictions about the results of the experiment. For example, for the girder bridge activity (Technorama, n.d.) a suggested question may be “How long could a beam be made?” Visitors must then think about possible failure modes of the girder if it is left unsupported and extremely long, and then come up with solutions to the problems.
Appendix E: Post-Activity Visitor Observation Survey

<table>
<thead>
<tr>
<th>Type of visitor? *</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Individual</td>
</tr>
<tr>
<td>□ Group</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of group? *</td>
</tr>
<tr>
<td>□ Family</td>
</tr>
<tr>
<td>□ Friends</td>
</tr>
<tr>
<td>□ Pair</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate age of visitor? *</td>
</tr>
<tr>
<td>□ Child</td>
</tr>
<tr>
<td>□ Teenager</td>
</tr>
<tr>
<td>□ Young Adult</td>
</tr>
<tr>
<td>□ Adult</td>
</tr>
</tbody>
</table>
Which exhibit are you at? *

- Ball in a Bowl
- Rodeo Gyroscope
- Rope Squirter
- Pendulum Cradle
Ball in a Bowl

What did they do? *

☐ Get the small ball to rotate as fast as you can parallel to the ground

☐ Get the small ball to rotate without you touching the bowl

☐ Get the small ball to rotate diagonally and as close to vertically as possible inside the bowl

☐ Get ball to rotate (not super fast)

☐ Other: ____________________________

Rodeo Gyroscope

What did they do? *

☐ Sit on chair and move up and down

☐ Spin the exhibit

☐ Get the exhibit to rotate without sitting on the chair

☐ Move your partner who is sitting on the seat up and down, without touching them

☐ Other: ____________________________
Rope Squirter

What did they do? *

☐ Move the lever
☐ Touch rope with hand
☐ Touch rope with other objects
☐ Get the rope inside the ring using your hand
☐ Get the rope inside of the ring using the rod
☐ Get the rope inside of the ring by only using the ring
☐ Other: ____________________________

Pendulum Cradle

What did they do? *

☐ Released any number of balls
☐ Release balls from both ends at the same time
☐ Make the balls swing in such a way that the middle ball is always in motion
☐ Release different number of balls from both ends
Interaction

Did they read the challenges posted? *
- Yes
- No

Did they attempt the challenges?
- Yes
- No

How did they interact with others? *
- They didn't
- Showed others how to interact with exhibit
- Talked with others
- Other: _______________________

What were visitors' reactions/responses to the exhibit? *
- Frustrated
- Confused
- Excited
- Uninterested
- Interested
- Other: _______________________
<table>
<thead>
<tr>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much time did they spend at the exhibit? *</td>
</tr>
<tr>
<td>☐ Less than 30 sec</td>
</tr>
<tr>
<td>☐ 30 sec - 1 min</td>
</tr>
<tr>
<td>☐ 1-2 min</td>
</tr>
<tr>
<td>☐ 2-3 min</td>
</tr>
<tr>
<td>☐ 3+</td>
</tr>
<tr>
<td>☐ Other: [ ]</td>
</tr>
</tbody>
</table>

*Required question
Appendix F: Post-Activity Visitor Experience Survey

Exhibit Experience

We are a group of students from the US, working with Technorama to create activities to help you explore the exhibits. Our survey will help us better understand the ideal activity to achieve that goal. Any information that you share in this survey will remain confidential, and you can quit the survey at any time which will discard the information you have entered.

On a scale of 1-5, how much did you enjoy the exhibit? *

1 2 3 4 5

Strongly disliked 😞 Strongly liked 😊

On a scale of 1-5, was it clear what you can do with the exhibit? *

1 2 3 4 5

Very unclear 😞 Very clear 😊

Do you think you could have done more with the exhibit? *

☐ Yes
☐ No

On a scale of 1-5, how much did you enjoy the challenges posted at the exhibit? *

1 2 3 4 5

Strongly disliked 😞 Strongly liked 😊

On a scale of 1-5, how much did the challenges help you interact with the exhibit? *

1 2 3 4 5

Not a lot 😞 A lot 😊
Appendix G: Challenges for All Exhibits

Ball in a Bowl

Sind Sie bereit für eine Herausforderung?

Leicht: Können Sie die kleine Kugel in der Schüssel parallel zum Boden kreisen lassen?

Mittel: Können Sie die kleine Kugel kreisen lassen ohne die Schüssel zu berühren?

Schwer: Können Sie die kleine Kugel diagonal und so senkrecht wie möglich in der Schüssel kreisen lassen?

Are you up for a challenge?

