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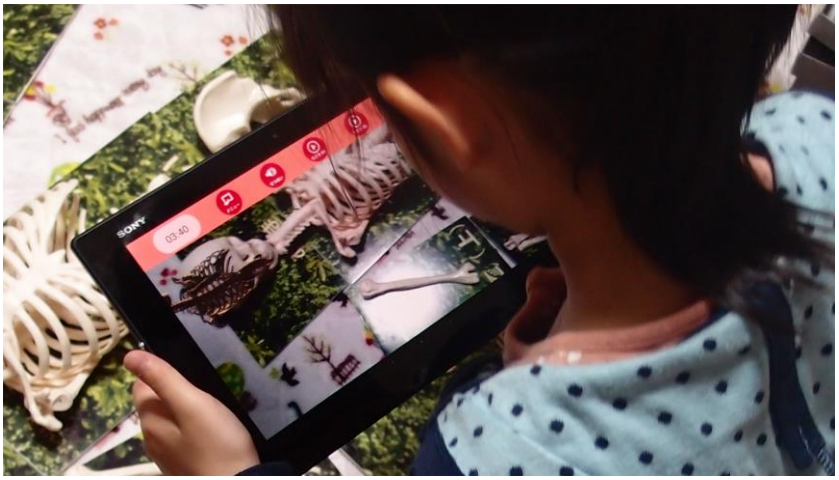
Moreno, Jacobo
Kyushu University
jacobo.mq@gmail.com

Kim, Daewoong
Kyushu University
dwkim@design.kyushu-u.ac.jp

Prototype Design of a Human Body Loan-Kit aimed at Fourth Grade of Elementary School.



Abstract

The prototype of a museum loan-kit aimed at fourth grade of elementary school was developed based on current school's science curriculum regarding the human body. The kit includes a print guide, *hands-on* elements, and augmented-reality games on a tablet computer in order to provide a multimedia set that can transmit the educational contents of the museum while being enjoyable for the children. A test and evaluation of the prototype took place with a group of elementary school students. The process of the developing of the prototype, along with its implementation and test results are presented in this paper.

Keywords: museum, educational resources, augmented-reality games

1 Introduction

In this paper we introduce the design of the prototype for the *fourth grade elementary school human body loan-kit;* an educational resource for elementary school science class based on and exhibition from The Kyushu University Museum. The loan-kit contains a print guide, *hands-on* elements, and a tablet computer with augmented reality (AR) games. A lesson plan was created in order to lead teachers through the activities in the classroom. The contents were based on the fourth grade science textbook used in Fukuoka city in order to make a direct link between the kit and the school curriculum.

The objective of this research is to encourage collaboration between the museum and schools by offering outreach programs via loan-kits for schools that are far away from the museum. *Hands-on* elements such as replicas and other analog components are used in order to introduce the museum exhibition and improve the children's involvement. In addition, a game-like experience is included in the kit in order to engage the students to learn while having fun.

A study took place in museums in Japan and around the world, via in-site observation and inquiry, web-site research, loan of available material, and interviews. The findings led us to focus on three points for the developing of the prototype: Creating a direct connection between current school's curriculum and museum contents, presenting a ready-made lesson plan for the instructors to use in the classroom, and taking advantage of digital technologies in order to offer an enjoyable experience for the children.

This prototype was tested with a group of elementary school students in order to receive feedback for improvement, the results and conclusions are presented at the end.

1.1 The Loan-kit

The *fourth grade elementary school human body loan-kit* is an educational resource intended for reviewing and expanding the contents learned in school while introducing part of the museum's exhibition. It is composed of a print guide based on fourth grade science textbook, *hands-on* objects (a set of boxes and a human skeleton replica) and a tablet with augmented reality games (Figure 1).
For this prototype, part of the unit on the human body from the fourth grade textbook was covered in three sections: bones, articulations of the body, and body movement. Reading, writing and drawing activities were included in the print guide, and for each section, a corresponding *hands-on*/AR game was made.

This loan-kit is meant to be offered by a museum in order to provide an educational support resource for schools in remote locations that do not have access to the museum so they can benefit from the museum's contents while tying them together with topics found in the school curriculum.

Figure 1
The *fourth grade elementary school human body loan-kit.*

1.2 Background

Loan-kits are educational sets offered by museums in order to be used by educators in the classroom. Schools in remote places that cannot assist the museum can be greatly benefited from this kind of resource, since they get access to materials that facilitate and expand the understanding on various topics.

