Move or Die

Interactive Installation for Museum

Influence of embodied interaction on players' experience

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Master of Arts thesis abstract

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Abstract

This thesis presents the interactive game installation, *Move or Die*, created for an exhibit at The Finnish Museum of Natural History. It documents the development of the project by describing ideas behind the concept, detailed components of the installation, and reasons for the design decisions made during the production process. For the theoretical section, the thesis investigates the influence of physical interaction on the players' experience based on the embodied approach. The museum context is considered a great deal in both the production and theory sections.

Move or Die is a gamified installation in which participants can save endangered species through bodily interaction. As the 'game' is projected onto the floor and Kinect sensors installed on the ceiling register movement, participants can catch and move the graphic animals on the floor by using their arms. *Move or Die* reflects a research method of the museum called 'assisted migration' and contains their research contents. It is designed to inform people of the situation of the endangered species and to offer participatory experience to the visitors at the same time.

It is the objective of *Move or Die* to simulate the experience of saving endangered species with the player's own intention and physical ability. Therefore, to investigate the interaction of *Move or Die*, it is significant to understand the players' experience. To analyze this interaction, three representa- tive aspects of the interaction are discussed separately: full-body interaction, social interaction, and reality-based interaction. This thesis tries to uncover comprehensive influences of the interaction beyond its basic functionality.

Keywords interactive installation, museum, embodied interaction, physical interaction

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1. Introduction

Move or Die[1] is an interactive game installation created for the Finnish Museum of Natural History (Luonnontieteellinen museo, Luomus). In the fall of 2014, the museum staff visited one Media Lab's Production Clinic course to invite students to participate in an idea contest for their new exhibition *Change in the Air*. When they chose the concept that I presented, I gained a valuable opportunity to work on the project with other talented students of Media Lab who are specialized in their own fields: Laura Uusitalo, graphic designer and animator; Joonas Pernilä, sound designer; Chen Ling, programmer; and Sanna Reponen, project manager. I worked as art director of the concept and a programmer. I was also in charge of the setup and configuration of the installation with the help of the museum staff. The project went through a year-long production period in total. The exhibition opened on November of 2015, staying in the museum for a 2-year duration.

This thesis presents development of the interactive game installation, *Move or Die* (*MOD*), and the investigation of its interaction design. The ideas behind the design concerns and decisions of the project are described in detail. Because the installation allows participants to play the game by engaging their own bodies, physical interaction plays an important role in shaping the players' experience. I deem that the interaction is also pivotal in the development of the installation, since the initiation of the whole concept starts from the idea of this interaction. Consequently, a great deal of attention is paid to examining the interaction in the thesis.

How does the interaction of MOD *influence the players' experience?*

As an attempt to answer the question, I conducted literature research about related interaction styles. However, it was a big struggle to find the appropriate definition concerning the interaction of *MOD*—there are a wide range of terms used to describe interactions of interactive installations. I ultimately came to the realization that a single term cannot

[1] The official Finnish title is Sopeudu, muuta tai kuole.

represent all the characters of the interaction. As interactive installations do not have a single unified interface and configuration, each of them drives different behaviors from its users. For that reason, I chose three representative and significant aspects to accurately outline the interaction of *MOD*, and investigated each one separately: full-body interaction, social interaction, and reality-based interaction.

The study tries to uncover comprehensive influences of the interaction beyond its basic functionality. I believe that the research dedicated to the interaction will give myself and the reader a better understanding of the user experience as a whole.

1.1. Motivation and personal background

From visual design to video production, I have explored different digital tools to express my ideas. However, I often felt the expression was trapped in a square frame. Only when I learned a new technique called 'interaction' did the square frame finally begin to break. It became the greatest joy to invite people to engage with my work. The integration of digital and physical worlds seemed to offer a much bigger opportunity for artistic expression and design methods. Since then, I have created interactive installations with a focus on interaction design.

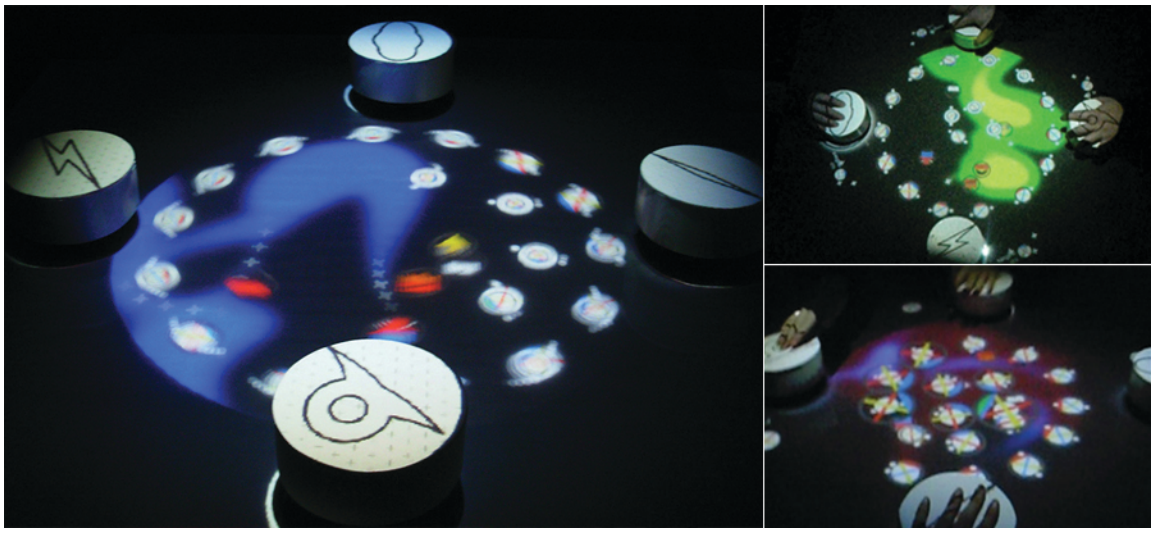

Figure 1. Digital PungMulNoRi installed in the exhibition, Seoul, 2010.

Digita PungMulNoRi is a project created during my undergraduate study (see *Figure 1*). *PungMulNoRi* is a form of traditional Korean performance involving musical instruments, dance movements, specific formations, and actors. I reconstructed and visualized it in a digital form to provide the experience of playing the instruments and observing the movements and formation to the participants. It was my first interactive installation for an exhibit that affords physical interaction, and, understandably, it was also the first failure. Although I did not consider it as a failure at that time, the system was too slow and it stopped working from time to time.

Furthermore, the interaction did not necessarily enhance the quality of the experience. After all, the installation did not fulfil its original goal of providing an entertaining experience to the participants. However, I still consider it as a significant project since it was also my first attempt to create an interactive installation that is entertaining and educational at the same time. Although the project was for a graduation exhibit, I considered it a suitable installation for a relevant museum exhibit.

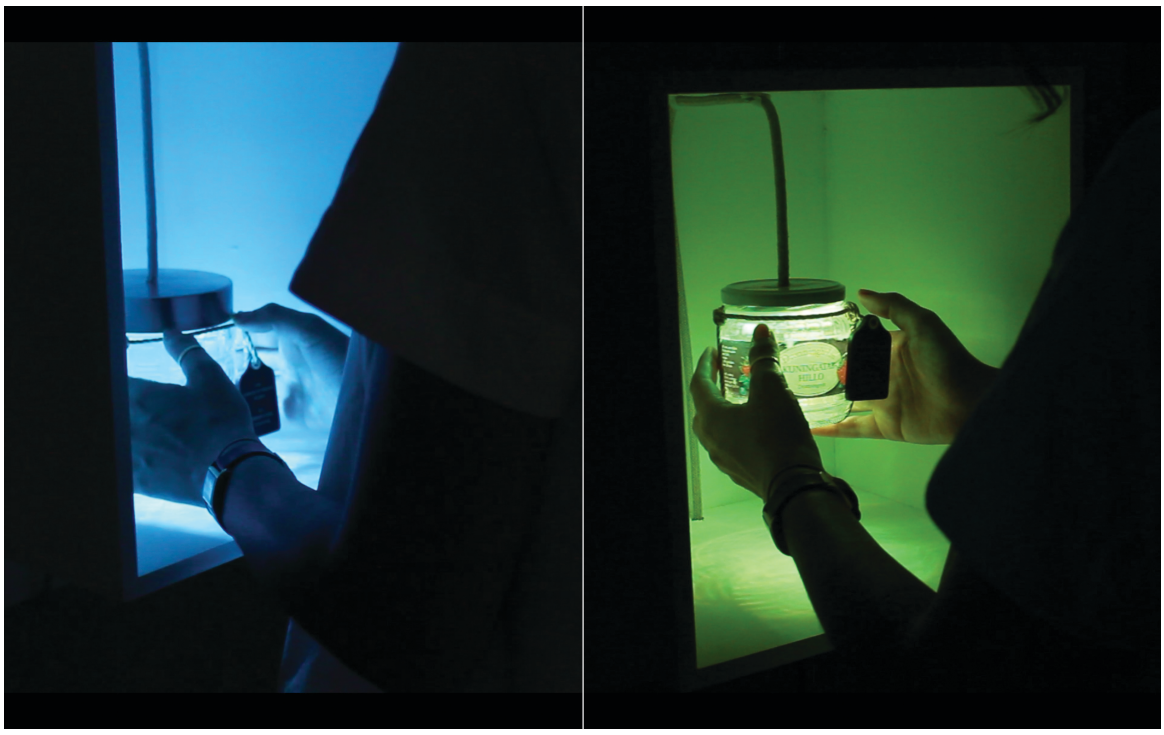

Figure 2. A visitor interacting with *Light Collector* in the exhibition, Seoul, 2016.

Light Collector is an interactive art installation that reacts to the touch of hands (*Figure 2*). The artwork consists of five glass jars containing lights, which represent the nature of

Finland. When a person covers the jar with her hands, it starts to glow with light. The first version of *Light Collector* was intended to simulate collected summer sunlight, as Finland has a long and dark winter that induces the collective feeling of missing the light. Since the artwork is all about telling a story of light collection, I wanted it to look like a magic rather than a electric device working with a switch. Accordingly, the interaction of participants covering the jar with their hands gives a feeling of touching something warm and precious. It was my attempt to bring an emotional experience by interaction.

Figure 3. Dancers performing with Passio musicae open source in Ateneum, Finnish National Gallery (Jonathan Loyche, 2015).

Passio Musicae Open Source (*PMOS*) is an interactive audio installation and sonification (*Figure 3*). This installation allows participants to trigger certain sounds as they walk around a space. Participants can engage their bodies to play a rich range sound, since different sound sources are mapped onto the space. This bodily engaging interaction was implemented through Microsoft's Xbox Kinect sensors. As it was a big team project and I mostly focused on the programming, I could learn to use Kinect's technology and implementation. The experience also gave me an opportunity to explore the possibilities of full-body interaction, which to an extent inspired me to come up with the concept of *MOD*.