Easy: Can you get the small ball to rotate as fast as you can parallel to the ground?

Medium: Can you get the small ball to rotate without you touching the bowl?

Hard: Can you get the small ball to rotate diagonally and as close to vertically as possible inside the bowl?

Rodeo Gyroscope

Sind Sie bereit für eine Herausforderung?

Leicht: Können Sie das Ausstellungsstück zum Kreisen bringen ohne auf den Stuhl zu sitzen?

Schwer: Können Sie Ihren Partner, der auf dem Stuhl sitzt, auf und ab bewegen ohne jedoch die Person oder den Sitz zu berühren? Dein Partner muss dabei stillsitzen. Die rot eingefärbten Teile dürfen nicht berührt werden.

Are you up for a challenge?

Easy: Can you get the exhibit to rotate without sitting on the chair?

Hard: Can you move your partner who is sitting on the seat up and down, without touching your partner or the seat? Your partner must sit still. For the hard challenge, you cannot touch the red area in the picture.
Rope Squirter

Sind Sie bereit für eine Herausforderung?

Leicht: Können Sie das Seil mit der Hand in den Ring befördern? (Tipp: Sie dürfen das Seil greifen.)

Mittel: Können Sie das Seil mit Hilfe des Stabes in den Ring befördern?

Schwer: Können Sie das Seil in den Ring befördern, wenn Sie nur den Ring zur Verfügung haben?

Are you up for a challenge?

Easy: Can you get the rope inside the ring using your hand? (Hint: You are allowed to grab the rope)

Medium: Can you get the rope inside of the ring using the rod?

Hard: Can you get the rope inside of the ring by only using the ring?

Dieses Bild zeigt, wie jemand das Seil erfolgreich durch den Ring bekommen hat.
This picture shows someone successfully getting the rope into the ring.

Pendulum Cradle

Sind Sie bereit für eine Herausforderung?

Leicht: Können Sie die Kugeln rechts und links gleichzeitig schwingen lassen?

Mittel: Können Sie die Kugeln so in Schwingungen versetzen, so dass der mittlere immer in Bewegung bleibt?

Schwer: Was würde passieren, wenn Sie eine unterschiedliche Anzahl Kugeln von beiden Seiten gleichzeitig loslassen?

Are you up for a challenge?

Easy: Can you make the balls on the left and the right swing simultaneously?

Medium: Can you make the balls swing in such a way that the middle ball is always in motion?

Hard: What would happen if you release a different number of balls from the two sides simultaneously?
Appendix H: Technorama Staff Interview Transcripts

Technorama Interviews

Interviewee #1

Interviewers: Ramona Bago, Nathan Charles, Karl Ehlers, Minh Le

1. Which exhibits have trouble retaining the visitors’ attention? Why do you think so?
   - Vertical Mobiles: the exhibit is not very interactive, but the exhibit is aesthetically pleasing
     - Hard to manipulate
     - Not astonishing: doesn’t grab someone’s attention
   - Jupiter Pendulum: only one know, not astonishing or surprising
   - Professor might understand some of the complex exhibits, but not ordinary visitors, so it might not be as enjoyable for them
   - If the exhibit doesn’t have any relation to daily life, it’s hard to relate and understand it

2. What do you usually hear visitors talk about at the exhibits?
   - This depends on who is visiting
   - Sometimes they talk about what others in the group see or experience
   - Fathers tend to talk about real life applications
   - Sometimes the visitors talk about the unexpected observations they make or they try to find an explanation
   - They might ask questions to discover what causes a certain exhibit to behave the way it did

3. Which exhibits do you consider best in the Mechanicum section? Why do you think so?
   - Turntable, or other exhibits that portray angular momentum, are pretty good
   - Turntable: open-ended, open sitting arrangement, people play together
     - Easy to observe
   - A good exhibit allows visitors to feel positive emotions and experience something unexpected
   - Exhibits that provide a physical experience, like the Rodeo Gyroscope, are also good
   - Some exhibits are aesthetically pleasing and look very nice
   - Double Gyroscope: difficult to understand at first, but people can talk about it; also provides a strong physical experience
• Waves in Springs: easy to see what is going on

4. How do you suggest visitors can be encouraged to spend more time at an exhibit and explore the science concepts presented?