One of the usual components of the loan kits are *hands-on* materials such as replicas, which can be either based on their own collections or related to its contents. There are many examples of these kind of resources, such as the Museum of Cycladic Art of Greece [1], the National Museum of Ethnology in Osaka [2], or the Australian Museum [3]. These museums offer kits for the learning of art, history, culture and sciences; their *hands-on* objects include replicas of actual art pieces, traditional clothing from different cultures for dress-up activities, and authentic objects such as animal bones, among others.

However, most of these resources are lacking contents that make use of new technologies in order to explain the educational content. New generations feel enthusiasm towards digital activities that require their active participation, "It's a lot harder to function in low-motivation, low-feedback, and low-challenge environments when you've grown up playing sophisticated games" [4]. Furthermore, by designing a loan-kit directed towards a specific unit of the school's curriculum, the students can benefit and learn about the contents of the museum while also improving their understanding on current topics being studied at school.

2 Related Works

References for the development the prototype include animal bones loan-kits from the Osaka Museum of Natural History, two similar resources found in a research conducted in Museums in Spain, and a few popular games and media among Japanese children.

2.1. Osaka Museum of Natural History

A visit to the Osaka Museum of Natural History was performed. There, an interview with the person in charge of the school support section took place and two educational kits were loaned for examination. They contained real animal bones, one was a set of a raccoon and Japanese deer skulls and the other was a raccoon's full skeleton. Apart from the *hands-on* elements, there were some explanatory charts and a book about bones, however it did not include a comprehensive guide on how to use the elements in class. In the interview, we were explained that the teachers could resort to the school support section in the museum to receive all the aid they needed, yet this would not be convenient for schools distant from the museum. In addition, we learned that classroom teachers at schools often don't know how to implement the kits into their classes. The hands-on elements are enjoyable by themselves, especially being authentic bones. Nevertheless, there is no material or suggested activity that extends the learning experience, and too much is left to the classroom teacher. While the loan kits of the Osaka museum are remarkable because of the *hands-on* objects they offer, they get short in facilitating their implementation into the classroom.

2.2. Findings from Museums in Spain

Similar educational resources are offered by the Cosmo Caixa museum in Barcelona, one was obtained in our visit. The kit wasn't a loan kit however; it was freely distributed, aimed at educators to use in the classroom [5]. The topic of the kit was drug prevention and it was aimed at high school students. It included two DVDs with videos and multimedia game-like activities and a print guide that not only introduced the contents of the discs, but also suggested several extra activities for the educator to carry out with the students. While this example does not implement *hands-on* resources, it is noteworthy because it actually offers a comprehensible guide for the instructor to use in the classroom, and makes a connection with an exhibit at the museum. Furthermore, it makes use of digital elements in the form of short interactions, for example a simulator on the effects of certain drugs.

In addition, an educational game embedded resource that used AR was found at the Thyssen-Bornemisza Museum in Madrid. Crononautas [6] offers a distinct way of walking around the museum with a storytelling game. The game asks the user to search for specific pictures and when the picture is seen through the tablet's camera, the game progresses. While this differs from a loan kit, its use of game elements and AR technology to guide the visitor through the contents of the museum is notable. However, on the day of our visit, no one was found actually using this resource, and the application itself contained program bugs that made it unplayable at certain point.

2.3. Game Referents

In order to present enjoyable game-like activities, some observation on current popular games among children took place. Since the loan-kit developed dealt with the human body and its movement, we looked for something related to that specific topic.

The Youkai Watch franchise had a great success among young children [7], along with its dance routine Youkai Taisou performed by 3DCG characters. This kind of dancing and idol culture influence on animation and games has already a long run, and while there are recent projects aimed at children, the renowned Vocaloid franchise along with its Project Diva games was the main influence to focusing this project on a dance game. Furthermore, a starter book for using the MMD free-resource dance animation program based on the Vocaloid characters, was also implemented in the prototype in order to make a dance game [8].

3 Prototype Production

The prototype developed was built upon the contents of the fourth grade elementary school science textbook in order to be used as support for current school curriculums [9]. At the same time, the contents of the Kyushu University Museum were considered for implementation into the kit: a human skeleton replica that could help the students on the topics regarding human body was chosen, however the inclusion of replicas of animal bones are being considered for further stages of the project development. The whole project is planned to be composed of five sections: bones, muscles, articulations, body movement and animal bodies. For the prototype, only the bones, articulations and body movement sections were developed.

