A Day at Tecnico's Computation Museum

Pedro Miguel da Silva Matos Maria
pedro.maria@tecnico.ulisboa.pt

Instituto Superior Técnico, Lisboa, Portugal

May 2022

Abstract

Museums are becoming increasingly disconnected with people's way of consuming entertainment. In the age of interactivity and instant feedback, museums must strive for the digital transformation that's happening everywhere. A way to tackle this is to try and incorporate digital devices into the museum that can enhance visitor's experience.

To accomplish this we developed an escape the room and infrastructure to be deployed in the museum. This infrastructure will manage several components of our solution as well as the game itself. We developed the escape the room in a modular fashion where we simply developed interactions that we then used in coordination with each other to create the game.

The results achieved show that we managed to enhance visitor's experience and motivate them to return to the museum due to the enjoyment they felt playing our game. On this note we also managed to validate that our infrastructure is able to support our game making use of very affordable hardware. We also saw that using the interactions in the context of the escape the room proves to be more enjoyable for visitors than using them individually.

To conclude, gamifying the museum through an escape the room produces positive effects on visitor's enjoyment, is an effective way of enhancing their experience and motivates people to return. This, in turn, signifies that our solution was able to tighten the gap between current generations and museums and provide a clear path for the latter on how to perform this digital transformation.

Keywords: Internet of Things, Escape The Room, Museum, Smart Museum, Serious Games, Gamification

1. Introduction

Museums are important cultural sites that have kept generations in contact with history and have been able to create this bridge in a way that we know to be unique for museums since these are the only sites where people can actually get in contact with artefacts. On the other hand, we know that museums are one type of institution that have been offering considerable resistance to perform the digital transformation that is taking place in many areas of people's lives. This disconnect leads to the invetiable ostracization of museums by generations that are used to consuming content in a format that is no longer the format that the majority of museums offer which is through audio guides and text plates. Instead, current and younger generations have a preference for ways of consuming content that make use of new technologies to deliever said content.

With this in mind, and to reduce this increasing generational gap between museums and its visitors, we intend to develop a series of components that, together, will prove to be the solution that will enhance all visitor's visiting and learning experience and motivate people to return. The components are, specifically, a support infrastrucuture that will manage several components of our solution, several interactions that people will use to acquire content and have more enjoyment while visiting the museum and, at last, the main part of our work, an escape the room game that will take part in the museum and that will make use of the two mentioned components to work. With this, we expect to increase visitor enjoyment and motivate them to return to the museum while at the same time attract audiences that crave for these new technologies as a medium to have content delivered to them.

2. Related Work

In order to develop a solution that stands out from what already exists and that takes care of people's different needs and ways of enjoying content in a museum we researched several studies that gave us insights on topics we need to be aware of. We start our research by first taking a look at other museums that are similarly themed to the computation

museum where we will be deploying our work but that also have made some efforts to provide their visitors with some digital means that visitors can enjoy to either learn or to acquire content. On this note, we came across several museums such as the Computer History Museum, The National Museum of Computing and the Living Computers Museum + Labs.

The Computer History museum is one of the best examples of museums that managed to integrated digital technologies into their spaces but still not in a way that feels ideal to us. The way they did it was by creating dedicated spaces for visitors to have a more hands on approach at the contents the museum is attempting to transmit. They have also made efforts to do something more closely related to what we intend which was making tablets available throughout the museum so that people have the possibility of consuming content via those tablets and have access to more content that will assist the material they already have available on the museum. Not only this, but the Computer History Museum also employed the use of a virtual version of its exhibits so that visitors can visit from anywhere. This a good attempt at integrating digital technologies in the museum but fails to be a part of the exhibit. In fact, the only device that became part of the experience were the tablets while the rest of their efforts were part of the museum but not integrated with the exhibit.

The National Museum of Computing also adopted a similar approach to the Computer History museum in the way that they also make available a VR tour to their spaces and also use dedicated areas for people to have a hands on approach to the item and subjects in exhibit. The last one, the Living Computers Museum + Labs is the one that stands out the most for providing its visitors with on-site VR and Augmented Reality devices, actually integrating them with the exhibits. Furthermore, this museum also provides practical activities for people both inside and outside of the museum, creating this bridge with the outside world.