• At Technorama, the staff doesn’t want people to worry about the time
• Perhaps the museum should get rid of some exhibits or provide sound dampening between floors so that people are not distracted as easily
• He described an exhibit that someone else is working on: recreating a walk in the woods
• In the forest, you are not distracted even though there are so many sounds and movements around you
• It’s exhibiting when you go off the designated path - that’s when you find the unexpected
• Technorama wants visitors to explore freely and if they choose to not go to an exhibit, or stop interacting with an exhibit if they want to

Interviewee #2

Interviewers: Ramona Bago, Nathan Charles, Karl Ehlers, Minh Le

1. Which exhibits have trouble retaining the visitors’ attention? Why do you think so?

• Wobbling Cylinder - people are not willing to wait...beautiful if done properly
• Electric Gyroscope - sometimes does not work if people don’t wait long enough
• Bike Wheels - people don’t realize you have to spin then just let go
• Double Gyroscope - not impressive
• Wheels on Carpet - need some experience (can hand to people)
• Ball Drop - looks like ball hovers in the air, however, people don’t know/aren’t patient enough to watch it at the end
• Vibrating Springs - some people can’t manage to get it to work
• Phased Pendulum - you have to pull on string at the right time, hard to understand
• Radi Max - hard to figure out so he just shows/guides visitors
• Oil waves - noisy/annoying

2. What do you usually hear visitors talk about at the exhibits?

• Depends on age
• People asking for help
• People explaining the scientific phenomena
3. Which exhibits do you consider best in the Mechanicum section? Why do you think so?

- Turntable
- Pendulum Cradle - Beats/music
- Ball in a Bowl
- Drawing - Lets it run the whole day
- Lissajous - challenge: draw lines
- Waves in springs - Makes sound

4. How do you suggest visitors can be encouraged to spend more time at an exhibit and explore the science concepts presented?

- Turntable is the best example
- When they decide to move on let them
- Show them what they can do at the exhibits (not the Technorama way)
- People don’t read instructions
- They need patients
- 1-2 min is too long
- Encourage them to play
- Stressed that there is too much

Interviewee #3

Interviewers: Ramona Bago, Nathan Charles, Karl Ehlers, Minh Le

1. Which exhibits have trouble retaining the visitors’ attention? Why do you think so?

- Too complex exhibits, too many parameters (buttons, levers, wheels, etc…). There are too much going on and visitors don’t know what to do with them.
- Only have a few seconds to catch users attention, so sit & wait & watch exhibits don’t work
- It’s better to make more exhibits than one exhibit with too many parameters

2. What do you usually hear visitors talk about at the exhibits?

- He didn’t spend much time observing visitors
- Adults explaining to children, people talking in general about the exhibits
- Sometimes visitors show astonishment
Visitors don’t talk about exploration, which is more important to him

3. Which exhibits do you consider best in the Mechanicum section? Why do you think so?
   - Turntable: strangers can interact with each other, both passively and actively. Things happen very fast, objects are colorful, and they can crash with each other
   - Coriolis fountain: people are fascinated because of the unexpected effect
   - Visible effect of the invisible: the waves are visible. Visitors don’t need to know about standing waves to appreciate the different waves made by the exhibit
   - Other exhibits that create the ‘wow’ effect or have unexpected results

4. How do you suggest visitors can be encouraged to spend more time at an exhibit and explore the science concepts presented?
   - Challenges can make people intrigued and investigate the exhibits more instead of just pressing buttons and pulling levers aimlessly.
   - People get satisfaction from finishing challenges: incentives.
   - Minimize reading: something more interactive or visually appealing instead of just reading from a piece of paper.

Interviewee #4

Interviewers: Ramona Bago, Nathan Charles, Karl Ehlers, Minh Le

1. Which exhibits have trouble retaining the visitors’ attention? Why do you think so?
   - The Vertical Mobiles art exhibits and the Vibrating String exhibit
   - Their placement in the room and the curtains around them kind of hides them from the visitor as most people usually wander around the center of the room

2. What do you usually hear visitors talk about at the exhibits?
   - Visitors are usually fascinated about the effects that the exhibits display and make remarks about them to each other
   - Some ask the staff members on the floor about the effects

3. Which exhibits do you think are best in the Mechanicum section? Why do you think so?
   - The Rodeo Gyroscope, the Rotating Chair with Bicycle Wheel Gyroscope, and the Harmonograph
   - What you can do with the exhibits is immediately obvious or easy to discover without instruction
   - They look fun and they are fun to play with
4. How do you suggest visitors can be encouraged to spend more time at an exhibit and explore the science concepts presented?