Looking back on these three aforementioned projects, I have found that each one has its relevance to *MOD*. *MOD* seems to be an extension of my previous attempts and studies, and it is surprising that I have not recognized this connection before. I am pleased to realize that my interests and studies support continuity and relate to each other.

1.2. Structure

The body of this thesis is comprised of three parts. The first part (Chapter 2) introduces the overall context of the thesis. The underlying concept, a pioneering work, and museum context are discussed.

The second part (Chapter 3) describes the project *Move or Die* in detail from its conceptualization to final outcome. Explanations of the concept, as well as each component of *MOD* are specifically discussed.

The third part (Chapter 4) deals with the theoretical research behind this thesis. The chapter is dedicated to analyzing the interaction of *MOD* with three different approaches. The influences of the interaction on the players' experience are investigated through the literary research and application of frameworks. This chapter is my attempt to ground the design of the interaction and to assign validity to its influence.

The last chapter presents my conclusive thoughts on this thesis.

2. Context

2.1. Embodied Interaction

The concept of Embodied Interaction was first introduced by Paul Dourish in 2001. Although he states that embodiment is not a new idea, it is apparent that he introduced the concept within the context of Human Computer Interaction (HCI) for the first time. The evolution of interaction models in computational systems has evolved toward increasing accessibility by incorporating existing human skills and abilities that are the center of tangible and social approaches to computing (Dourish, 2001). The author argues that tangible computing and social computing both incorporate this embodied approach directly, which means that they use our familiarity with the world of social interaction or the world of physical artifacts in designing the way we interact with these systems (Dourish, 2001). To borrow his words, they rely on "the way the everyday world works or, perhaps more accurately, the ways we experience the everyday world" (Dourish, 2001, p. 17).

This approach corresponds to the view of phenomenology in which Dourish (2001) finds the origin of embodiment. Embodiment is an important notion in the field of phenomenology. He explains that phenomenology sees mind and body as intertwined, and through this mind-body relation we understand and experience the everyday world by interacting with it and exploring chances of actions the world provides (Dourish, 2001). In other words, the way we perceive, feel, and think is formed by our active bodily experiences, which occurs on the basis of close linkage between the bodily physicality and the experience of physical surroundings (Hornecker, 2011).

Dourish (2001) clarifies that the term 'embodied interaction' should be understood as an approach for design and analysis of interaction, not as the literal meaning of it. This approach is pervaded in "a wide scope of systems relying on embodied interaction, body movement, tangible manipulation, and physical embodiment of data, being embedded in real space and digitally augmenting physical space" (Hornecker, 2011, p. 19).

Move or Die is one of the systems taking embodied approach in the design of its interaction. Even though *MOD* is a small 'system' designed for a single task, the interaction happening in *MOD* employs the ways we interact with the real world. In Chapter 4, I will demonstrate how the interaction of *MOD* takes the embodied approach by looking into different aspects of this interaction in detail.

2.2. Pioneering work

The pioneer of artificial reality and interactive art, Myron W. Krueger, explored interactive artificial environments already in the 1970's. He created early interactive media arts, some of which used cameras to track participants and respond in real-time. The development of tracking technology has produced sensors like Nintendo's Wii and Microsoft's Xbox Kinect which "have revived models of embodied interaction that Myron Krueger proposed in the 1970s" (Kwastek, 2013). In a similar context, Hornecker (2011) claims that tangible and embodied interaction is an implementation of Krueger's vision in a sense, as he supports expanded "physical engagement and direct interaction" (Hornecker, 2011).

One of his well known projects, entitled *VIDEOPLACE*, is a projected interactive environment in which participants can interact with real-time images of each other or with graphical objects in artificial reality. Krueger states that *VIDEOPLACE* reflects his consideration on how the real world can be represented in the world of a video environment. However, *VIDEOPLACE* is not a mere simulation of reality, but a modified version of the real world with extended abilities to overcome the limitations of physical laws. Participants can explore *VIDEOPLACE* by interacting with objects and the programmed environment. The system of *VIDEOPLACE* detects if the images of participants make contact with graphic objects, and responds to these changes (Krueger, 1991).

Krueger (1991) claims that the participants feel a connection to their own images on a screen, and thus feel self-consciousness about these self-images much as they would about their own bodies. Accordingly, Krueger (1991) asserts that the moment when the

interaction between a participant and an object occurs, "both the object and the experience become real." (Krueger, 1991, p. 39) The argument shows his conviction of the possibilities that *VIDEOPLACE* possesses. Krueger saw *VIDEOPLACE* as a new medium in which new types of interactions can be explored, therefore testing and developing various applications based on it.

Figure 4. A person interacting with *CRITTER* (MediaArtTube, 2008).

One example of a related application is *CRITTER* (*Figure 4*). *CRITTER* is inspired from observation of his previous project, *METAPLAY* (Krueger, 1991). He observed that people react to a mouse cursor on a screen as if it were alive. He then got the idea of "a playful sprite with an artificial personality" (Krueger, 1991, p. 46). The graphical creature reacts to the silhouette of a particiant: it tries to chase the image, climb up to the top, or dangle from a finger tip. In Krueger's observation of how people interact with *CRITTER*, I noticed an especially interesting behavior sequence:

> After seeing thousands of people try to capture CRITTER with their hands, we made it sense when it is surrounded, search pathetically for an exit, and explode if there is no escape. Happily, reincarnation is instantaneous. (Krueger 1991, p. 46)

This particular behavior corresponds to the behavior of the graphical animals in *MOD*. When surrounded by the silhouette of players, the animal struggles to escape and eventually dies if no other action is taken. Then reincarnation happens shortly afterwards. The observation on *CRITTER* in a way supports that *MOD* makes good use of people's expectation concerning the behavior of a graphic creature: namely that people expect the creature to be responsive and that their silhouettes could apply physical force to it. Even though *MOD* present a circle rather than an exact silhouette of a participant, it works in a similar way, since the circle is a responsive modification of the

silhouette. Using the modified circle might reduce the feeling of self-involvement, but it also has the benefit of easily integrating multiple players into one unifying representation in collaborative gameplay.

To sum up, *MOD* contains similar framework to *CRITTER*, only with more embellished contents. One of Krueger's ways of perceiving an artificial reality describes both *CRITTER* and *MOD* accurately: "It is a space that the participant can explore, where he can interact with graphic creatures or become involved in a graphic adventure" (Krueger, 1991, p. 87).

2.3. Museum context

Museums have evolved to adopt various media to increase the variety of their exhibitions. In particular, the application of cutting-edge technology has received a wide interest since "[m]useum curators increasingly view digital technologies as a means to improve communication with visitors" (Rudloff, 2012). These technologies diversify the channels of communication, which helps to create engaging and participatory experiences for the visitors. In addition, interactives that the new type of media offer meet the need of the museum as "part of the entertainment and media industries" (Witcomb, 2006, p. 354). Accordingly, interactive installations have become widely exhibited in museums in recent years, now noticeable in "historical homes and sites; science and technology and nature centers; aquaria, zoos, and botanical gardens; as well as the traditional art, history, and natural history museums" (Falk & Dierking, 1992).

Along with high expectation, there are critics seeing the application of new media in the context of the museum as "threatening the authenticity of the artifact, the authority of traditional sources of knowledge, and as vulgarizing museums" (Henning, 2006, p. 302). However, it is too early to conclude that interactive installations do not offer much, since the study on the influence of interactive media exhibits on visitors' experiences is relatively deficient (Rudloff, 2012). *Move or Die* was born into the status quo, where expectations and skeptical concerns intermingle. Although I developed the project with healthy expectations and an optimistic view, I do not advocate the use of interactive media in a museum unquestioningly. Therefore, the musem context is handled with great consideration throughout this thesis, in order to better understand the influence of *MOD*.

Figure 5. Visitors playing *Move or Die.*

3. Project

This chapter is dedicated to describing the project, *Move or Die* (*MOD*) (see *Figure 5*). Firstly, the ideas behind the concept development will be discussed. Secondly, I will describe different components comprising *MOD* in regards to their content and purpose. Lastly, the gameplay scenario and observation on user test will be discussed.

3.1. Concept

The Finnish Museum of Natural History was looking for an idea for "[a]n activating, multi-sense, interactive, educational and experimental exhibit" (L. Schulman, presentation slides, October 7, 2014) that visitors of the museum could actively participate in. At the introductory presentation, the museum staff presented the aim, directivity, and conditions of the idea they were looking for. Based on that, I summarized three main requirements that I considered essential to accomplish the objective:

1. It must be simple and easy to use.
2. It must reflect one of the research contents of the museum.
3. It must evoke the feelings of the visitors.

I will examine each item regarding its significance and expectation, and then conclude how they are adapted into the final concept.

3.1.1. Usability

As museums pursue multisensory experience, the use of cutting-edge technology has become inevitable. However, the use of personalized interfaces along with unfamiliar technology can easily induce a negative user experience through complexity and unclarity. Museums have a wide range of visitors with different ages, genders, education levels, and technical standards. For that reason, a visitor's experience relating to the technology implemented can be extremely different from another visitor. Therefore, the technology and interaction approaches should be simple and easy to use for the majority of visitors.

Eva Hornecker and Matthias Stifter, the two authors of *Learning from Interactive Museum Installations About Interaction Design for Public Settings* (2006), evaluate user experience with interactive installations in an exhibition at the Austrian Technical Museum Vienna (TMW). Through various techniques of evaluation—interviews, observation, and analysis of log files—they interpreted the following: visitors' behavior

regarding 1) where and why they stay for a longer or shorter time, 2) how they interact with the installations, and 3) whether a group of people acts differently than an individual visitor (Hornecker & Stifter, 2006). The authors report that installations with usability issues showed low usage: 1) the one that takes several minutes to figure out how to use, 2) the one that requires actions that are demanding even for adults, and 3) the one that has a delay in the system response time (Hornecker & Stifter, 2006). As a result, the authors advise that it is indispensable to lower the threshold for interaction in order to facilitate access of users, particularly when considering the limited time and attention that visitors can spend on one installation in a museum (Hornecker & Stifter, 2006).

In another paper, entitled *Towards an Integrative Approach to Interactive Museum Installations* (2013), Ray and van der Vaart investigate how user interface design and other factors can affect the experience of museum visitors. Ray and van der Vaart (2013) evaluated two different interfaces for the same installation by comparing feedback from users. There was an interface with a simple approach, and another with a more complex approach. The authors concluded that the simple user interface was more successful than the complex one from the perspective of user experience (Ray & van der Vaart, 2013). Even though the complex interface provided more access to the contents, most of the users preferred the simple UI, which enabled them to navigate its contents relatively easy and in a shorter time (Ray & van der Vaart, 2013). In other words, more freedom for exploration ultimately works as a constraint to the users in practice.