2.1. Interaction Types

Another important topic to consider before developing our solution are the interaction types. We have seen a few interaction types when talking about the museums like virtual and augmented reality as well as tablets but these are not the only interaction types which are relevant for us to consider. In fact, for our work we considered relevant to study interaction types such as serious games, tangible interactions, context aware interactions and virtual reality and brain-computer-interfaces. Serious games are an important subject because of their nature as both an entertainment form as well as an educational one and are one of the types of games to which we must pay most attention because when developing our solution, one of the aspects that needs most attention is this delicate balance between entertainment and education since creating interactions that focus too much on the educational component can become boring for people that are actually looking for some degree of entertainment while on the other hand, focusing too much on the entertainment can lead the interactions to becoming no more than just games, completely disregarding the museum's mission.

Tangible interactions are a very important part of this work as we'll later realize. Tangibles are part of a major discussion from a study[1] where the authors determine that people with different visiting styles have preference for different types of devices. In this study they create several categories, two of which are the fish and the ants and state that the people that belong to the fish category are more prone to move around and would rather have an overview of an exhibit which in turn makes them prefer devices such as mobile phones and tablets that allow them to have this mobility and don't force them to get close to anything unless they want to. On the other hand, the visitors fitting the ant category like appreciating each piece, observe the details and reading the information provided and these people have a preference for tangible interactions. This is important to take note in order to, when developing the interactions and escape the room, we make sure we aim for diversity of types to not leave out anyone's preferences.

Context aware interactions, virtual reality and brain-computer-interfaces are the last types of interaction that are important to briefly talk about. Context aware interactions are very important to study in the context of our work because context provides a lot of opportunities for the development of interactions that can be seem seamlessly integrated into a museum environment and make use of said environment for content delivery. On the other hand, virtual reality and brain-computer-interfaces are important to mention because they will be some of the next future technologies that will become more and more present in people's lives. Virtual reality on its end allows museums to, on site, transport visitors to other times and allow them to live historical moments in ways that were not possible without this technology and the maturity rate that it has already achieved. Brain-computer-interfaces are slightly different because these devices are still in very early stages of development but are of key importance for museums when they become mature enough since they provide valuable insights on what people are feeling towards certain items in exhibit. This opens the

possibility for custom tailored experiences and can also provide museums with valuable insights as to what people liked and disliked the most with regards to the exhibit.

2.2. Technologies

The next step in our research for related work is understanding key technologies that we can use in order to design and develop both our infrastructure and interactions which then will make up the escape the room. The first technology worth mentioning is Bluetooth Low Energy and the importance of it is related to its low energy characteristics as well as being a very widely supported communication protocol by several devices. We emphasize this technology because the applications it can have in the museum are several. We can start by indoor location finding using Bluetooth beacons for that effect. It can be used to establish communications between devices where battery is a concern and that is an application from which our work can benefit a lot.

RFID and NFC are also two other technologies which are very important, especially when it comes to not only their relevance nowadays in people's lives but also for the enormous applications they can have especially when it comes to the construction of tangible interactions and providing more ways for people to interact with exhibits. This technology, similarly to Bluetooth Low Energy, is becoming more a more popular with time due to its increasing applications and has benefited from a surge in popularity due to the COVID-19 pandemic.

Lastly, also having benefited from an increase in popularity with the COVID-19 pandemic, we have the QR-Code. The QR Code is another interesting technology both for our work and for museums in general due to its versatility, affordability and overall ease of use and accessibility. QR Codes are codes that can be easily generated and can store some amount of information that we can use for several purposes, either delivering content or actually integrating it into an interaction, like, for example, a context aware one. Additionally, what makes QR Codes so attractive, is the fact that they, nowadays, are guaranteed to be able to be read by any person possessing a smartphone with a camera. While RFID/NFC for example need dedicated equipment like the tags and readers, QR-Codes simply need a camera to be read. All of these technologies, alongside others, are important for us to consider because this way we can develop an infrastructure that supports these technologies and interactions that make use of them.

3. System Overview

The Peddy Room System, as we designate our solution, is composed of several important components, each of which we will be giving a good overview throughout this section. The four main components are:

- Master Pi
- Interaction Pi
- Interactions
- Escape the Room

Before we detail the functionality and architecture of each one, we must first start by stating the requirements we established for our infrastructure. This work is intended to be deployed in a museum that is a living and always changing entity and creating a static infrastructure that will not be able to adapt itself to this changing nature of museums would deem our solution a failure with the passage of time. For this, we need as a first requirement, a solution that is scalable in order to not only support these changes in museums but also to allow our solution to be adopted by museums of different scales, from a small one with a couple of rooms, all the way up to museums with several rooms, floors and even buildings. This requirement in itself is related to another requirement which is inter connectivity which states that the elements of our system must be able to organize and connect themselves via network. This is an important requirement if we want to have our system being able to support museum with big spaces and will also allow us to have a central point of management of the infrastructure, allowing for ease of use.