Each section has activities on a print guide and a corresponding game on the tablet. In the "Bones" section, the students read about the parts of the body and then try to identify bones, muscles and articulations on their own. In the tablet game, they assemble a set of boxes with the parts of the body on top of them, and then they have to match a bone to each one via AR. At the end, they get to open the boxes to discover the actual bones. In the "Articulations" section of the guide, the students learn about the articulations of the body and think about what kind of movements they make. In the tablet, they look at 3DCG animations of possible movements of the articulations and have to choose the right ones. Finally, in the last section they read about body movement and play the "Idol Game", which is a bone and articulations matching activity that involves a 3DCG dancing character.

3.1 Concept

According to the Guide for Museum Activities from the National Museum of Nature and Science, when teaching about the bones, remembering their names or exact location is not really important, "What is important is to feel interest towards one's body, and feel the mystery surrounding its construction"[10]. The concept for the "Bones" game was conceived based on this premise of mystery. By maintaining the human skeleton replica hidden, making the children imagine how the bones are like before seeing them, and finally opening boxes containing the bones, there is an expected process of curiosity, imagination and discovery.

Also mentioned in both the guide and the textbook is the importance of the act of aligning the bones to assemble the full skeleton, this is present in the "Articulations" section. Once the skeleton is assembled, a game of searching for the articulations and observing the kind of movements they could make. Finally, the "Body Movement" section includes a dance game that responds to the bones input via AR recognition. This was expected to be an overall review of what bones correspond to the parts of the body along with the articulations.

3.2 Hardware and Software

The device used for the prototype was a Sony Xperia Z2 tablet with the Android 4.4 KitKat operating system. The developing environment chosen was the game engine Unity 4 over the native android SDK option. This was because Unity offered the appropriate tools necessary for the game components and also eased the visualization of 3D components. Furthermore, the Qualcomm Vuforia 3 Unity Extension was used in order to provide the AR recognition system. In addition, ready-made 3D models and animations from the MMD program were used for the "Body Movement" level where a character dances for the Prototype phase. However original characters are planned to be made in further development stages. A special extension was used in order to implement the MMD data into Unity.

3.3 Print guide

A print guide was made to present the same educational contents of the fourth grade textbook, while expanding them by adding AR elements like videos of moving parts of the body. A lesson plan was created for a forty-five minute class in order to guide the classroom teacher through the multiple activities (Table 1).

Lesson plan of the fourth grade elementary school human body loan-kit prototype

Topic	Activities	Contents	Time
Introduction	・Introduce the activity	Introduction of the loan-kit	1min
Bones	・Reading	Read about bones, muscles and articulations.	2 min
	・Hands-On	Observe bones, muscles and articulations by touching the own body.	3 min
	・Drawing	Imagine and draw the bones of the body inside the human silhouette.	3 min
	・Use tablet		10 min
	・Preparation	Read the instructions on the tablet and assemble the body boxes.	(3 min)
	・Game	Assign a bone to each of the body boxes.	(5 min)
	・Conclusion	Open the boxes and take out the bones.	(2 min)
	・Drawing	Look at the bones and draw the bones of the body once more.	3 min
	・Presentation	Compare the two drawings. Discuss.	2 min
			Total: 24 min
Articulations	・Reading	Read about articulations.	2 min
	・Drawing	Draw a line to assign articulations to things with similar movement.	3 min
	・Use tablet		10 min
	・Preparation	Read the instructions on the tablet and assemble the skeleton replica.	(2 min)
	・Hints	Look a the video hints on the guide with the tablet.	(1 min)
	・Game	Assign a movement to each of the articulations.	(5 min)
	・Conclusion	Look at the results of the game. Discuss.	(1 min)
			Total: 14 min
Body Movement	・Reading	Read about body movement.	2 min
	・Use tablet		5 min
	・Game	Search for the right bones of the parts of the body or articulations.	
			Total: 7 min
			Total: 45 min

Table 1
Lesson Plan for the different activities in the loan-kit.

A panda character was designed in order to attract the attention of the students, he offered extra tips on the topics and also served as a mark for five recurrent activities found through the guide: reading, drawing, hands-on and using the tablet (Figure 2).