The study consequently shows that detailed control with more functionality may not always be what users need. To understand unfamiliar interactions (such as body movements and subsequential feedback of the system) and use them proficiently requires significant time and effort from the users. It is not a desirable situation that users' energy is spent on learning how to use the system instead of learning contents. The overloaded congitive system causes a negative impact on learning (Kiili, 2005).

This research supports the idea that simple and easy usability is effective for an installation with personalized user interface. Based on these arguments, simple and easy usability became the most crucial precondition for my concept, as outlined in the following points:

To be understandable for a wide range of visitors.

To be doable for a wide range of visitors.

To take as little time as possible to learn.

To have only one interaction goal.

3.1.2. Research content

The International Council Of Museums (ICOM) defines a museum as follows:

> A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment. (The international Council Of Museums [ICOM], 2007, para. 2)

Being informative and educative is undoubtedly one of the main objectives of a museum. The Finnish Museum of Natural History (Luomus) understandably wanted one of their research methods to be reflected in a concept designed to educate visitors about climate change. The museum presented three different research methods regarding conservation of species studied at Luomus and encouraged to include one of them in the concept idea.

One of these research methods is called 'assisted migration' $(AM)^2$. Assisted migration is implemented to help species move to where they can thrive. This is used when their original habitats are not ideal anymore, but they cannot migrate to better habitats by themselves. I chose to adopt the central notion of assisted migration—direct human intervention for migration—to instruct people on the issue of endangered species, as well as to provide them a simulated experience of saving a species, which satisfies the purposes of education, study and enjoyment.

[2] Recently formally defined (by Luomus researchers) as follows: "AM means safeguarding biological diversity through the translocation of representatives of a species or population harmed by climate change to an area outside the indigenous range of that unit where it would be predicted to move as climate changes, were it not for anthropogenic dispersal barriers or lack of time." (L. Schulman, presentation slides, October 7, 2014).

3.1.3. Experience

The museum wanted to evoke the feelings of visitors by enabling them to see the issue of climate change in a more personal light. As the objective is not merely the delivery of information, I needed to create a participatory experience rather than a passive one. To be engaged in an activity or an event can help someone become immersed in a situation. In addition, I wanted participants to engage their own bodies actively to make the experience more personal. To use the body plays a role in internalizing the experience, which is significant to evoking feelings. As a result, the concept employs full-body interaction as a central experience of this installation.

3.1.4. Gamification

In addition to the three initial requirements, I added a gamification feature to the concept. The definition of gamification is "the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals" (Burke, 2014, para. 1). There are attributes of gamification that are different from a game in a classical meaning. *Move or Die* (*MOD*) has mixed attributes of game and gamification (see Table 1). The colored blocks are attributes that *MOD* adopts (Index number 1,2 and 5 in Gamification, and index number 3,4 in Game).

Gamification enables the delivery of detailed content alongside playability. In addition to the experience, detailed scientific content needed to be delivered in *MOD*, such as different kinds of species, realistic threats and obstacles to each one, and the results of assisted migration. The contents are illustrated in the background so that participants can observe them during gameplay. In other words, the gamification satisfies two objectives without conflict: instructiveness and playability.

Although I refer this project as a game for the sake of convenient reference throughout this thesis, I must clarify that my approach of the thesis considers the project as a gamified installation rather than a game, since the written work concentrates on the analysis of interactivity of an installation that is situated in a museum environment.

Table 1

Difference between games and gamification ("Gamification of Education", n.d., para. 8).

Index	Game	Gamification
1	Games have defined rules & objectives	May just be a collection of tasks with points or some form of reward
2	There is a possibility of losing	Losing may or may not be possible because the point is to motivate people to take some action and do something
3	Sometimes just playing the game is intrinsically rewarding	Being intrinsically rewarding is optional
4	Games are usually hard and expensive to build	Gamification is usually easier and cheaper
5	Content is usually morphed to fit the story and scenes of the game	Usually game like features are added without making too many changes to your content

Note. Reproduced from Gamification Wiki.

3.1.5. Final Concept

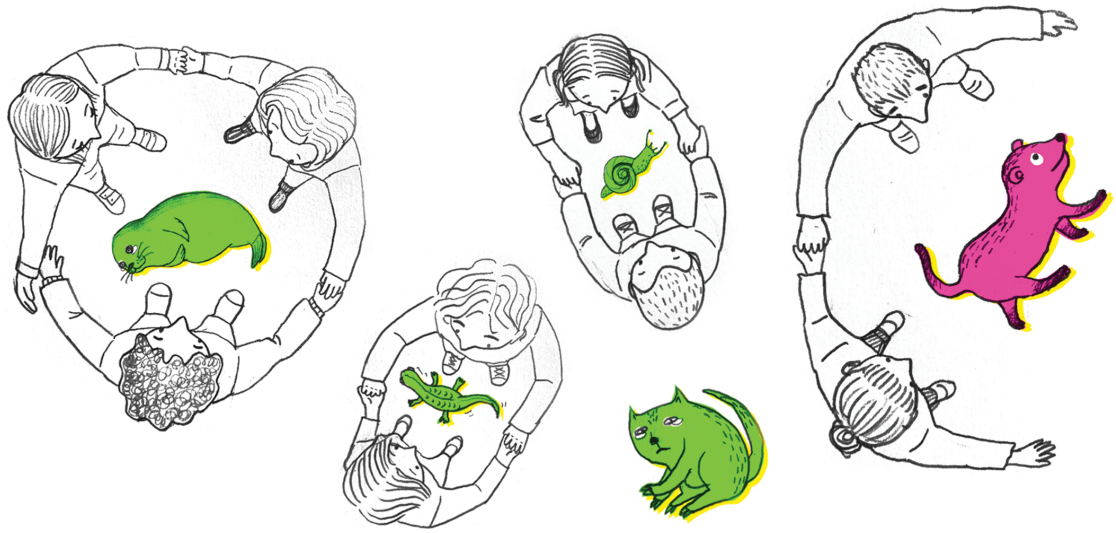

Figure 6. Final concept sketch.

Based upon the requirements and contents provided, I proposed the concept of interactive game installation (*Figure 6*).

> When visitors walk into a game area, an endangered animal appears on the floor. Players have to move the animal to a safe area to save it. To move it, a player has to capture it by surrounding it with their own arms. Multiple players can do this by linking their hands together. Once they capture the animal, they should move to the safe area without losing it.
>
> The concept supports simple and easy usability.
> The concept reflects the research method of assisted migration.
> The concept enables participatory experience through bodily interaction.

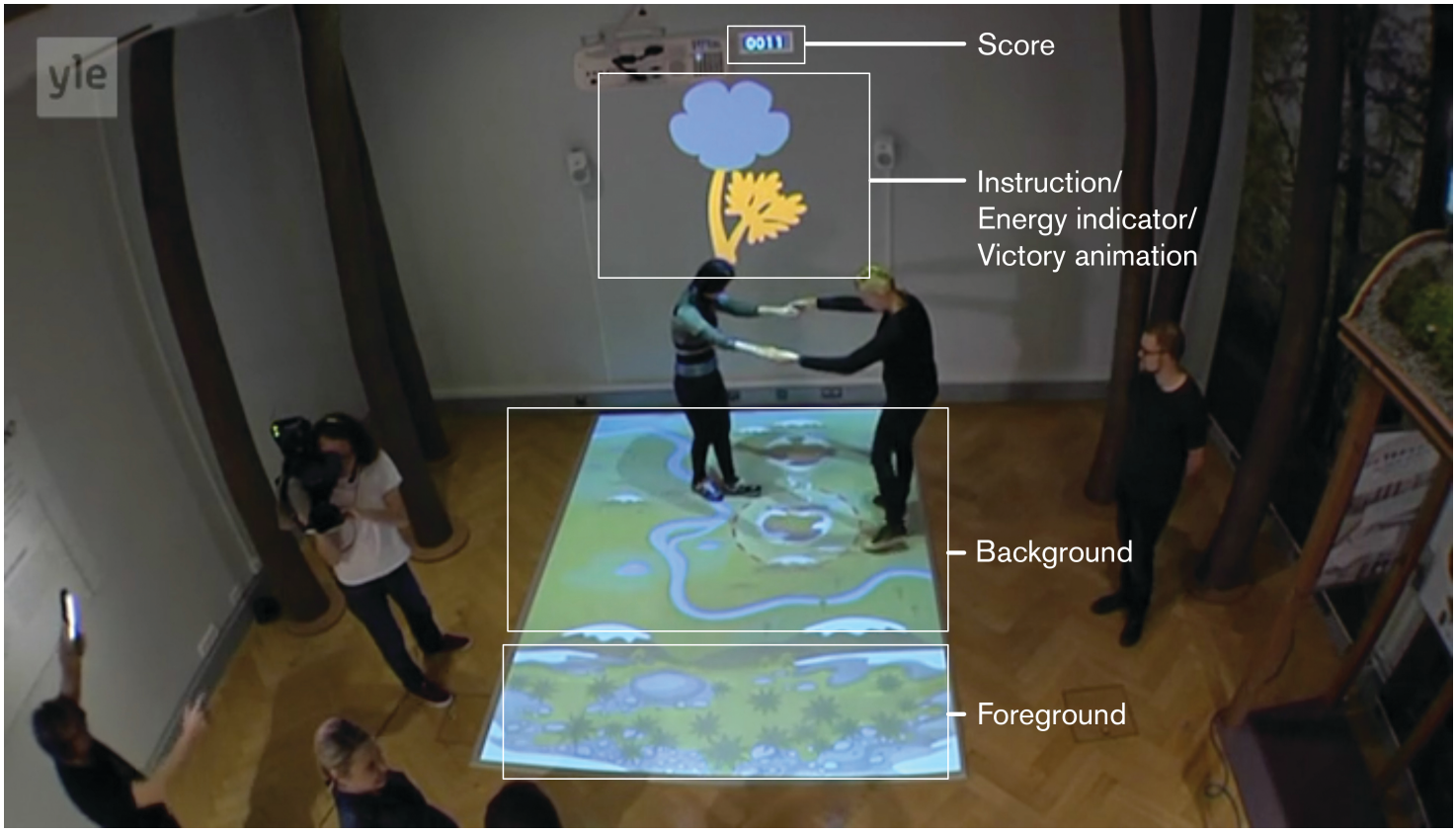

Figure 7. Two players playing *MOD* in the museum. The graphics of lines and texts are added on the screenshot of the video to show how the game area is structured (Ylen aamu-tv, 2015).

3.2. Content

The contents of the game are projected on two different surfaces, the floor and the wall (*Figure 7*). The floor is the main area where the actual gameplay happens. The floor consists of two areas, the foreground and the background. The foreground is a deadly habitat and the background is composed of obstacles. The game starts from the foreground and proceeds toward the wall. The wall includes contents of instruction, an energy indicator, a victory animation, and the score.