Another very important requirement is discreetness as making a solution that cannot blend in easily with the museum environment makes our solution inadequate for museums to adopt it while conserving their spaces the way they want to. This discreetness is a key requirement for our solution since failing to have a discreet system will imply that museums will not want to adopt this solution due to the fact that it becomes hard for them to integrate it with their existing spaces. On this note, affordability is also a key requirement for adoption, developing a very good solution that, to be deployed and maintained, requires a strong money investment creates a big barrier for adoption and ultimately makes our solution not fit to be adopted by museums.

The last two requirements, which relate to the first, and are key requirements for our solution, are modularity and extensibility. If we have a modular solution that means we can easily replace components out of that solution without that having to affect the entire system and we can simply isolate problems and repair them in a more focused and easy way. Extensibility on the other hand relates to

the objectives we have for the future of this work. As we have previously mentioned, new types of interactions are appearing, new technologies are getting more mature and the way people prefer to consume content is also in constant change and making a static solution that fails to adapt itself to the new technologies and devices ultimately will condemn it to failure making extensibility another key requirement to have into consideration when designing an architecture.

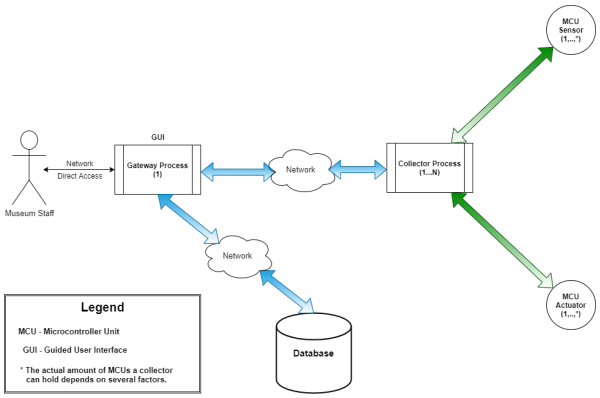

Figure 1: Simplified architecture of the Peddy Room System

The Gateway process, commonly referred to in this work as Master Pi, is the process that coordinates the entire system. It is from the Master Pi that we can manage the collector processes and have access to their management interfaces without needing to directly connect to the collector process machine. Not only this but it is from the Master Pi that all of the logic related to the escape the room can be setup and the game can be prepared to start. This is also the receiver of relevant communications from the collector processes since if anything happens to these, they will communicate the occurrences to the Master Pi so that a user of the system becomes aware of these occurrences and may act upon them. This component is also responsible for coordinating services related to the museum itself since it is from here that a user can have access to sensors scattered throughout the museum and connected to the collector processes.

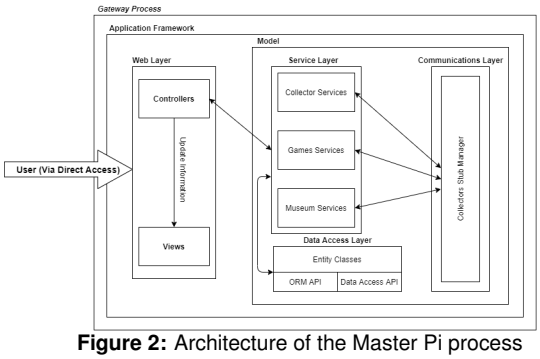

Figure 2: Architecture of the Master Pi process

The Collector process on the other hand, commonly referred to in this work as the Interaction Pi, is the process that coordinated the Interactions and collects and send relevant messages from and to them respectively. It is in the Interaction Pi that a user can have access to an interface that manages several aspects of the interactions. When, for example, a user intends to add a new interaction to the overall system, the user simply needs to connect that interaction to the system, access the management interface of the interaction pi to which the interaction connected and then add said interaction so that it can then proceed to trade some setup messages to get some basic information and make the interaction available to be played. This logic we described for the interactions is also a logic that applies to the sensors as well as it is the responsibility of the Interaction Pi to collect all of the readings from the sensors and report them to the Master Pi.

