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Planning and Developing a Museum Outreach Program for Schools

Bringing educational content from the museum to the classroom

through digital and physical materials



Abstract

In this research we explored various approaches for the design of an outreach program that worked as an educational support tool from a museum to schools. We developed a loan kit that provided teachers with a variety of activities included in a lesson-plan that they could easily insert into their regular curriculum. With the use of tablets for expanding content from textbooks via augmented reality and introducing replicas for hands-on learning along with digital content, we created a lesson that was engaging for the students and also presented the educational content from the museum. Furthermore, a session with a professor from the museum was also included as part of the lesson. In this section, the students had the opportunity to speak directly with an expert from the museum. "The human body and its movement" loan kit was developed and tested in three schools from Miyazaki Prefecture, the process of its production and our findings from the tests are presented in this document.

Keywords: Educational Digital Content, Museum Outreach Program, Replicas and Hands-on Learning.

1 Introduction

1-1. Collaboration between schools and museums

Schools can use museums as a form of educational support; through guided visits, classes on the museum and hands-on experiences, students can get a deeper understanding of a topic compared to what they would get at a regular class at school. The Ministry of Education, Culture, Sports, Science and Technology of Japan recognizes this fact, and in its Elementary School Curriculum Guidelines for Science it was stated that collaboration between schools and museums & centers for learning science should be promoted [1]. Since then, museums in Japan have started to offer more activities directed towards school groups in order to both serve as educational support and interest students in subjects exhibited in the museum. However, not all schools can get access to the activities that museums offer. Across Japan, there are towns

	Elementary Schools (N=514)	Junior High Schools (N=663)
There is no museum or appropriate facility nearby	70.0%	64.6%
There is no time for going to the museum	46.3%	64.7%
A trip to the museum cannot be adjusted in the schedule of the subject's classes	18.3%	39.7%
An educator that leads the activity cannot be ensured	13.4%	17.8%
Correlation with the school's curriculum cannot be clarified	8.2%	4.7%
There is no knowledge/technology for using the museum in class	12.3%	13.6%
Learning efficacy of the activity cannot be clearly identified	7.0%	5.1%
There is no information about the museum exhibits and events	5.6%	5.6%
Transportation and/or admission costs are not covered	46.7%	51.0%

Table 1. Reason of why schools find difficult using museums in their classes (translated from the original)

located in difficult-to-reach places, such as mountains and islands; and while some of these places have local museums and institutes, many of the schools located there have a hard time accessing the benefits that come with the collaboration between schools and museums, because of transportation expenses and time.

A questionnaire research on elementary schools and junior high schools, performed by the Japanese National Museum of Nature and Science, shed light on various points regarding the collaboration between schools and museums [2]. According to this study, the main reason why schools find it difficult to use museum activities in their classes is because there is no museum or appropriate facility near them (70%). The next reason is because of transportation and attendance costs (46.7%). Finally, the next most selected reason was the lack of time for going to the museum (Table 1). From this, we can conclude that schools far from museums face problems with transportation expenses and time spent, which makes it difficult for them to visit these institutions in order to benefit from the educational activities and programs that they offer.

Additionally, through interviews with elementary school teachers we carried out, we learned that the educators have to deal with different additional issues aside from preparing and teaching their classes, which leaves little time for visiting a museum since it would become a great burden for them. Because of the above, it is necessary to think about programs that museums can offer for schools located far away, without demanding excessive time and effort from the educators. These have been called **outreach programs**, and they have been implemented increasingly in museums around the world.

1-2. Outreach programs

As the name suggests, "outreach" means to reach out to somewhere located far from the point of origin. In museum educational programs, it refers to the idea of bringing museum-achieved experiences to remote places in order to transmit its knowledge. While there are many ways of doing this, our research focuses on two: long-distance classes and loan kits.

1-2-1. Long-distance classes

One way of reaching schools located far from the museum is through virtual classes given via Internet. The Asahiyama Zoological Park's "i-Network Class"[3] is one example of this. Several cameras were placed inside the animals' cages at the zoo, and the zoo staff gives explanations about the animals while showing the real-time footage. The students can watch the animals in their current conditions and listen to the appropriate explanations from their classrooms, allowing them to experience the zoo and still learn directly from a representative from the institution. This program allows the school to avoid transportation and time costs, while also letting the students see the animals and listen to the experts at the institution. However, in this type of class, the students are not able to experience freely looking at the animals or touching them in sections like the petting zoo. While they can get educational benefits by taking the virtual class, they would lack some experiences that cannot be transmitted through video only.