The size of the projected area on the floor is approximately 2.5 m by 3.5 m. The floor is lifted a few centimeters and the edges are inclined to facilitate wheelchair access. Around the game area there are artificial tree trunks and free space for spectators to stand and watch others during gameplay.

3.2.1. Character and background

The researchers of the museum had selected five animal and plant species which are affected by climate change. They provided the information of the scientific names, environmental changes, and the ideal target habitats of each species (see Table 2). Based on the contents, the graphic designer created characters and backgrounds for each species, divided into five different scenes according to each of the selected species: butterfly, toad, flower, fish, and polar bear.

Table 2

Five species, their habitats and threats

Kind	**Scientific name**	**Area**	**Symptoms of climate change**	**Obstacles**	**Ideal habitat**
Butterfly	Silver-spotted skipper (Hesperia comma)	Northern hemisphere	Dry land Plants dying	Mountains, river, cities	Green meadow
Toad	Panamian golden (Atelopus zeteki)	Panama	Pond drying	Cloud forest Rainforest	Pond with lush vegetation and moist meadow surrounding it
Plant	Glacier buttercup (Ranunculus glacialis)	The Arctic (Alpine meadow)	Snow melting Lack of growing space caused by invasive plants growing too close	Swamp Fell	Rocky land surrounded by snow
Fish	Coral coby (Gobiodon okinawae)	Indonesia	Reef bleaching	Open sea Predators	Artificial coral reef
Polar bear	Polar bear (Ursus maritimus)	The Arctic	Ice melting	Open sea with no ice	Zoo cage

Other elements comprising each scene are patches and a guiding line. The patch is the imaginary place where the animals and plants can temporarily stay on the way to the ideal habitat. As the patch represents a safe area, the illustration is similar in appearance to the ideal habitat of each species. The guiding line is drawn from the player's position to a patch a player should go. The feature was added after the first prototype since we observed that first-time players did not notice the patch soon enough. As Dourish (2001) notes, it is important to guide users' activity at every moment.

The degree of reality was a source of trouble throughout the entire production process. Because *MOD* illustrates specific content, there was often a need for deliberating between realistic and game-like representation. The appearance of each species was discussed with the museum staff since the beginning. The staff proposed a reference on the matter with the image of a snake collection (*Figure 8*). In the reference image, snakes are listed from too lifelike to too stylized, or from entirely photographic to overly cartoonish. The snakes from number four to nine were suggested as a desirable range as they are recognizable and cute to some degree. Naturally, other visual elements of *MOD* (such as background images and animation of the species) follow that same standard.

Figure 8. Collection of different snakes. The image shows the different degrees of realism of a snake character (L. Heikkinen, personal communication, December 31, 2014).

However, the size of each species is determined in relation to the size of the game area and human body. The rough size of a circle an adult alone can make is about 40 cm in diameter, therefore the size of a species cannot be much bigger than that. Additionally, the size of species cannot be too small in regards to visibility, since players look at the floor from a distance. As a result, the size of a species does not reflect reality much—there is no drastic difference between the size of a butterfly or polar bear.

Figure 9 shows screen captures of the five game scenes (butterfly, toad, flower, fish, and polar bear) including background, species, a patch, guiding line, and a blob.

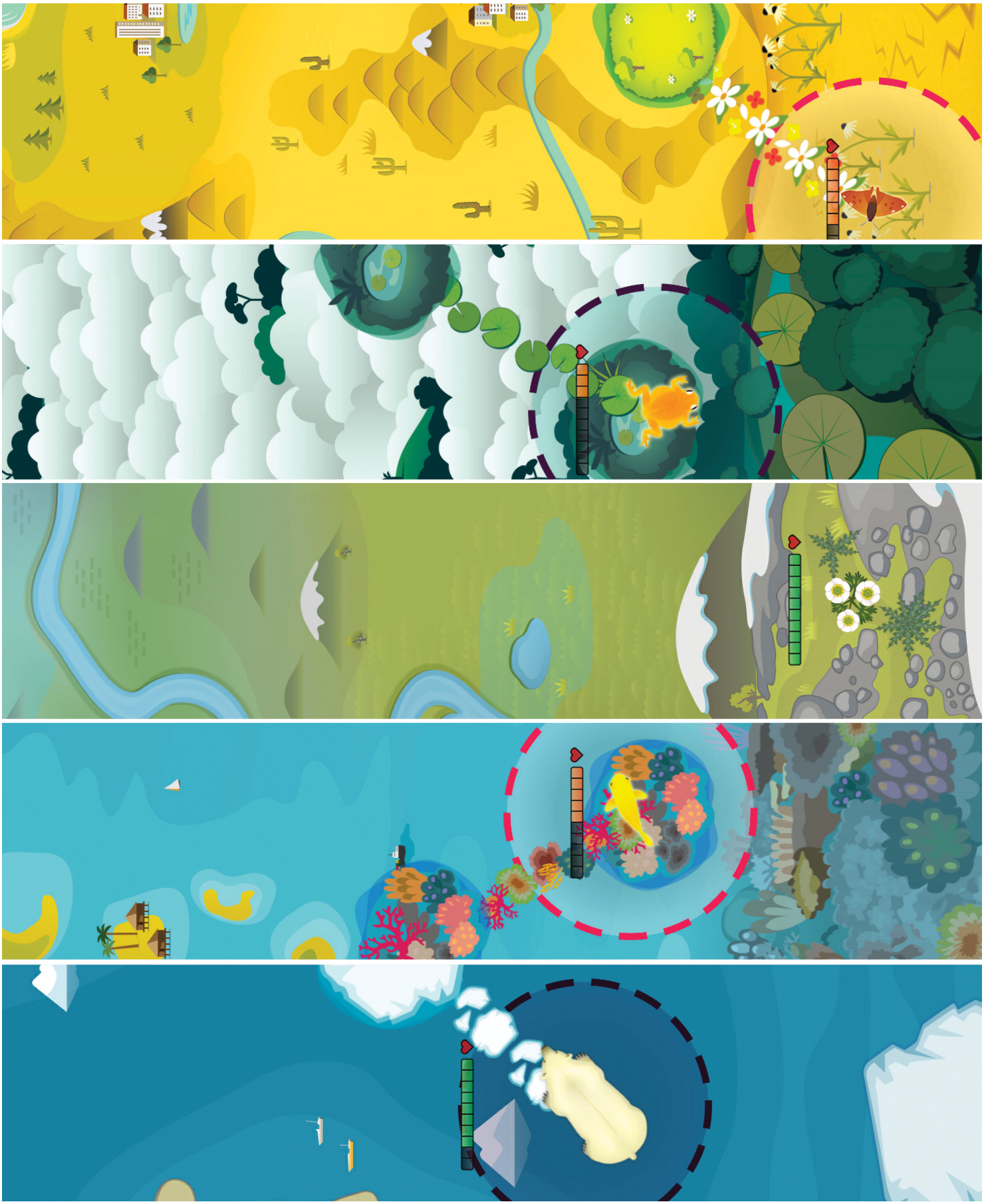

Figure 9. Five scenes with background, species and a patch: butterfly, toad, flower, fish, and polar bear (from top).

3.2.2. Sound

Move or Die has various sound sources designed for each species (see Table 3). The ambient sounds and species' sounds are aimed to design realistically. Ambient sounds embed environmental information about each species, and action sounds bring each species to life. Both the action and dropping sounds also indicate the state of species: if it is moving around, and if it is caught or released.

Table 3
Description of sound sources for each scene.

Species	**Ambient**	**Action**	**Dropping**
Butterfly	Dry wind, insect	Wing flapping	-
Toad	Swamp, jungle	Crying	Squashed
Flower	Strong wind	Plant growing	Seeds dropped
Fish	Ocean, wave, seagull	Swimming	Small splash
Polar bear	Ocean, wave, seagull	Stepping on snow	Big splash

On the other hand, there are artificial sound effects for occasions such as when species is caught, when species is on each patch (1^{st}, 2^{nd}, 3^{rd}), when energy is running out, and when the species is dead. The sounds are distinct from the realistic sounds, as they indicate the significant actions of players. They perform an important feedback functions that provide further information than visual elements alone.

3.2.3. Instruction

As Norman (2010) states, "most gestures are neither natural nor easy to learn or remember. Few are innate or readily predisposed to rapid and easy learning" (p. 6). Even though the interaction of the game mimics a conceptual model from the real world—blocking, capturing, holding and moving—it is never exactly the same as the reality. The action to lift arms to a certain degree and to hold hands is designed to adapt to an artificial setting which embeds technological limitations. Therefore, some instructions on how to play the game are necessary for the visitors. The video instruction is projected onto the

wall directly behind the game area. Players can see the instruction in full at the starting position of the game. The video consists of two scenes: single-player mode and two-player mode (*Figure 10*). Any text description is excluded for the purpose of eliminating any possible language barrier and complexity. Later while observing a user test group and museum visitors, it was noticed that the instruction seemed to be congruent with players understanding how to act and what to expect sequentially.

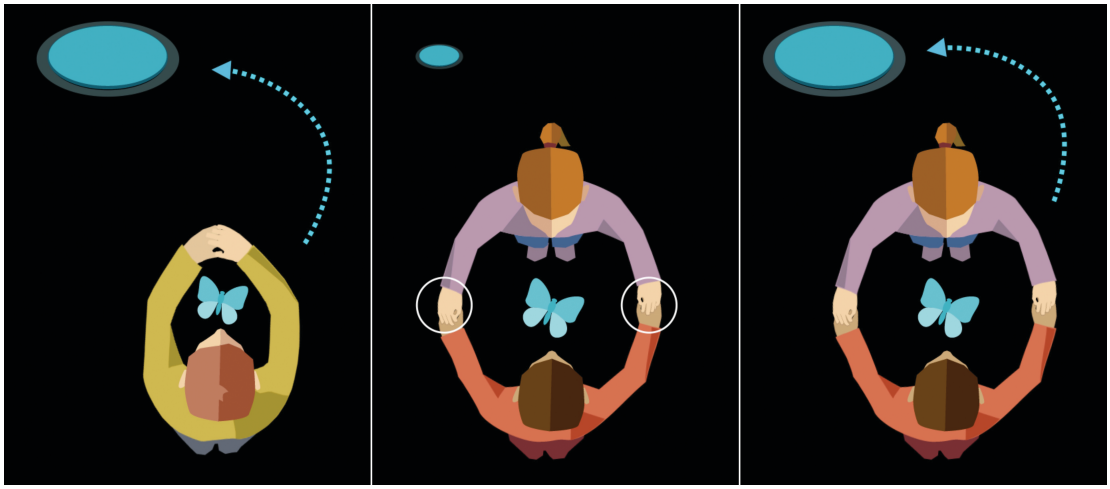

Figure 10. Instruction animation. The left image shows one-player mode and the other two images show multi-player mode.