Figure 2
"Teacher Pan-pan" was a panda character that explained and offered tips through the print guide

3.4 Analog Elements

The analog elements included in the kit are a set of boxes with illustrations of parts of the body placed on top of them, meant to be assembled like a puzzle (Figure 3). Inside of the boxes, there were the corresponding set of bones for each part

of the body, placed on top of platforms (Figure 4). Both the boxes and the platforms for each bone were used as AR targets that triggered 3D models and animations in the tablet application. The platforms with the bones go inside their corresponding boxes, and are hidden from the children until they open the boxes themselves at a certain point of the activity. One last AR is found as a separate card for using in the "Idol Game".

Figure 3
Set of boxes depicted the body of a human character for the children to assemble.

Figure 4
The human skeleton replica was divided and placed in multiple platforms.

3.5 Application

An application containing three levels corresponding to each of the ones found in the guide was developed.

In the "Bones" level, the children have to hover the tablet over each of the boxes in order to select what bone they think corresponds to each part of the body. When one of the targets from the boxes is recognized, arrow buttons appear on the screen; by pressing them, the student can search between AR 3DCG bones (Figure 5). By pressing the set button, the current bone would be set and the "Remaining Bones" counter will go down by one. When the students finish setting all of the bones, or five minutes have passed, they can open the boxes and discover which bones were the correct ones. In addition, the game also checks the right and wrong answers at the end.

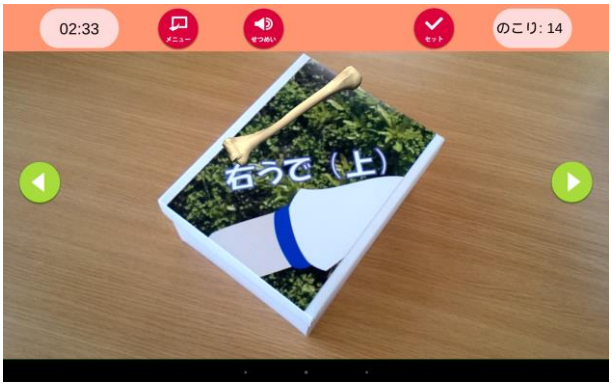


Figure 5
When the top of the box is shown in the tablet, the user must tap the arrow buttons to search for a bone and select it with the "Set" button.

In the "Articulations" level, the children have to arrange the bones in order to assemble the skeleton. Afterwards, they have to hover the tablet over the bones looking for articulations. When an articulation is found, the correspondent 3DCG bones would show, along with two play buttons (Figure 6). By pushing the buttons, the children can observe two different animations of possible movements of that articulation, and choose the one they think is correct. When they finish finding all of them or five minutes have passed, the correct and wrong answers will be marked in the screen.

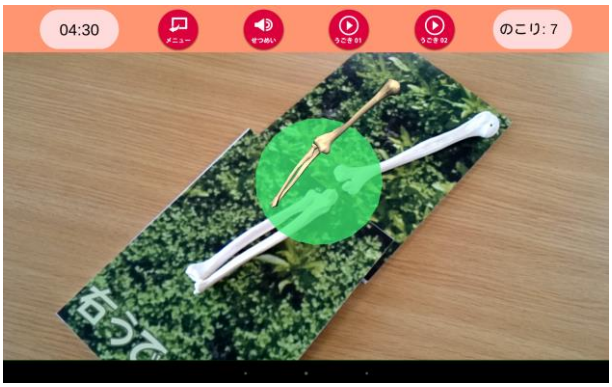


Figure 6
An articulation is found by reading two consequent bones, a green ball appears along with two reproduction buttons.

Finally, in the "Body Movement" level, the children play an "Idol Game" that involve the body parts and their corresponding bones. The silhouette of a 3DCG character will come out from an AR card and dance along with a non-vocal version of the song. At certain times the character stops and a red ball appears in a part of her body. At this point, the player is prompted to search for the corresponding bone. The students have to hover the tablet over the right bone in order to continue, then, they can receive a higher score depending on the time they spent finding the right answer. After clearing the first stage, the silhouette character becomes a skeleton and the game continues. However, instead of one bone corresponding the body part, they have to search for the two bones

corresponding to an articulation. Once the song is over, the final score will show up, along with the vocal version of the song and the completed character (Figure 7). The application flow is showed in a graph on Figure 8.

Figure 7
The idol game has three phases: silhouette, skeleton and complete idol.