The advantages of a virtual class taught by the professionals at the zoo, museums and other institutions are that the students can actually listen to the experts and get a unique opportunity to ask them questions without leaving their classroom. The experiences that are lacking from this video-only activity could be achieved through other methods, like with loan kits. Furthermore, these other activities could be experienced before the actual session with the experts, in order for the students to immerse themselves in the topic and get a richer experience.

1-2-1. Loan kits

Loan kits are educational sets directed at schools in order to teach about topics related to a museum, serving as a support tool that utilizes and puts into practice the knowledge from the museum. They include different educational materials that aim to cover a specific topic, including illustrated books, games for learning, and sometimes objects for touching and observing, such as replicas of objects from the museum's collection. Schools can obtain loan kits for free for short periods of time so they serve as a way for the museum to outreach.

One example of these sets is the KyuuPack [4], which offers four kinds of activities: looking and reading, interacting with tangible objects, trying to build something, playing with puzzles and games. Loan kits aim to offer educational assistance not only by giving out books and information, but also by offering activities that engage the students. Through different learning paths, like using games and touching things, the students' curiosity is stimulated and enjoyable experiences are offered in order to keep them motivated, making sure that the activities remain in the students' memory along with the content they learn. The activities that allow students to touch and experience things with their own hands, called hands-on activities, are especially relevant to this study.

We performed a visit and interview at the Osaka Museum of Natural History, and also borrowed loan kits from the institution for analyzing. The kits included not replicas, but real animal bones, along with explanatory charts and a book about animal bones. Bringing real bones to the classroom would allow students to have a hands-on experience by presenting them with authentic objects. However, no explanation of how these elements should be introduced in the class was included in the kit, while also lacking any extra games or activities that could be performed with them. While the museum offers support for the teachers via on-site workshops and dedicated telephone lines, the loan kits may create a burden for the teacher since it is him who will have to study the specialized topics and plan how the class should go, without having specific references or ideas offered in the kit.

Using the outreach programs explained above as a starting point, our goal in this research was to design, develop and test a loan kit that both included a variety of activities for supporting learning in the classroom, along with the inclusion of a session taught by an expert in the museum. For this purpose, a variety of digital technologies were used in order to secure enjoyable activities for the kit and facilitate the transmission between museum and schools of the content.

2 Methods and Content Planning

2-1. Conception of the loan kit

First of all, the outreach program we planned had to offer a lesson plan for the teachers in order to avoid putting too much burden on them. This class had to include a variety of activities that would interest the students and let them learn while having fun. In order to achieve this, tablets were considered as a way to provide different activities inside one device: a textbook with augmented reality content that would expand the regular reading process, video game components (like the inclusion of characters and mini-games), and hands-on objects like replicas made in 3D printers that could be used along with the digital content. Furthermore, a twenty minute video lesson by a museum expert would be included, where the students would listen to a short lecture and then asked questions.

We collaborated with the Kyushu University Museum, and started developing the loan kit based on the museum's collection of human and animal bones. In order for the kit to be relevant for the students, it had to link the museum's knowledge with the current school curriculum. For this reason, the fourth year elementary school science unit, corresponding to the human body and its movement, was selected as the target subject. The topics in this unit dealt with the human bones, muscles, articulations and movement, while also including information on their animal counterparts. We also planned to approach schools in rural parts of Miyazaki Prefecture for the testing, so the contents of the kit were mainly based on the school textbook used in that area.

2-2. General explanation and contents

The loan kit was initially planned to cover three school lesson blocks of forty-five minutes each, in order to complete all the activities prepared. However, after an initial meeting with the teachers and heads of the schools that would collaborate in our tests, we decided to extend the class one more block because they suggested that the students needed more time for assimilating the content. In the class, the students would go through the topics of the textbook divided in 4 sections: *bones, articulations and movement, muscles* and *animals.* Finally, they would receive a twenty minutes class taught by an expert from the museum.

The basic structure for each section in the class is as shown below (Figure 1).