3.2.4. Energy indicator

While someone is playing the game, the indicator of energy state of a species is shown on the wall (*Figure 11*). The content is designed for spectators of the game. The player's eyes usually focus on the floor so he cannot afford looking at the wall much. However, the spectators who observe the gameplay can check the energy level and even warn the player to hurry when the energy is too low. It provides a channel for the spectators to be a part of the game, which further emphasizes the collaborative trait of the game.

Figure 11. Energy indicators of different species: butterfly, fish, and polar bear (from left).

3.2.5. Victory animation

Victory animations show the species settled into better habitats (*Figure 12*): the butterfly in a meadow, a toad in a pond, a fish in an artificial coral reef community, and the flower on a cold mountain. The polar bear's ending is particularly interesting: migrated to a zoo. It is a rather crucial reward for 'winning' the game. Nevertheless, the museum wanted to reflect the reality in the game: the natural habitat of polar bears has almost disappeared, so they have nowhere else to live but the zoo.

Figure 12. Victory animations: butterfly, flower, toad, fish, and polar bear (from top left).

3.2.6. Score

The techniques of gamification seek to exploit the behavioral characteristics of people, such as competition, achievement, status, altruism, and collaboration ("Gamification", n.d., para. 3). The use of these points is one of the most common game mechanics used as a reward ("Gamification", n.d., para. 4).

MOD adopts scoring mechanics to give an objective to players. Every time a species is

saved, one point is added. Earning a score can provide the sense of accomplishment, which is a significant element to increase engagement. The score only continues to increase until the end of a day, then it resets to zero the next day. The score is used as a reward for collaborative efforts, not as a means for competition or the determination of failure.

3.2.7. Dwell time

To have a long line of people waiting to play the game is not a desirable situation. It is especially problematic in a museum where visitors often come in groups. Therefore, the overall gameplay time of *MOD* should not take too long.

Each scene (i.e. one species) of *MOD* takes about 30 seconds when it is played without a mistake; it takes around 3 minutes in total, including the time of watching the instruction animation. Although 3 minutes is a relatively short time required to play an entire game, the feeling of short and long can be subjective. Additionally, the necessary time for gameplay depends on the individual capability.

The discontinuity of *MOD* also helps keep its efficiency. The five scenes are disconnected and each one has its own beginning and ending. The player starts to play at the scene the previous player left, and the instruction animation is continuously played. People can interrupt and play at any time without additional operation and waiting according to the situation. Players can choose how many scenes to play, which can limit dwell time when it is necessary.

3.2.8. Difficulty

Museums naturally have a wide range of visitors. It is therefore desirable to increase accessibility for as many visitors as possible, despite the target audience of *MOD* being weighted towards underage students. Thus, the difficulty degree of *MOD* is standarized downward to support the gameplay of even young children. It also facilitates circulating turns of different players. The initial plan of having different degrees of difficulty for each scene was discarded to prevent a player from getting stuck in one level.

Settings in the game have been adjusted to control the game's difficulty: the speed of the animals, the speed of energy lost, the speed of animals running away, the size of the animals, and more. The values of these settings have been adjusted numerous times throughout the development process of the game to find the right level of difficulty.

In the user test, the students the around age 14 showed no difficulty in playing and understanding the game. For younger preschool children it can be more demanding, but they can still play the game with the help of their guardians.

3.2.9. Gameplay scenario

I will describe the process of the gameplay with an example of single player in the butterfly scene.

a) Start

The starting of the game is the deadly habitat in which an endangered species cannot escape. A butterfly is flying around in the deserted habitat where flowers are drying up. The butterfly is flapping around hastily, trying to escape the deadly environment.

However, beyond the habitat, there are cities, a wide river, and high mountains, all of which obstruct the butterfly from migrating to a desirable habitat. As time passes, the energy of the butterfly diminishes, and then the butterfly dies and disappears eventually. However, a new butterfly flies into the deserted area soon again.

b) Play

A player enters into the game area. She lifts her arms and holds her own hands together. As she makes a blocked area in the air, a circular dotted line appears under her arms on the floor. The circular line is a tool to capture the animal. The tool is scaled and moved according the position of the player's arms. She walks toward the butterfly and orients her body to overlap the tool with the butterfly; The butterfly gets caught in it.

As soon as the player catches the butterfly, a green meadow patch appears on

the area with obstacles. A guiding line is drawn toward the patch. When the animal is caught by a player, its energy goes down even faster so there are only few seconds left until it dies. The player has to move quickly to keep it alive.

The player walks toward the patch and moves the butterfly on top of it. The butterfly regains a bit of energy when it is inside of the patch, and the second patch appears in a different position. The player moves to the second patch, and the third and last patch appears in a different position.

c) End

As the butterfly arrives safely on the last patch, the player loses control of it. The butterfly flies toward the wall and disappears out of the game area. After the butterfly flies away, a score is added and a victory animation is played on the wall.

The scene is then changed to the next, a fish scene.

All the species except the flower have the same storyboard. As the flower is the only botanical species, it has a different type of animation. In reality, migration of the endangered flower requires the preservation of its seeds. The seeds are preserved in a seed bank and then planted in a good habitat, if possible. To reflect reality, the game illustrates the transformation of the flower to the seeds. The players can move the seeds only after the transformation ends. To use the concept of a seed bank was also discussed, but it was eventually dropped to keep the consistency with other scenes.

The species in the detrimental habitat die when there is no intervention to save them. Even though it is a correct reflection of reality, there is the problem of a constant reappearance of the species. It might give the wrong impression to players that there is unlimited amount of species, as if the endangered species are never going to be extinct. However, if the species keep moving in a hostile environment and never die, it might also give the impression that the species are not endangered. As neither is necessarily the wrong choice, the repeated death scenario was chosen. It was the decision of the museum to emphasize the severe situation the endangered species face, and is one of the factors that shape the story of the game, along with the tragic ending of the polar bear. The orientation to reveal the harsh reality is shown here significantly.

3.3. User test

The user test was conducted in October 2015. The students of a local school, all around 14 years old, participated in the test. The group was divided into two, a small group with two participants and a bigger group with seven participants. We aimed to get more detailed feedback from the small group and expected to observe different user behaviors between the two groups. Before participants saw the game, they listened to an explanation concerning what the exhibition would be and the objective of the test. However, any information regarding the game content and rules was not divulged in order to observe how the participants access, learn, and interpret the game from beginning to end. Any non-verbal interference was not allowed from the moment participants enter into the room. In this chapter, I will illustrate my observation on each session and how some findings are reflected in *MOD*'s final version.

The first group consists of two male students. They stand outside the projected game area and watch the instruction animation on the wall. After watching it for three loops, they observe the moving endangered animal (the fish in this case) on the floor. They first try the two-player mode. They mimic exactly the same gesture as the instruction animation, placing their hands palm down with only their fingertips touching the other's, making an unstable circle with a loose connection. The intention of the instruction is to show that multiple players have to hold their hands or connect them, but could be misinterpreted by the uncertain illustration.

The players' unexpected fidelity to the instruction enables detection of an issue which otherwise might be missed. The image is modified afterward to have overlapped hands. With the slightly modified image, the same issue did not occur again in the observation of museum visitors. There is a possibility that the participants of the test group may have felt pressure from being observed, and were therefore overly discreet.

Not long after the two boys catch the fish, its energy runs out and dies. The participants show enlightened expressions. The participants seem to learn the rule of 'move fast or the animal dies'. This rapid cycle of birth and death seem to facilitate fast learning following an early failure. After the failure of their first trial, one participant catches the fish alone. The other participant instructs him to go to a new patch. The natural

communication between the players occurs. They successfully move the fish to the final patch and watch the victory animation on the wall. The victory animation catches the players' attention at the right timing. My concern that the players might miss the victory animation while they walk back to exit the game area becomes a non-issue.

As the scene changes to the polar bear, the participants try the multi-player mode again. It seems that the participants assume more people are needed to catch a bigger animal, even though the size of the circle does not affect the gameplay as long as the size is big enough to be shown. In the multi-player mode, the players show difficulty in placing the animal on a patch. The problem is that the animal should be placed right at the center of the patch, so sometimes one player has to move outside of the game area to access the center of the patch (which is places at the area's edge), making them lose the animal. A few adjustments were made to fix the issue: the position of patches were adjusted to be further inward, and the species is dragged to a patch automatically when a little part of it touches the patch. The participants show more interest in the ending of the polar bear than with the other species.

The second group consists of seven students. As the session starts, all of them step into the game area at the same time. They first try to understand how the circle reacts by repeatedly holding and realeasing their hands. While most students play with making circles, one participant catches the animal. The active participant successfully plays few scenes. Subsequently, the phenomenon of modeling within the group occurs—the other passive participants also start to join the gameplay.

After the successes, the player becomes so skillful that the time required to play a scene is immensely shortened. From this point, it is clear that the game is not challenging enough to intrigue the player to continue playing. As the group explores the game with progressively less self-consciousness, some students express sympathetic emotion with facial expressions and exclamation of pity when the animal is dropped or dead. Even though there is no visible reaction when it is dropped, the sound feedback of the dropping sound seems to work as a strong indicator of the action. The same reaction is observed when some players intentionally step on the animal. Although the pitiful emotion is accompanied with entertaining emotion, it shows that there is a certain degree of empathy involved in their experience.

After the participants play the game as long as they want, a discussion session proceeds. They answer questions regarding their general feeling, understanding of the content, and difficulty or uncertainty of the game. Overall, they provide positive feedback and show a clear understanding of the content. The negative comments were about the uncertainty of the flower scene and the degree of difficulty. The different type of animation sequence in the flower scene causes hesitation, and the game is deemed not challenging enough for the participants.

We did not modify the animation sequence however, since the participants figured out the rule not long after. Nor did we increase the difficulty of the game, since we understood that the age group did not fully represent the different age groups of museum visitors; this user test cannot be used as an absolute criteria to evaluate the full user experience of the game. The game can be much more challenging for younger players. However, I would regard the test as significant to observe certain user behaviors and draw meaningful findings and practical issues from it as a result.

Additional findings

In demonstration sessions, I learned that people do not necessarily face toward the wall during gameplay: instead they adjust their bodily orientation frequently. Since I presumed that players would face the wall as I did, I adjusted Kinect tracking to work best with the orientation. It was a hasty assumption and I changed the setting back to neutral so that the bodily orientation would not affect the tracking.

I also found that young children tend to try to touch the graphical animals on the floor as if the floor is a big touch screen. Although it seemed like a good idea for the animals to be responsive to touch, we did not have time to work on the extra function. It could have enhanced the feeling of empathy, since people interpret it as something more like a social actor when it is more responsive (Norman, 2004). However, it could have misguided players into thinking that touching is related to a function of the game and given a false impression that touching or harassing the endangered species is acceptable. As a trivial change like this can have an impact on overall experience, “designing for specific forms of action and interpretation require designs that are simple and well defined with clear interactive and non-interactive elements” (Price et al., 2016, p. 581).