- Good, readable questions that aren’t super detailed
- Challenges with three levels of difficulty for each exhibit are also an option
- Perhaps nothing happens when they try a challenge or explore with a question, and then they can just move on

Interviewee: Technorama Staff Member #5
Interviewers: Ramona Bago, Nathan Charles, Karl Ehler, Minh Le

1. Which exhibits have trouble retaining the visitors’ attention? Why do you think so?

- Resonant Rods and Phased Pendulum
  - People will try almost everything but these two have trouble because they are boring or difficult
  - Resonant Rods doesn’t show a lot of movement so there is not much to see, and Phased Pendulum takes a little bit of time to get to work properly

2. What do you usually hear visitors talk about at the exhibits?

- Visitors usually show each other what they have been able to do and share reactions to exhibits.

3. Which exhibits do you consider best in the Mechanicum section? Why do you think so?

- Rope Squirter, Rotating Chair with Bicycle Wheel Gyroscope, Ball in Bowl, Rodeo Gyroscope, and Gravitation Model or Energy Well
  - All of these are understandable without instructions

4. How do you suggest visitors can be encouraged to spend more time at an exhibit and explore the science concepts presented?

- Not sure, the Mechanicum section is very easy
Appendix I: Guide

Choosing Exhibits for the Challenge Activity

More suitable exhibits to add challenges to:

- Has multiple ways for visitors to interact with it and see a phenomenon take place
- Interactions with the exhibit are not straightforward and very obvious

Example of exhibit that may benefit from challenges:

*Rope Squirter*: This is one of the exhibits that we have chosen to implement our challenge activity on, and according to our data, visitors tend to interact with this exhibit more after reading the challenges. The exhibit is very visually interesting; the rope moves fast in unusual ways and displays a very interesting phenomenon. The Rope Squirter is also very physically interactive and dynamic, as visitors can touch most parts of the exhibit that each cause something new to happen. In addition, it is usually not very clear what visitors can do with this exhibit, which is why the challenges were effective. They encouraged people to try more things while not being too difficult to achieve.

Other examples of exhibits that may benefit from challenges: Turntable, Electric Gyroscope with Turning Chair

Less suitable exhibits to add challenges to:

- Limited methods of interaction
- Limited number of possible outcomes, e.g. can only see one result regardless of visitor input

Example of exhibit that might not benefit from challenges:

*Ball-in-a-Bowl*: This is another exhibit that we chose for our challenge activity. This exhibit is usually the first one that many people see when they enter the Mechanicum section. However, since the section is so large, visitors most likely realize that there are a lot of exhibits they have to see, so they try to interact with the Ball in a Bowl as quickly as possible and ensure that they have sufficient time to see the remaining exhibits. Also, this is a fairly straightforward exhibit so many people might think they already know what to do and end up not reading the challenges. There is only one way to interact
with the exhibit: to move the bowl in order to move the ball. This can cause the exhibit to lose the visitors’ attention quickly, and thus make the challenges less effective. Other examples of exhibits that may not benefit from the challenges: Visible Effects of the Invisible, Waves in Springs

**Developing Challenges**

**Tips on how to start thinking about the challenges:**

- Carefully read the instructions of the exhibit you are considering adding challenges to. Many instructions already encourage visitors to try certain interactions with the exhibits; the challenges should encourage visitors to explore further than these interactions.
- Explore the exhibit with at least one other person. Complete the interactions mentioned in the instructions and then ask yourself some “What if…” questions. Try all possible interactions you can think of.
- Observe how visitors interact with the exhibit and note any innovative interactions that are uncommon.
- Referencing your interactions with the exhibit, write questions that will prompt people to try those interactions.
- Create challenges with increasing difficulty.
  - Easy challenges should be quite obvious and most visitors should be able to solve them with minimal effort.
  - Medium and hard challenges should take some effort and exploration to solve, while not being tedious or frustrating.

**Do’s:**

- Do focus on exhibits that are highly interactive and where visitors can spend a lot of time.
- Do try all possible interactions with the exhibit you considered. No idea is a bad idea.
- Do explore the exhibits with at least one other person. Doing so will allow you to discuss and perhaps use each other’s ideas to come up with new ones.
- Do ask others to read and try your challenges to ensure that the wording is clear. If the medium and hard challenges seem to be too difficult, include hints to help the visitors.
- Do add pictures to the challenges if needed for clarity.
**Don’ts:**

- Don’t get discouraged if designing ideas for an exhibit is challenging. Not all exhibits benefit from the challenges.
- Don’t focus too much on exhibits that are not as interactive.
- Don’t make the wording of the challenges extremely long.
- Don’t add too many challenges to one exhibit. Even though there may be many challenges possible, visitors might not be interested in completing ten challenges at one exhibit. You can choose the best three challenges or even change the challenges posted from time to time.
- Do not display how to complete a challenge through any pictures of graphics. Those should be used to display the end goal of a challenge or for clarification purposes.