Figure 1. Flow-chart for each section on the class.

First, an introduction to the topics would take place in a paper textbook where the students read aloud along with their teacher, similar to a regular class. Then, the students would carry out a drawing activity corresponding to that section; for example, imagining what the bones look like and then drawing them inside a human silhouette. In the next step, students would grab the tablet computers and point them at the textbook to look at augmented reality videos. Finally, with the tablet on hand, the students would look for the corresponding analog elements of the section and play games that incite them to observe and touch the replicas repeatedly.

The reasoning behind this process was to begin with an introduction through traditional teaching methods of reading and drawing, in order to present both the teacher and the students with a familiar teaching environment. Then they would be directed towards the digital materials through augmented reality content that appear on what otherwise looks like a regular textbook. Finally, the games alternated between virtual reality and augmented reality, which was intended to make the students interact with the replicas in front of them over and over. This way, the tablets are not the main focus of the lesson, but rather a tool that can enrich the experiences with other materials.

The final version of the kit included the items listed below (Table 2). Their specifications are explained in the next chapter.

Table 2. "The human body and its movement" loan kit contents

Students' Textbooks	One printed copy for each student
Teacher's Guide	A printed guide explaining the class plan
Teacher's tutorial DVD	Portrays each step in a mock-up class
Tablet computers	Nexus 5, with the application installed
Boxes Set	Contains the parts of the human skeleton
Human Skeleton Replica	With an NFC tag appended to each piece
Animal Bone Replicas	A Lion skull and leg, and a frog skeleton
Augmented Reality Targets	Additional pictures for the games
Hint Cards Sets	23 cards per set, one set for each student

3 "The human body and its movement" loan kit

3-1. Teacher's guide and DVD

A printed guide with the steps for the class progress was prepared in order to present the lesson plan to the teacher. In addition, after meeting with the heads of schools and teachers, we realized that it was necessary to devise a more detailed way to introduce the materials since all of the teachers had little or no experience in using digital educational materials during class. For this reason, we prepared a DVD with a mock class where every step was visually presented and explained, this way the teacher could jump from one step to another, from the preparation of the replicas to the game's instructions. This preparation for accurately transmitting the mechanics of the kit was necessary in order to relieve the teachers of burden as much as possible.

3-2. Textbook

The loan kit was required to be meaningful for the students learning process, so it had to include actual content that they would study according to the established curriculum. Furthermore, by presenting a familiar element in the kit, both the teacher and students would feel less overwhelmed. For this reason, the textbook we made included the same content as the textbook used in the schools in Miyazaki Prefecture [5]. We also followed similar design patterns as regular textbooks, such as highlighting important parts in bright colors and including a mascot character that provided hints (Figure 2).



Figure 2. Drawing activity on the textbook, explained by a panda character on the side.

In the textbook, an "AR (Augmented Reality) page" was included in each section, with pictures that started moving when looked at through the application on the tablet. For example, this served to show the behavior of the muscles correspondent to different body movements (Figure 3). With this, the students had their textbooks expanded, using the tablet as a tool to allow them to see content beyond the paper.



Figure 3. Augmented reality videos will trigger on the tablet when pointed at the image targets

3-3. Objects for hands-on learning

A human skeleton replica along with a lion's head and leg, and a frog skeleton were produced using a 3D printer (Figure 4). The human bones had near-field communication (NFC) tags attached to them, while some small image targets were put on the animals bones; this was done in order to use the bones in the games explained in the next chapter.

While real bones would provide a different kind of impression for the students (as with the Osaka Museum's loan kit presented above), replicas can effectively bring them the experience of touching objects that would be difficult to access if they were authentic. For example, we learned from one of our visits to the Kyushu University Museum that human skeletons are treated with special care and respect in Japan, so they cannot be carelessly handled. Furthermore, 3D printing allowed us to reproduce a lion's head and leg, and an

International Journal of Asia Digital Art&Design



Figure 4. Human and animal bone replicas

enlarged frog skeleton, which allowed the students to have rare animal parts in their hands and a bigger reproduction of an otherwise very small and fragile one.