3.4. Technology

The application of *Move or Die* is built on openFrameworks. Two Microsoft's Xbox Kinects and three projectors are used to realize the installation. In this chapter, I will describe the major technical matters I dealt with during the production process.

Figure 13. Kinects and projectors installed in the museum. Two Kinects and two projectors face down to the floor, and one projector faces the wall.

3.4.1. Kinect

The Microsoft's Xbox Kinect sensor is optimized for the motion detection of the human body. Although this technology is suitable for *MOD*, there were challenges caused by using two Kinects and tracking from the top of a head. I will describe them now, since they were unexpected and time-consuming to perfect the tracking for the game. Moreover, it might also be informative for people who want to use Kinect in a rather unconventional way as I did. However, I will not elaborate detail concerning the solutions to these issues, as they involve a lot of programming jargon.

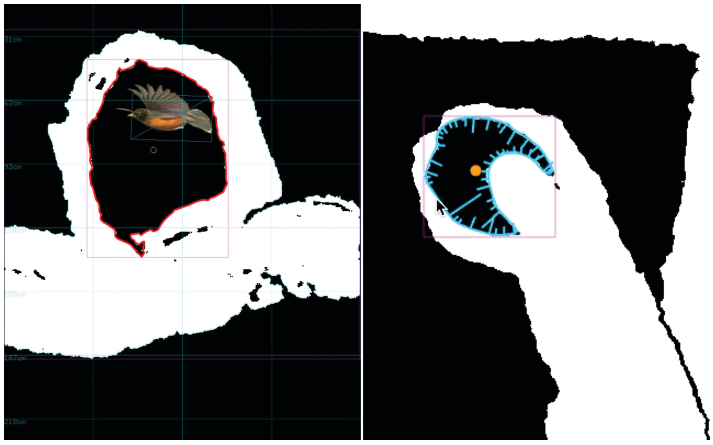

Figure 14. Tracking test from a frontal view.

There was early tracking testing performed in the initial planning, using one Kinect sensor (see *Figure 14*). Since one sensor is placed in front of a person, issues of merging two images or blocking the tracking area were not found at that time. The tracking seemed to be clear and stable.

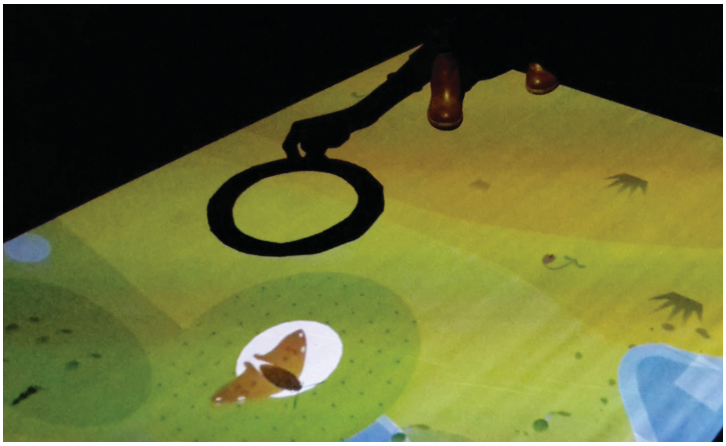

Figure 15. Tracking test from a top view at a low height.

A subsequent test (shown in *Figure 15*) was done with one Kinect installed on the ceiling. This was the first time I could set up a Kinect and projector simultaneously, but the ceiling was so low that I had to use a tool to create a blocked area. Again, issues related to tracking could not be found, but the mismatch between the projection and the actual tracking area was identified. The distance between the shadow of the tool and the butterfly shows how big of a mismatch occurred, since they are supposed to overlap.

With the help of Design Factory (Aalto), we installed two Kinects at an appropriate height of about 4 metres. Once we had the right setting for Kinects, the issue of merging the two video images was identified (see *Figure 16*). Even a tiny tilt of the Kinects can cause huge distortions of the images. This tilt made a blob (marked by the red line in the *Figure 16*) that disappeared when a person passed by the area where the two images met. This

could not be fixed by the mere adjustment of the Kinects.

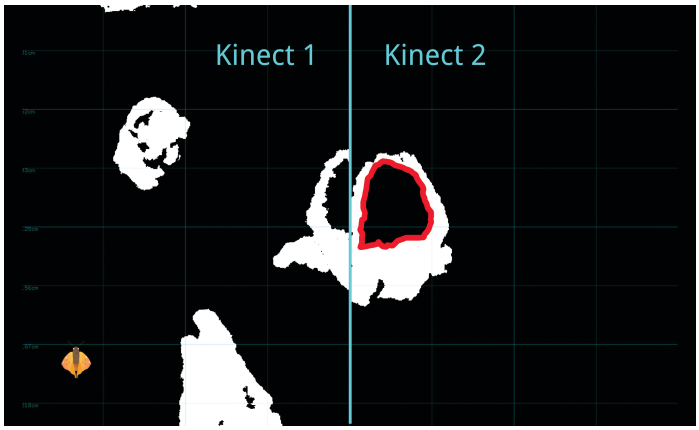

Figure 16. Two Kinect images not merged properly. The middle of the image clearly shows that the two Kinect video images are not aligned.

Another issue caused by the overhead tracking is that a person's head can block the Kinect's view. The game uses the blocked area in front of a body, which seems to make sense from a player's own viewpoint. Unfortunately, the view of Kinects on the ceiling is completely different from a person: there is a head hiding the view of the blocked area. The way to clear the view is to hold my chin up and not to look down while playing, which lowers the quality of the entire gameplay and is impractical.

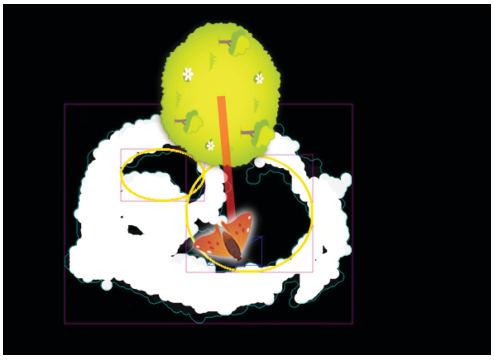

Figure 17. Two blobs caused by missed tracking.

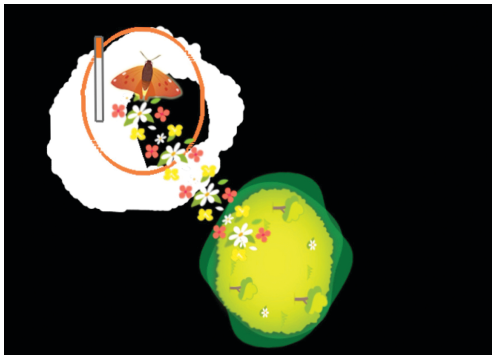

Figure 18. Stable tracking after modifications.

For an unidentified reason, Kinect did not track a certain part around the head. My assumption regarding this issue either relates to the position of a person or dark hair color. As shown in *Figure 17*, it created an unnecessary blob on the head, which caused confusion during gameplay.

The following changes were applied to solve the aforementioned issues and to enhance the tracking (*Figure 18*).

1. Instead of getting a depth image from Kinect, point clouds are used to create the tracking image, which facilitates a more detailed adjustment of the image.
2. The implementation of these point clouds enables fine tuning of the tracking image: contour size, position of point clouds (x/y/z axes), the area of tracking, depth range of tracking, etc., which solves the issues of the unnecessary blob and merging the two images smoothly.
3. A circle is drawn instead of using the actual contour of the blocked area (blob). It means that even if the head blocks a big part of the blob, a tiny bit of left space can be used to create the circle in which the species can be caught. The use of the original contour was to provide more lively interactive experience, but the alternative circle adapting to the width and heighth of the contour in real time also provides sufficient responsiveness.
4. A delay function (timer) is applied to each blob, which prevents frequent blob disappearance caused by a high framerate (30 fps) and/or noise.

3.4.2. Projection

One of the big issues with floor projection is that people cast a shadow, and this shadow covers the image on the floor (*Figure 19*). This can interrupt smooth gameplay and the delivery of contents. Two projectors are therefore used to mitigate the problem, facilitating the diffusion of the strong shadow by projecting the same image from two different angles. This enhances visibility of the image, but causes another problem: the two projected images do not match perfectly, creating an overlap that causes a blurry final image. To adjust the angle of the projectors or to modify projector settings did not solve the problem, as it requires fine tuning.

In order to fix this issue, a program enabling fine distortion of the projected images seperately was built. First, the vertices of grids are adjusted in the calibration program (see *Figure 20*). That data is then applied to the game application, which results in perfectly matching images. During the period of testing in the museum, it was found that the angles of projectors can change minutely as time passes due to vibrations from the ceiling. This means that calibration needs to be done occaionally to maintain a clear image. Accordingly, detailed verbal and written instruction was delivered to the museum staff so that they could maintain the installation on their own.

Figure 19. Difference of shadow intensity. The left image shows the dark shadow caused by using only one projector, and the other two images show more mild and diffused shadow in the setup with two projectors.

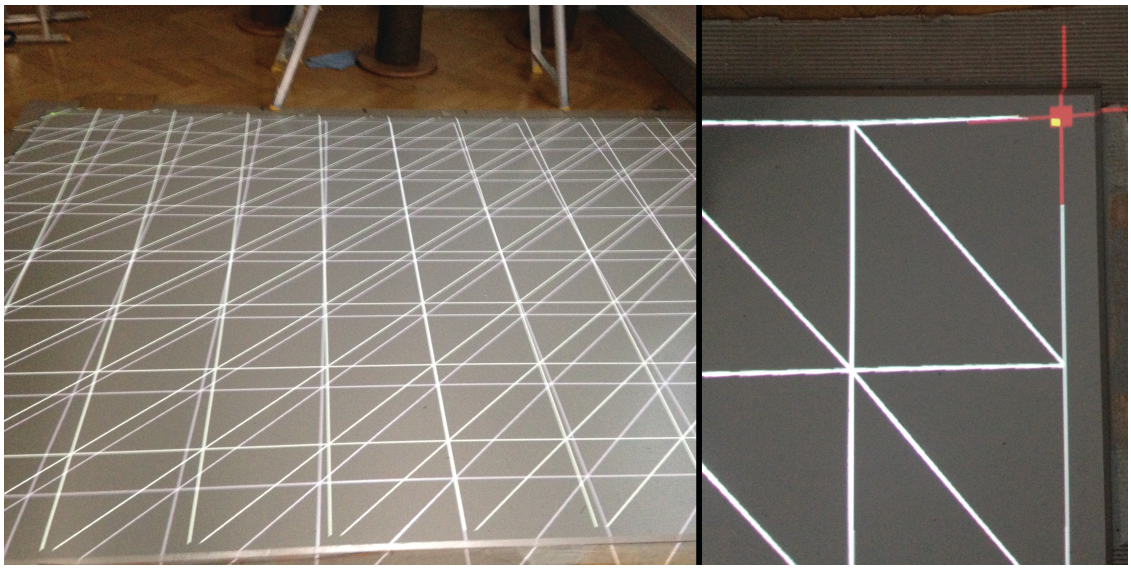

Figure 20. Calibration program. The left image shows unmatching grids before calibration and the right image shows part of the grid after adjusting the vertices.