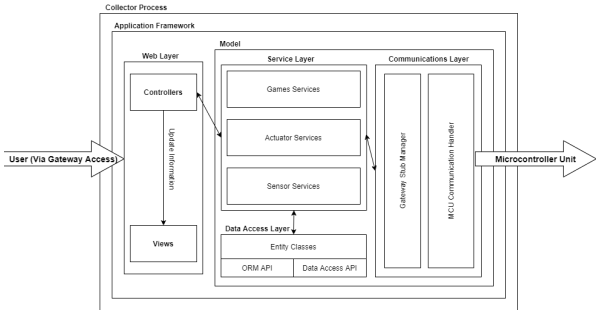

Figure 3: Architecture of the Interaction Pi process

The interactions is a components of our system which does not have an architecture or specific implementation but instead is a concept component of several implementations. In order for us to develop an experience that makes use of digital devices we determined that the best way to implement this is if we developed the interactions we wanted and make them all obey to an API that will allow them to always communicate with the infrastructure. In total, we developed 12 interactions, all of them sharing the same API, and each developed in order to be played in a standalone mode (without requiring the other interactions). We started this development by thinking conceptually about the interactions and decide what would the gameplay be, how would the resolution of the interaction look like and, also important for our work, if we were able to build the interaction themed for the museum and related to some concept that it could explore so that the users could have a hands on approach at learning that concept. Once this was clear and the code for the interactions was developed, we moved on to performing the designs of the enclosure where all the components the interaction required would be living.

This process of designing the enclosures in-

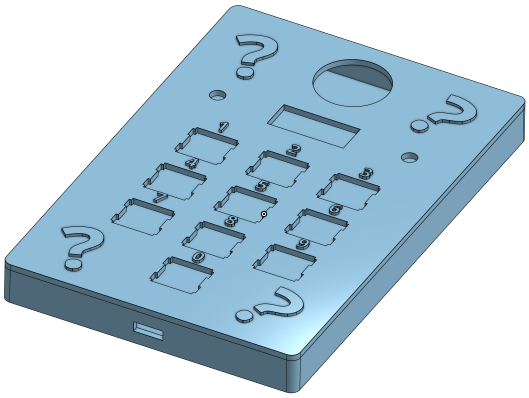

Figure 4: The 3D model of the Ordered Numbers interaction

volved a lot of trial and error due to the tolerances not being appropriate due to the lack of precision from the 3D printer that printed the enclosures but once everything was correctly printed the interactions were ready to be assembled, tested and, afterwards, integrated into the infrastructure to check their correct behavior.

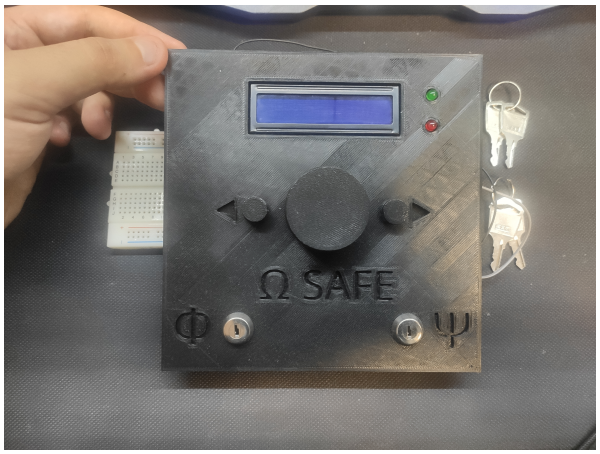

Figure 5: The Digital Safe interaction fully assembled and ready to use

The last component of the four is the escape the room. The escape the room is a component of our solution that makes use of the 12 interactions we developed, grouped together and organized in a way that makes up the game. In other words, the escape the room was designed and developed in a way where it is simply the concept with the rules and not something done specifically that cannot be changed. The way it was designed allows us to change the interactions almost completely freely and add and remove interactions and still the game would work the same way as it is expected of it. We designed the game having into consideration the rules and enforced those rules in the system such as the time limit of 1 hour, limiting the teams to at most 4 participants and at least 2, among other mechanisms that are important to have in place in our infrastructure that allows the game to run without any issues.

4. Results & discussion

After developing all components of our system, we decided to first test the interactions individually and only after move to test the escape the room. The reason for this is because we intended to have the users have contact with the interactions in order for them to point out some flaws that they might have and to actually see what is the degree of enjoyment of the users when using the interactions alone as opposed to using them in the context on an escape the room.

We tested the interactions on several components, namely enjoyment provided to the users, how clear was the feedback that they returned when a correct or wrong input was introduced as well as other metrics that allowed us to perform some changes on the interactions and have some increased degree of confidence on them before moving on to the escape the room.