Aside from the bone replicas, a set of boxes with image targets on top of them was also included in the kit, which also presented an opportunity for hands-on learning. When learning about human bones, it is more important to feel interest towards one's body and think about the mystery surrounding its composition rather than, for example, memorizing all the bone names [6]. For this reason, the boxes were conceived with the purpose of hiding the human bones replicas and first make the students imagine how the bones look like by feeling their own bodies, and afterwards revealing them in such a way that the students could feel the thrill of discovery. The boxes also had different image targets attached to the lids in order to be used in the augmented reality games (Figure 5).



Figure 5. The bones were hidden inside the boxes

3-4. Strategies for engaging with game elements

Various ways for keeping the students interested and facilitating their engagement with the class were devised based on current video game logic and components. Foremost, the students had to choose from four characters whose 3D models and voices would accompany them through the games (Figure 6). The students had the option to select between two boy and two girl characters, similar to video games that ask the players to choose a main character to control at the start of the game. They were designed with the intent of presenting variation, in order to attract different tastes and allow the students to relate to them differently. Each character had a personality that changed the way they talked and reacted when, for example, an answer on the game was correct or incorrect.



Figure 6. Four different characters were designed

A set of 23 cards that included the topics of the class and provided additional explanations was designed. These cards were obtained digitally in the game, but after finishing each section, the students would also receive the physical version. By having a collection component, the students would be interested in getting all of them, and they would also serve as a type of flash cards for learning and remembering the topics of the class.

The games varied from section to section, but always attempted to alternate between the tablet screen and the hands-on materials in order to avoid staying in the digital component for too long. In the bones section, the students had to first look for bones on three different augmented reality stages that appeared on top of the boxes (Figure 7). Once they were all collected, they had to assign them to the parts of the body of the character to clear the game, and then they would open the boxes to discover the replicas. This was intended to generate curiosity about what would be inside the boxes, and establish a process of first making the students look at the bones in digital form before actually holding them in their hands.



Figure 7. The students touching objects in augmented reality

In the articulations and movement section, the students had to assemble articulations by reading the NFC tags on the human bones with the tablet and matching the appropriate parts (Figure 8). Then they would assign the articulations to the character in augmented reality to make them dance. With this, the students were urged to repeatedly hold the bone replicas, identify their different forms and look at which bones matched in order to form an articulation. The dancing character served as an incentive to look at all of the main articulations.



Figure 8. Matching bones digitally through NFC tags

In the muscles section, the students had to assemble the skeleton on top of a large image target mat. When looked at through the tablet, a muscular system model appeared. By touching the marked parts that appeared, the students would play a series of muscle training mini-games (Figure 9). This was intended to make the students associate body movements with the muscles used in them. In the fast paced mini-games, the character was shown performing the corresponding movements repeatedly.



Figure 9. Mini-game about jumping over obstacles

Finally, in the animal section, a quiz game would take place. The students had to point the tablet towards the augmented reality targets in order to trigger a quiz, which asked them to search for the answer by observing the animal and human bones, for example by assigning the corresponding bones to the bodies (Figure 10). For each quiz, they would receive a character for a password and, at the end, they had to combine them with the ones found by other students in order to input the full password and clear the game. The quizzes asked the students to touch the replicas and compare between the animal and human bones, which incited them to observe and analyze the different parts. Additionally, other animals that were not made into replicas were shown as 3D models via augmented reality.



Figure 10. Observing the replicas for solving the quizzes

3-5. Session with the museum expert

At the end of the class, the students had to write questions that they would like to ask the expert from the museum. By doing this session at the end, the students would already have background knowledge of what they learnt through the day and could think about questions related to the topics they had been studying.

We contacted the Kyushu University Museum and met with one of its affiliate professors in order to present them the loan kit and to agree on the topics that would be presented in the class & how the session would take place. The professor would connect via Skype through a tablet and start a video call with us. We would have the camera pointing at the students and start the 20 minutes session (Figure 11).



Figure 11. Long-distance class with the museum professor

The professor would explain about four-legged animals and two-legged animals and use the replicas that the students would have in their hands to make examples, also showing parts of the objects in the museum with the camera. Afterwards, the students would ask questions about topics related to the class. Through this, the students would have actual contact with an expert from the museum with a virtual class that also used the objects they have been manipulating throughout the day.