4. Interaction

"I hear and I forget. I see and I remember. I do and I understand."

- Chinese proverb

Though the scoring is an important function of *Move or Die*, it is not an ultimate purpose that is expected for the players to reach. As endless chances of retrial are given to players without an extended delay, the damage from failure is very little. Even if a player fails to move a species to the final patch, the experience the player had is still valid concerning a sense of achievement.

Successful gameplay does get rewarded with a score and a victory animation, but neither of them help the rest of gameplay in quality. The two cases of success and failure may convey different messages from each other. However, it does not necessarily mean that one is particularly more meaningful than the other. A player with successful gameplay could feel satisfaction and think that it is rewarding to save an endangered species (even though it is artificial), but on the other hand, a player with an 'unsuccessful' gameplay could feel sorry and understand that it is quite demanding to save an endangered species (again, even though it is artificial). In short, players can reflect meaningfully on the reality of the situation regardless of the result.

Therefore success or competition is not the ultimate purpose of the game, as there is no winning or losing in the context of a typical game. To have the experience of saving an endangered species with the player's own intention and physical ability is the objective of the game, because the bodily experience of the player can shape the way he or she understands and feels about the subject of the game.

To understand the experience, it is inevitable to study the interaction the game affords. Accordingly, I extracted three key aspects of the interaction to support their influences on the players' experience: full-body interaction, reality-based interaction, and social interaction. Each aspect represents significant properties of the interaction: physicality,

reality, and sociality. In this chapter, I will investigate the attributes and benefits of each aspect on the basis of relevant literature, thereby better clarifying the very center of the experience.

4.1. Full-body interaction

The use of bodily movement as an input in interactive systems has been supported by artists, designers, and researchers (Norman, 2010; Bianchi-Berthouze, 2013; Snibbe & Raffle, 2009). Norman (2010) claims that "physical gestures can enhance the pleasure and engagement of participants" (p. 9). Bianchi-Berthouze (2013) asserts that "the increased involvement of body movement during game plays results in increased enjoyment" (pp. 40-41). She claims that the influence is one reason of success of games using full-body interaction such as Nintendo Wii, Microsoft's Kinect, and Sony Move (Bianchi-Berthouze, 2013).

The development of sensor technologies (e.g., the Microsoft's Kinect, the Asus Xtion, and the PrimeSense Carmine) and their ability of body detection with high accuracy have accelerated various uses of body movements in computational systems. Museums also employ physical interactivity to increase the engagement and enjoyment of their visitors. Providing a physical activity can satisfy a need of family visitors in a museum who expect to find "something enjoyable to do" for all the family members rather than just viewing an exhibition (Falk & Dierking, 1992). The use of physical gestures and body movements further enhance the learning experience of visitors, especially young children. Snibbe and Raffle (2009) support the view with studies of Bruner (*Towards a Theory of Instruction* in 1996) and Piaget (*The Grasp of Consciousness* in 1976):

> Younger viewers 4–10 years old absorb the educational and cultural message only as a secondary experience to their main experience of physical play, since children this age experience the world primarily through full-body interaction. (Bruner; Piaget;, cited in Snibbe & Raffle 2009, p. 1449)

Snibbe and Raffle (2009) further explain that people can comprehend the visceral

experience across boundaries of language and culture. It is certainly useful for a museum with international visitors, and *MOD* maintains this virtue by using text only for the score panel.

Taken together, the arguments above support that the use of full-body interaction is beneficial in the museum context. The full-body interaction brings increased enjoyment, which is one of the basic needs visitors expect to have met in a museum. It increases the effectiveness of education for children, who are the majority visitor group of a natural history museum. Additionally, the active use of full-body interaction maximizes the benefits of physicality more than the use of small hand gestures or objects can. Therefore, I claim that to use full-body interaction is a beneficial choice to support the educational and entertainment experience in a museum.

4.2. Social interaction

The maximum number of 4 or 5 people can play the game together by holding hands to create a blocked area and to move around at the same time (see *Figure 21*). This collaborative gameplay is a significant characteristic of the game, so much so that the very first concept phrase was 'Let's save the endangered species ALL TOGETHER'.

Collaborative gameplay is an essential function for people who have difficulties playing the game alone due to physical limitations. Preschool children who are too young to make a big enough circle can play the game with help of their guardians, since this feature widens the range of the user group. Another advantage is that collaborative gameplay facilitates communication between players, or even with spectators. Once multiple players hold hands, they have to move together to a specific position without releasing their hands. In this situation, verbal or non-verbal communication becomes inevitable. As players stand in a circle, there is a player whose back is facing the target position so that his vision is blocked. To guide the 'blind' player, the other players have to instruct him by saying where to go or by pulling and pushing him to the position. Spectators around the game area may also become involved in instructing the player. Consequently, the participants work in a collaborative and communicative way to accomplish the shared task of saving the endangered species.

From a semantic perspective, the primary purpose of having collaborative gameplay was to embed a message that more than one person's effort are needed to actually help the endangered species. For these reasons, it had be designed so that the game would work only when there is a minimum of two players. However, the idea was eventually dropped to provide an equal chance of gameplay to the visitors who are unaccompanied.

Nevertheless, the merits of collaborative gameplay should not be overlooked, as it encourages social interaction between participants. In this chapter, I will examine how the social context of *Move or Die* influences participants' experience.

Figure 21. Four people playing the game together.

4.2.1. Social immersive media

Snibbe and Raffle, the two authors of *Social immersive media: pursuing best practices for multi-user interactive camera/projector exhibits* (2009), report their interaction design principles and techniques to "create strong emotional responses and social engagement through visceral interaction" (p. 1447). I have found the principles informative and helpful in understanding the social aspect of *MOD*, since their study explicitly deals not only with interactive projected exhibits in museums, but also deals with their phenomenologically-driven approaches.

Snibbe and Raffle (2009) define the interactive system that emphasizes social interaction as social immersive media, explaining that they employ "the public and social nature of the museum context" (p. 1447). They suggest six design principles for social immersive media: visceral, responsive, continuously variable, socially scalable, socially familiar, and socially balanced. The principles are designed "to reward users' participation" (Snibbe and Raffle, 2009, p. 1449) by responding and reflecting within a proper setting. I will examine if the principles are implemented in *MOD* on the basis of the authors' case studies:

> *MOD* is visceral, since it responds to the body movements of players.
> *MOD* is responsive, as it updates the position and silhouette of players at 30 frames per second (fps).
> *MOD* is continuously variable, applying the updated changes to the projected images on the floor.
> *MOD* is socially scalable, accommodating multiple players without a change of setup. Players can have a richer experience by collaborating and interacting with other players. *MOD* is socially familiar, since it employs concepts of everyday actions such as blocking, catching, moving, and releasing.
> *MOD* is socially balanced, as its interaction requires a player's attention equally to the game feedback (media), graphical reflection of the player himself (awareness of himself), and other players (other users).

The substitution indicates that *MOD* satisfies the requirements as social immersive media: it reacts to the players' body movements and reflects the changes in real time,

supports collaborative gameplay of multiple players in a beneficial way, augments "existing collocated social behaviors" (Snibbe and Raffle, 2009, p. 1449), and "equally emphasizes a user's awareness of herself, other users, and the media itself" (Snibbe and Raffle, 2009, p. 1449).

Corresponding to the design principles gives validity to share the authors' argument—social immersive media provide the less strict and more relaxed and open way of learning that museums advocate (Snibbe and Raffle, 2009). Social immersive media can evoke strong emotional responses from the users by providing bodily engaging experiences in museums where public and social context is settled (Snibbe and Raffle, 2009). The authors describe the experiences as "emotional, social and physical" (Snibbe and Raffle, 2009, p. 1447). The wording is significant as it implies interrelationship between emotion, sociality and physicality. In a similar context, Bianchi-Berthouze (2013) asserts "that body movement supports cognitive processes, regulates emotions, and mediates affective and social communication" (p. 41). In conclusion, *MOD* as a social immersive media creates a physically, emotionally, and socially engaging experience, which brings the enjoyment and engagement of participants.

4.2.2. Emotion

Another study confirms the relation between social interaction and emotional engagement of participants. In the study of digital gaming in a socio-spatial context, De Kort and Ijsselsteijn (2008) argue that social context plays a role in shaping the emotional experience of players. The authors support the view that people's need to belong is the basis of high levels of arousal and positive emotions derived from the social context of game settings, and that a person's need to belong is fulfilled by being in a common social network and feeling each other's emotion while they play together (De Kort and Ijsselsteijn, 2008).

Jakobs et al. (1997) articulate that "social context effects on emotion" (De Kort and Ijsselsteijn, 2008, p. 5) is determined not by the mere presence of others, but by compositive conditions such as following:

What the role of the other people are

What their relationship with the other people is

Which emotion the situation is dealing with

If the other people express their emotions

More specifically, the role of the other people is distinguished by whether they are actors or observers, and whether they are competing or cooperating (De Kort and Ijsselsteijn, 2008). Along with this, the relationship between a subject and the others has an effect on the game experience. For instance, intimacy with friends or family could bring more warm and engaging interactions (De Kort and Ijsselsteijn, 2008), which is a big advantage for a museum exhibit, since group visitors are often comprised of family and schoolmates.

De Kort and Ijsselsteijn (2008) claim that local co-presence of others has strong influences on deriving social affordances such as monitoring, awareness, mimicry, immediacy, reinforcement, and verbal and non-verbal communication, which induces a sense of social presence. Mimicry is particularly important in facilitating social interaction, intimacy, and empathy between people (Bianchi-Berthouze, 2013). These all physchologically impact the players' experience (De Kort and Ijsselsteijn, 2008).

As *MOD* allows direct physical interaction with co-players at a close distance, it is presumable that those social affordances actively occur and impact the players' emotional experience during gameplay. In conclusion, *MOD* being exhibited in a museum where a lot of group visitors are already in close social relationships, as well as the fact that *MOD* supports the direct social interaction between participants indicate that the players' emotional experience can be strengthened during collaborative gameplay of *MOD*.

4.2.3. Learning

Because humans are social beings, we learn through social interaction by talking with, listening to, and watching each other (Falk & Dierking, 1992). School literature reports that "cooperative learning experiences may enhance learning" (Johnson & Johnson, cited in Falk & Dierking 1992, p.51), and working in pairs facilitates participants to supplement each other's "recollection and meaning-understanding" (Otitoju and Harrison, 2008, p. 201). As the collaborative gameplay of *MOD* facilitates communication between participants, it is fair to assume that the communication encourages discussion regarding the contents, and eventually assists learning.