The first aspect was aesthetics and dimensions. We inquired users to see what were their thoughts on the dimensions and aesthetics of the interactions and we obtained very positive results when it came to the designs and the dimensions as the majority of users thought that the interactions were well designed and possessed dimensions that were adequate for the environment where they would be inserted. We also took the opportunity during testing to see the average time it took participants to solve each of the 12 interactions to see, in terms of resolution times, how was the actual difficulty trying to solve the interactions. These results showed that on average, users took almost 1 hour to solve all interactions but, looking at the data in detail, we see that the interaction that took the majority of the time to solve were the keypad interaction, the Morse code interaction, the ordered numbers interaction and, finally, the Simon Says interaction. In case of the Keypad interaction, this time is justified by the complexity of the clues and because of the problems the interaction presented both in terms of interface as well as construction problems (when a key was pressed, multiple registered because the keycaps were very close to one another). When it came to the Morse code interaction, this was developed in a way that the Morse code being played was in such a speed that only a trained hear could understand the dots and dashes being reproduced by the interaction which ultimately led us to slow down this interaction when all tests were finished. The Simon Says on the other hand was the biggest surprise for us since users did not quite understand how the interaction

was meant to be solved. They eventually understood what to do in general terms but they failed for a long time to understand the logic behind the interaction.

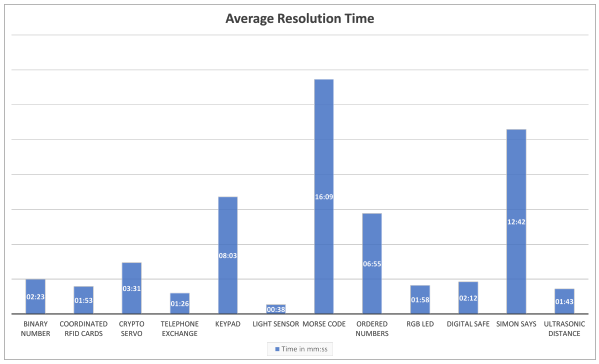

Figure 6: The average time it took to solve each interaction

Given that these interactions are to be deployed in a museum, it was important for us to also understand what effect, if any, did users feel these interactions would have on their learning and visiting experience. The results collected show that users, after having used each interaction, felt that they would actually have the ability to enhance their experience at the museum. Not only this but, when inquired about their overall degree of enjoyment regarding each interaction, we were met with very positive results where only one participant reported and horrible experience with the Light Sensor interaction. All the rest of interactions always had results that, on average, were very positive which clearly indicates to us that, even though the interactions have clear problems, they were developed well enough to the point where they are able to have a positive effect on users both in terms of enjoyment as well as positive effects on their experience in the museum.

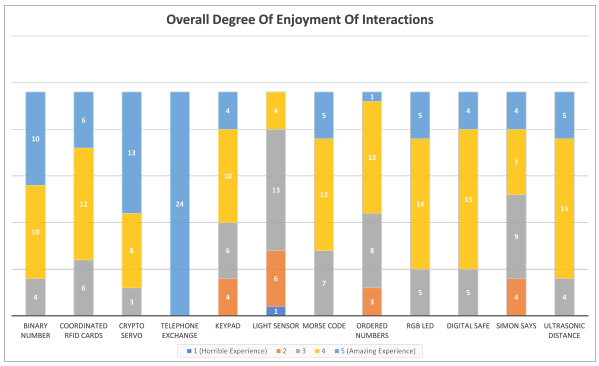

Figure 7: The overall degree of enjoyment felt by users when using the interactions

4.1. Escape the Room

The escape the room was where the most relevant results were collected because it was this game that was going to test our entire solution as well as all of the components we developed. In order to detail the results we collected and have a some context to them, we must first state that we had 15 participants, 1 group of 3 and 6 groups of 2 elements playing our game where of these groups, only 3 were able to successfully finish the game successfully while the rest managed to solve some interactions but failed to complete the game within the established period of 1 hour. Even though we did not have a very good completion rate, we observed that more than half of the participants enjoyed playing the game with only 27% reporting having an average experience while 13% actually reporting having a bad experience.