4. Testing in elementary schools

We tested the loan kit, "The human body and its movement", in three elementary schools from Miyazaki prefecture: Kozaki Elementary School of Shiiba Town, Sakatani Elementary School of Nichinan City and Katagami Elementary School of Nichinan City. A total of 31 students ranging from third to sixth grades participated in the classes planned for the loan kit. Their respective science teachers taught the class and we assisted as supporters, in case any problems with the materials arose, and as observers. The physical layout of the class had the students with their textbooks and tablets in front of them, and the rest of the materials in the center of the tables (Figure 12). Depending on the activity, the students would stand up, grab their tablets and perform the different activities.



Figure 12. Example of the layout of the class

The teacher's guide, DVD, a tablet with the application, and part of the image targets and replicas were prepared and sent through mail to each of the schools one week before the testing dates. We sent it beforehand in order to allow the science teachers to get to know the dynamics of the kit and prepare themselves before the class. Additionally, we offered assistance via e-mail and phone for any questions and problems they could have.

The tests were made in the following order: First, we set up the loan kit parts and had a brief conversation with the teacher in order to solve questions and explain the final details. Then, the class of four blocks took place, with a small recess between each block. Later, the twenty-minute session via Skype with the professor from the museum was carried out. Finally, the students and science teachers would answer a questionnaire about our research, and a meeting with the school's heads and science teachers was made, where we would receive comments and observations about the kit.

4-1. Results from observations

In general, we observed that the students had a positive response towards all of the contents of the loan kit. A few

International Journal of Asia Digital Art&Design

students had trouble with the games, but both the teacher and other students were able to help them progress through them. Many of them did not have much experience manipulating a tablet, however they adapted quickly. The activities went smoothly in most of the cases, and the students showed interest and seemed to have fun. Many of them also looked surprised when they realized the class was already over, having lost track of time. One issue we noticed was that, in all of the three schools, the planned time for the class was either not enough or just barely enough, so we actually had a fast-paced lessons.

Regarding the usage of the contents, we observed that the behavior of the students required us to make a few changes along the way, so we went to adapt the order of the class plan. For example, once the students had the human bone replicas in their hands, they were instantly eager to put them in order, so it was more effective to assemble the human skeleton immediately after they took the parts out of the boxes. Another change was the timing; when the students received the printed hint cards, we planned on distributing them at the end of each section. However, receiving the physical card at the moment they got the card on the digital screen resulted in a more exciting activity, since they felt instantly rewarded and collecting the cards represented a clear objective for the games. Finally, there were some technical problems with the tablets regarding the NFC tags recognition before the last test, so we had to assign one tablet per two students. However, this resulted in a more enriching experience for the students since they collaborated and went through the digital activities more smoothly compared to the performance in other schools.

The long-distance class session with the museum professor was accomplished trouble-free in every case, and the professor was able to give explanations to the students while showing them around the museum and making comparisons with the replicas they had in front of them. The only instance in which we found that the time provided was not enough was in the school with the biggest number of students: the professor was not able to finish answering all of the questions the students had, even though the time estimate had seemed appropriate.

4-1. Results from questionnaires

4-1-1. Students

A seven-point questionnaire was distributed to the students after the class, the total results from the three schools for each of the questions is presented below (Table 3).

At the end of the questionnaire, an open question about the student's thoughts on the class was made. All of the comments were positive: the students wrote about how fun it was to go through the class with the tablets and how they would like to have one class like this again.

	Very much	Yes	Neither	No	Not at all
Q1. Was "The human body and its movement" class	97%	3%	0%	0%	0%
fun?					
Q2. Was "The human body and its movement" class	81%	19%	0%	0%	0%
easy to understand?					
Q3-1. Were the games fun?	95%	5%	0%	0%	0%
Q3-2. Were the games easy to play?	37%	10%	23%	19%	11%
Q4. Were the explanations of the tablet and its use easy	97%	3%	0%	0%	0%
to understand?					
Q5. Was learning through touching human and animal	74%	26%	0%	0%	0%
bones easy to understand?					
Q6. Would you like to try a class that uses tablets and	97%	3%	0%	0%	0%
materials from the museum again?					