5 Testing and Feedback

The prototype was tested in a domestic study group of four elementary school students, the activity took place as an actual class. A person took the role of the teacher and guided the students through the materials. The activity was observed, a survey was conducted, and there was a space for open talk at the end.

The class progressed smoothly, the children performed the activities without losing focus, though the scheduled time was surpassed by a few minutes. This was because in certain points of the activity, the children would take more time than the expected, such as in drawing activities. We observed that there was an immediate positive response from the parts regarding puzzle activities, for example the organization of the character with the boxes and the assembly of the skeleton (Figure 9). Without hesitation, the students cooperatively assembled the body of the character and the bones in a matter of seconds. We confirmed that they eventually had a preference for puzzle games in the open talk.

The panda character created was well received, and his tips were found easy to understand for the children. Also we observed how they got absorbed by looking at the character dancing in the “Idol Game”. There was an initial difficulty in understanding the games, but after some trial and error, they knew what to do and were excited to continue. However, the time limit assigned for the games of “Bones” and “Articulations” resulted insufficient and the children themselves pointed that they felt hurried and that they would like to have had more time for completing them. We also noted and discussed at the end that one single tablet for a group of four might be not enough. Even if they were sharing cooperatively, the main activity could be performed by only one at a time, meaning that the other three would not have a major active role and will stand as observers (Figure 10). Plus, the time of passing the tablet from one person to the other could have had an impact on the time issue previously mentioned.

Figure 9
There was a high enthusiasm of the children when assembling the boxes and the bones.

Figure 10
Only one tablet was contemplated for a group, however it felt to be not enough for the four of them.