Previous studies on social immersive media and social context effect suggested their strong influence on emotion. The cognitive psychologist Gordon H. Bower reports influence of emotion on memory and thinking based on his experiments. He argues that a person can remember an event better if he feels the same emotion he felt during the event. Furthermore, the intentsity of the emotion also enhances memory about the event (Bower, G. H., 1981). In other words, emotion works as a guide to access the stored memory. Since memory is an important component of the learning process (Falk & Dierking, 1992), if players of *MOD* can have strong emotional experience encouraged by physical movements and social interaction, it is more likely that they will recall the contents of the game in the future. And unlike most memories that need reinforcement to settle in a brain, "strong emotional experiences may not require reinforcement" (Squire; cited in Falk & Dierking 1992, p. 108). Likewise, the social context not only activates emotions, but also enhances learning.

4.3. Reality-based interaction

The concept of the game is to save endangered species with the method of assisted migration (AM). The game incarnated AM in the artifical environment by adapting actions analogous to reality. Jacob et al. (2008) report that interactions based on knowledge and skills congruous with reality could enable users to operate a system with less mental effort; since they already know the skills required they could excel at learning how to use the system. This merit of reality-based interaction is particularly necessary in a museum, where visitors have limited time and opportunities to explore an entire exhibit. Accordingly, the full-body interaction is composed of analogous actions related to the interaction of reality: blocking, embracing, catching, holding, carrying, moving, and dropping.

However, in reality, the process of assisted migration would include more detailed actions and complex steps. To exactly mimic the actions involved in the real process would be the most 'natural' user interaction, but it does not correspond to the purpose of the game. It might serve its purpose if the game is for a simulation practice, but the physical interaction is there to support the empirical side of the game, not epistemic side. Therefore, the essential act of assisted migration—to directly move endangered species through human intervention—is simplified and reconstituted into the physical interaction toward a more controllable and enjoyable direction.

4.3.1. RBI analysis

Reality-Based Interaction (RBI) is a notion proposed by Jacob et al. (2008) in a paper entitled *Reality-Based Interaction: A Framework for Post-WIMP Interfaces.* They declare that post-WIMP[3] interaction styles such as "virtual, mixed and augmented reality, tangible interaction, ubiquitous and pervasive computing" (p. 201) and more can be seen under the same framework of RBI, because they apply analogies of the real world into the design of interactions. My aim is to "present evidence of RBI" (Jacob et al.,

[3] Post-WIMP refers to the new generation of user interfaces after WIMP(windows, icons, menus, pointer) based interfaces ("Post-WIMP", n.d., para. 1).

2008, p. 201) in *MOD* by applying this framework to the design of the physical interaction of the game. It will grant validity to the reflection of the authors' observations and arguments on the interaction design of *MOD*.

The authors define four main themes from reality, on which the framework focuses:

> Naïve Physics: people have common-sense knowledge about the physical world.
> Body Awareness & Skills: people have an awareness of their own physical bodies and possess skills for controlling and coordinating their bodies.
> Environment Awareness & Skills: people have a sense of their surroundings and possess skills for negotiating, manipulating, and navigating within their environment.
> Social Awareness & Skills: people are generally aware of others in their environment and have skills for interacting with them.
> (Jacob et al., 2008, p. 202)

The four themes "can be applied to analyze the design of post-WIMP interfaces" (Jacob et al., 2008, p. 202). The authors claim that the unnecessariness of interface-specific skill learning caused by applying the RBI concepts (e.g., naïve physics) on design of an interface may actually promote improvisation and exploration (Jacob et al., 2008). However, they further assert that the RBI principles alone cannot apply to the design of interactions because "useful interface will rarely entirely mimic the real world, but will necessarily include some unrealistic or artificial features and commands" (Jacob et al., 2008, p. 205). They subsequently suggest a principle of tradeoffs which involves six qualities: expressive power, efficiency, versatility, ergonomics, accessibility, and practicality, which are eligible to trade off at a cost of reality-based components (Jacob et al., 2008). The authors highlight that designers should give up features of reality only in return for one of these six qualities, otherwise, they should try to design interfaces which enable realistic performance (Jacob et al., 2008). The authors assert that the RBI principles are observed in many cases of emerging interaction styles (Jacob et al., 2008), and they illustrate four case studies to prove the argument. With reference to their case studies, I will identify if *MOD* can be referred to as a reality-based interaction.

RBI Themes

The basic feature of *MOD* is moving a graphical feature to different positions. The object manipulation is drawn from naïve physics (NP), body awareness and skills (BAS), and environment awareness and skills (EAS). The feature employs players' understanding of reality-based actions and their consequences (blocking, carrying, and dropping). *MOD* is based on the full-body interaction that uses body movements as the interface's input. Players already possess the body control skills that they can use to control the system. With these skills, players can position their arms at the right height and adjust their own body gestures (BAS). Moving from one patch to another requires environmental awareness and skills (EAS) of players. Players can orient their bodies toward the right direction.

The "task directly leverages users' knowledge of their own bodies and their ability to move their bodies to different positions in an environment (BAS, EAS)" (Jacob et al., 2008, p. 206). *MOD* also supports collaboration among multiple players, which hinges on their social awareness and skills (SAS). The skills "include verbal and non-verbal communication, the ability to exchange physical objects, and the ability to work with others to collaborate on a task" (Jacob et al., 2008, p. 203). Players can work together to move the graphical feature, or they can compete to take it away from each other. Players use "their existing social interaction skills (SAS)" (Jacob et al., 2008, p. 206) on the social gameplay.

Tradeoffs

The realistic and natural actions of saving endangered species include much more complex steps, gestures and control. *MOD* makes a tradeoff between reality and accessibility in favor of accessibility to support the simple and easy usability for a wide range of participants. *MOD* supports only one functionality with one possible interaction. The system is built for a specific purpose, and therefore does not support any other functionalities. If it was a GUI(Graphical User Interface)-based system, it could have had multiple usages. However, *MOD* gives up its versatility in order to construct the solid artificial world instead of building a multi-tasking kiosk.

Move or Die provides visual feedback on users' actions and the state of the game. When players adopt the gesture of making a blocked area in the air, a graphical circle which represents the size and position of it appears. There are also graphical guiding lines drawn from a caught species to an aimed patch. Those graphical features are not abnormal to be in the game world, but they do not exist in the real world. Although the components constructing the game world are based on the reality (such as city, nature, animal), the game world of *MOD* uses a different arrangement, relative scale, and perspective from the real world. These non-realistic features are there to facilitate better gameplay. Therefore, even though *MOD* is built on an artificial game world, the feedback features further diminish realistic degree within the game world. It is a tradeoff of expressive power (functionality) over reality.

4.4. Conclusion of the interaction analysis

Throughout the chapter, I have analyzed three different aspects of the interaction of *Move or Die*. The analysis shows that each aspect enriches the players' experience with different influences. The influences are interconnected with each other, and they influence one another.

In the analysis of the aspect of the full-body interaction, the influence of physical gestures and body movements are examined. The studies indicate that the full-body interaction brings enjoyment and aids in the education of young users. The two influences are certainly beneficial in a museum setting.

The investigation on the social side of the interaction confirmed three linked influences apart from the practical and semantic objectives. *MOD* satisfies the basic requirements as social immersive media to afford social interaction or social context among participants. Accordingly, the social context of *MOD* including people's need to belong, local co-presence (the role and relationship), social affordances, and other settings that strengthen the influence the emotional experience of players. Consequently, the strengthened emotions have the ability to enhance memory, which eventually assists participants' learning regarding content.

The correlation between the full-body interaction aspect and the social interaction aspect is as evident as physicality is within both aspects. Although they have a few different functions, both aspects suggest emotional and cognitive influences that are simultaneous and interconnected, according to Norman (2013). Norman (2013) explains that the interaction between emotion and cognition is biochemical behaviour involving the transmission of hormones, and that the emotional system and cognitive system work together on information processing. As the emotional system decides the value of a situation, the cognitive system reflects the decision in understanding (Norman, 2013). "[E]motions change the way we think, and serve as constant guides to appropriate behavior" (Norman, 2004, p. 7). This influence of physicality on human emotion and cognition intrinsically correlates with the notion of embodiment.

The analysis based on reality-based interaction principles demonstrates the evidence of RBI in the game. The game employs reality-based features and sometimes gives up the features to achieve necessary design goals. To apply reality-based metaphors in an interaction design like this reduces mental effort in learning how to play the game, and provides an experience closer to the reality. Hutchins, Hollan, and Norman (1985) also claim that to give the feeling of directly engaging with the control of semantic objects of goals and intentions also minimizes the cognitive effort needed to use the system. The use of metaphor can also induce players to be absorbed in their role as the savior of an endangered species: to recognize and take on a role, users can cause their own emotional experience to widen as they experience role-related emotions (Bianchi-Berthouze, 2013). To exploit the existing ways that people interact with the real world indicates that reality-based interaction is also embodied interaction.

In conclusion, the three aspects of the interaction shape *Move or Die* to be enjoyable and to be influential on emotional and learning experiences of the players while using a minimum amount of their cognitive efforts. The categorized analysis of the interaction of *MOD* demonstrates the positive influences from each aspect and interrelation between them, and confirms the embodied approach it possesses.

5. Conclusion

Throughout this project, I have undergone countless steps to realize a single idea. To document the project along with personal reflection, I described the production process in as much detail as possible, which ultimately helped me to understand how the project was constructed from the beginning. I also hope that my description and personal reflection can benefit the reader regarding considerations that apply to building an interactive media installation in a museum setting.

Although I initiated the project with a certain amount of confidence, I had always asked myself what the actual benefit or influence of creating interactive media installations was when other types of media solutions are available (especially since it usually requires a lot of resources, multidisciplinary skills, and complicated processes). What is there that cannot be achieved from passive media or traditional object-centered exhibits? I felt a need to look into other artists, designers, and researchers' relevant works and writing to see what the grounds were for them to create and study this type of work.

To write this thesis was a process in answering this question, and I have found some of the meaningful benefits interactive media can bring: increasing enjoyment and engagement, activating emotions, and enhancing learning. Fundamentally, the artists, designers, and researchers found these same benefits or influences based on the understanding how we humans work in the world. We feel the visceral pleasure coming from physical activity, we as social beings understand the world by communicating with others, and we have inherent ways of perceiving the world. I insist that the value of creating interactive media is the rich experience we can create on top of our understanding as human.

As *Move or Die* already concluded a year ago, there is no further development or modification planned in the future. However, it seems that my attempt to create engaging interactive media installations will continue, and what I have learned through my thesis will help me approach new projects with more confidence and understanding regarding people and their experiences.

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LIST OF FIGURES

The video documentation of the project is available at http://gamemoveordie.wordpress.com