Table 3. Overall results from the students' survey

4-1-2. Teachers

The science teachers' questionnaire had more detailed questions and open answers, since there were only three of them. For this reason, we present the relevant points summarized below:

- Neither of the teachers had ever used museum content in their classes. When asked about the reason, they answered it was because of time issues and distance from museums.
- The class with the loan kit was praised for effectively interesting and engaging the students with the learning content. However, one of the teachers said that it needed more work before suitability for regular class use.
- The teachers' opinion towards digital materials after the class was that they are interesting and surprising. However, one teacher considered their implementation in class was still a difficult matter.
- They considered that the replicas greatly helped to better understand the lesson content, and that they interested the students.
- While the hint cards attracted the students' attention, their educational usage was not encouraging enough.
- The time planned for covering the topics was considered insufficient. The teachers felt the class had to be covered very fast.
- Regarding the multiple activities and games, the teachers had mostly positive answers, and considered them important for improving the students' willingness to learn and better understand the content. However, in a few cases, the games were thought to be not educational enough and stayed too much on the entertainment side.
- The teachers considered the session with the museum's

professor a positive and valuable experience for the students. However, one of the teachers said that the content explained was too difficult for elementary school.

• Finally, two of the teachers answered they would like to use this sort of loan kit in the future, but the remaining teacher expressed reluctance to use it in class. However, the latter suggested using it as an extra-curricular activity inside the school.

5 Conclusions and Discussion

In this research we developed a museum loan kit aimed at schools that have difficulty accessing museums. It included a variety of activities that could engage and transmit educational content to the students in order to promote collaboration between museums and schools. Presented below are the conclusions we achieved from our observations and the results from questionnaires and interviews carried out after the tests in elementary schools of Miyazaki prefecture:

The students considered the class interesting and fun, and they demonstrated interest in participating in this kind of activity again. Even if there was an initial introduction through the traditional textbook, the class was not limited to this but went through connecting digital and analog content that proved effective for stimulating the students' willingness to learn. The objective of this research, planning a museum support tool for schools that would result enjoyable for the children, was achieved. Furthermore, the experiment results suggest that it was effective. We identified an issue with the difficulty setting in the games: we received mixed results when students were asked whether the games were easy to play. However, this did not seem to affect their enjoyment while playing them, and it also presented an opportunity for the students to help each other clear the games. This could



lead us to think that since the students were deeply engaged in the games, their difficulty did not represent an obstacle for continuing to attempt and achieve the goals planned. Moreover, by maintaining a level of difficulty for the games instead of making them too easy, the children were compelled to clear the games because it provided them with a sense of accomplishment. We could observe that the difficulty of the games did not have a negative impact in their appreciation according to the children. A comparison of this experience with one with easier games would entail a different kind of research.

On the other hand, from the teachers' side we learned that, while the contents could engage the students, there is still work to do regarding the balance of games and educational elements. Moreover, the main problem with our loan kit was its expected class time management, which could be reworked at a later date by better analyzing the time required for the students to complete the different activities planned, and how the time in a regular class is managed. One obstacle we had from the beginning was asking the teachers to adopt a completely different class model within their regular teaching style. Additionally, while one of the teachers felt reluctant of them, the others gladly received the idea of using materials such as the ones presented in our loan kit in their classes.

The replicas were successfully implemented with the digital games, and the constant interaction with them helped the students understand the lesson's content. They were also beneficial for the session with the museum's professor, since they used them as examples and compared them to the museum objects, while the students could actually look and touch them.

The goal of the long-distance class session was also achieved, as there was a direct connection between the students and the museum, the museum's professor being its representative. The teachers also considered this class a valuable experience for the students, and while some of the content explained by the professor were somewhat advanced for the students' level, the museum's knowledge reached the students.

Regarding the technology used, NFC tags and augmented reality had some minor technical issues, but ultimately they were sustainable enough for the class plan we proposed. The 3D printed replicas were overall well crafted and accurate, and while some unavoidable damage happened to delicate pieces due to their constant manipulation, they were easily repaired.

In our research we served as a link for connecting a museum with schools that do not have easy access to it. We maintained contact with both the museum and schools, presented our project and went to improve it along the way with their suggestions. We consider that this communication channel was critical for developing satisfactory results. With the design of both digital and physical content, we developed materials for a class planned on the foundations of the current school curriculum and the museum's exhibitions. The previous conclusions lead us to think that a path towards offering this kind of outreach programs can still be expanded by creating opportunities to collaborate between museums and schools.

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