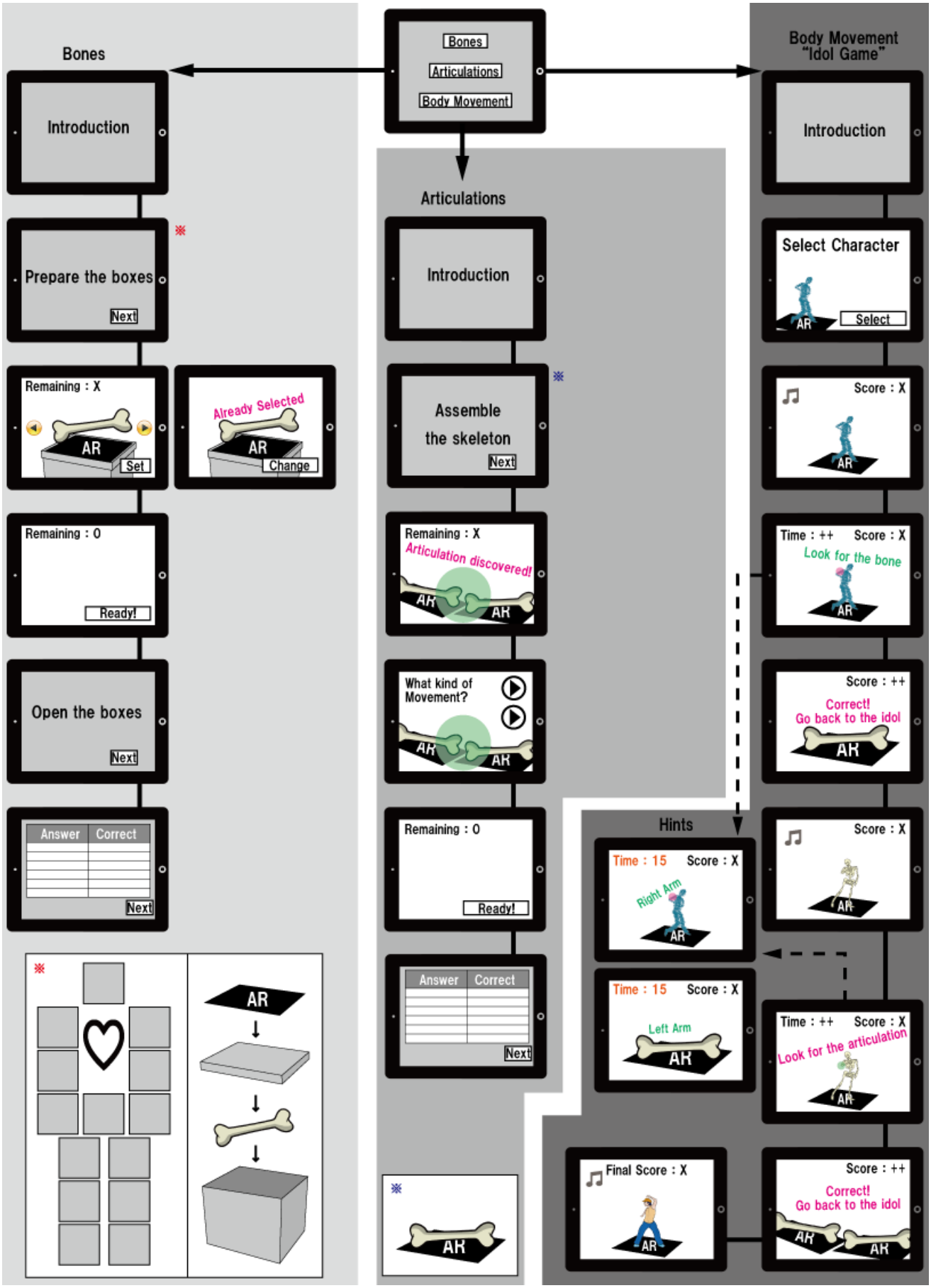


Figure 8
Flow of the three parts of the application

Overall, from the surveys we learned that the children enjoyed the class and understood the topics taught through it. They liked the games and had a slight preference of the "Idol Game", although most of them found the games moderately difficult. As for the museum-kit itself, there were still software bugs that intervened in the games, especially in the "Bones" section. There was also some AR tracking issues due to the light and reflectivity of the materials. Furthermore, the bone's platforms intervened with the hands-on contact expected. The testing itself was a success, the museum-kit resulted enjoyable for the children, and it transmitted the expected contents satisfyingly. The observations and results will help in further developing of the project.

6 Conclusions

From the development process and the testing with the users, the following conclusions were made:

1. The activities on the tablet were successful, but since one tablet resulted insufficient for a group of students, activities that involve more tablets and different active roles for each participant, should be considered.
2. Puzzle elements in the games were particularly enjoyable for the children so they should be explored more.
3. AR elements were successful, however further research on ways of not being limited by the technology should take place. For example trying out object recognition in order to discard the platforms of the bones and use the objects themselves as AR targets in order to enable more contact with the replicas.
4. Character creation should have a particular focus in order to attract children, also more characters could be implemented in order to appeal different tastes.
5. The times assigned should be reviewed in order to give enough time for the children to do certain activities instead of others, or do together for a single activity, for example drawing as a group on a big piece of paper.
6. Finally, the portability of the museum-kit should also be reviewed to facilitate its transportation to distant places.

The prototype described in this paper is the first step on the development of the full length *fourth grade elementary school human body loan-kit*. By testing and receiving feedback from the users, we could prove that the goals set at the beginning of the project are being achieved, however further work is needed, and what has been achieved up to this point will help to improve the project in its next phase.

References

[1] Cycladic Art Museum. *Museum-kits*. Web. 01 Jun. 2015. <http://www.cycladic.gr/frontoffice/portal.asp?cpage=NODE&cnode=86&clang=1>.

[2] National Museum of Ethnology. *Min Packs Types of Packs.* Web. 01 Jun. 2015. <http://www.minpaku.ac.jp/research/sc/teacher/minpack/contents>

[3] Australian Museum. *Museum in a Box*®. Web. 01 Jun. 2015. <http://australianmuseum.net.au/Museum-in-a-Box>

[4] McGonigal, J., *Reality is Broken: why games makes us better and how they can change the world*, Penguin Books, pp. 127, 2011.

[5] La Caixa. *Drug Use Prevention Program*. Portada. Web. 01 Jun. 2015. <http://www.hablemosdedrogas.org/en/home>

[6] Educathyssen. *Crononautas*. Web. 01 Jun. 2015. <http://www.educathyssen.org/crononautas>

[7] Level5. *Youkai Watch Series*. Web. 01 Jun. 2015. <http://www.youkai-watch.jp/>

[8] Yoshikawa, T., ed., *Miku Miku Dance Starter Pack*, Shinyusha, 2010.

[9] Arima, A., et al., *Fun Science 4th year-1*, Dainippontosho, 2014.

[10] National Museum of Nature and Science, ed., *Guide for Activities in The Museum for Using in The Classroom*, Shonen Shashin Shinbunsha, 2011.