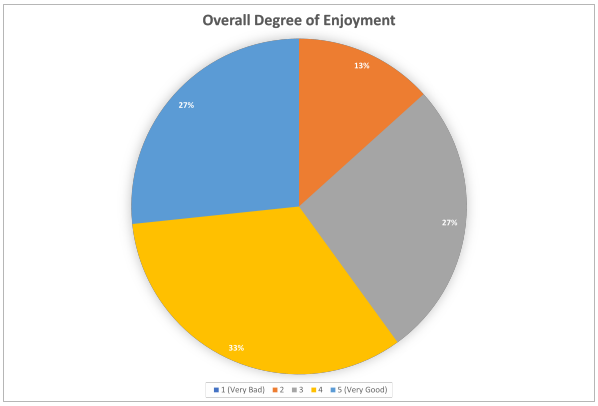

Figure 8: Enjoyment felt by participants towards the escape the room

With this game, all participants found that the degree of interactivity they experienced was superior to what is usually found in traditional museums but only 11 people actually reported this interactivity as being something positive while 3 of the participants found it neutral and 1 actually found it harmful.

Another important metric we collected because of the relevance it presents to our solution was how people felt about the different interaction types present in our solution and what effect did this diversity have on their experience. We discovered that the participants enjoyed the tangible interactions the most with the computer being the second most enjoyed interaction type and the smartphone coming as the least enjoyed interaction. On this note, participants also reported that they found this diversity as something that positively contributed for their experience while the remaining 4 found it to be indifferent.

In the end, we also validated the effect our solution had on users in terms of their motivation to return to replay the game and revisit the museum. On this we were also able to achieve positive results as 13 out of the 15 participants answered that they felt motivated to return to the museum to replay the escape the room.

5. Conclusions

To conclude, we saw throughout the data we collected from both the interactions and the escape the room that we managed to be successful when it comes to the points we were intending on proving. From the interactions, we managed to determine that we were able to properly develop the interactions and that using them individually also proves to be an enjoyable experience for the users. We saw many issues with these interactions in terms of their assembly but none the less those issues did not become deterrent for users to enjoy a good time while using the interactions. When it comes to the escape the room we also observed positive results when it came to user enjoyment and motivation to return to the museum to replay the game and revisit. Even though these results suffer from severe limitations such as the lack of more age groups and overall lack of more participants, we can say that with the results collected we are moving forward in a positive direction in terms of motivating current and future generations that would like to see this digital transformation happening in museums, to actually become more in contact with these institutions, and vice-versa, since this is a kind of approach that appeals to all age groups and is able to provide, as the results show, an enjoyable time for visitors.

This work gives museums a clear understanding of a possible path to follow with the use of games that prove to be as fun as they are educational and, not only this but, this solution has shown the possibilities that it offers to museums and to their visitors as the requirements established in its design make it a solution that can be easily acquired and setup by museums as well as tailored to any museum of any theme.

5.1. Future Work

In terms of future work, the participants of both the interactions and the escape the room made us aware of several improvements that our solution needs to have across the entire system. The majority of the negative feedback revolved around the interactions due to the way they were built. The interactions need to be redesigned in order to change certain problems that they have with too fragile parts that can easily be broken as well as others that are bending due to the tension placed upon them by the components. No only this but there were several minor issues with the assembly of the interactions that were enough to cause problems to the users to the point where the last group of users playing the escape the room already found the interactions in a state of big wear. These problems go from components that were supposed to be glued together falling off, wires coming loose due to not being properly attached as well as the support of the interactions being breadboard based due to the lack of capability to assembled them all within their enclosure.

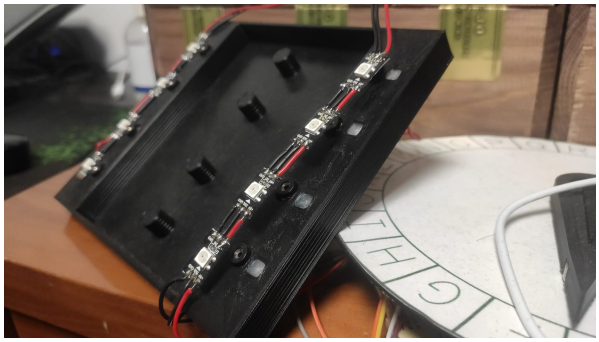

Figure 9: Assembly problems being revealed due to the usage the interactions had

Having this in mind, we will be performing improvements on the interactions from the design of the enclosures to the assembly itself in order to make the interactions more sturdy. We will also be performing several improvements on the interfaces and source code of the infrastructure in order to have a more user friendly interface as well as an easier way to connect and reconnect interactions to the system as this process is one part of our solution that takes a lot of time to do when performing the initial setup of the system.

References

[1] Ethnographie de l ' exposition : l ' espace , le corps et le sens / Eliseo Veron , Martine. page 18373, 1983.