

Analyzing the Effect of Museum Practice by Using a Multi-Mouse Quiz among Children from Different Grades — A Reflection Perspective

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SUMMARY Multi-Mouse Quiz (MMQ) is a quiz application based on the Single Display Groupware (SDG) [1] concept through which several users can answer quizzes by sharing a computer to take the quiz in a classroom or any other learning environment. We conducted a practice, where we used the MMQ to support collaborative learning, which was combined with a museum visit. In the previous research, we found that the 3rd-grade children were able to operate the MMQ without any special assistance from the researchers, and that their use of the MMQ was characterized by high engagement [2]. In this study, we also conducted qualitative evaluation in the form of observation data and a free description of the questionnaire; we found that, compared to previous studies, which used MMQ with 6th-grade children, the 3rd-grade were more willing to use body language to express their emotions, and this tendency made the whole class more active. Furthermore, MMQ quiz learning inspired children with reflection perspectives to participate in the museum activity and activities in the computer room.

key words: quiz learning, museum learning, elementary school, reflection

1. Introduction

The national curriculum for elementary schools in Japan requires “The Period for Integrated Studies” to be offered as a general learning class. It aims to develop children’s understanding regarding the advantages of exploitative learning, their expression ability with regard to solving problems that occur in real life, and their cultivation of positive attitudes towards participation in society [3]. As part of this program, elementary schools have to conduct 70-hour classes every year for students from 3rd-grade to 6th-grade. Social educational facilities such as museums are commonly utilized by elementary schools in their class design for the period of integrated studies. Such activities aim to encourage the children’s interest in science, increase their knowledge, or deepen their understanding of the region where they live. The conventional style of learning about the museum involves visiting the museum and writing essays after the visit. Kotani & Nogami [4] have pointed out that educators often wish to change such activities from “play” into “learning”

during museum learning. However, school teachers often face constant problems when they attempt to utilize reflection in children’s learning activities.

In the traditional class, the children write an essay to reflect their museum learning. Contrary to this approach, in this study, the children carried out a study task that involved creating quizzes or answering quizzes combined with a museum visit, and they finished their task after visiting the museum. This study aims to improve children’s engagement with the museum learning activity and promote their reflection.

2. Related Work

2.1 Reflection

Reflection is an active, persistent, and careful consideration toward self-constructed knowledge and meaning through the use of one’s experience, action, and beliefs [5]. Research has often placed greater focus on the process of learning compared to the outcome [6, 7]. In [7], Boyd and Fales contend that experiential learning must be conceptualized as a process and that the research required for examining the phenomenon of experiential learning must also focus on the process because the learning is experienced personally by individuals. This study will carry out a process evaluation of children’s learning.

2.2 Information Communication Technology (ICT) Support in Museum Learning

Several systems have supported museum learning. Yatani et al. developed a quiz system using a Personal Digital Assistant (PDA) to support children’s collaborative learning in a museum [8]. For college and high school students, Hirasawa et al. developed the voice guide system for museum learning by using an iPad [9]. Ishiyama et al. developed the Stamp-On system, which provides the user with detailed information about exhibits when he/she puts a stamp on the iPad [10]. They measured the effectiveness of this system in a college class.

However, these ICT systems support users’ study only when they are observing exhibits inside the museum. This study aims to support children’s study before and after they visit the museum.

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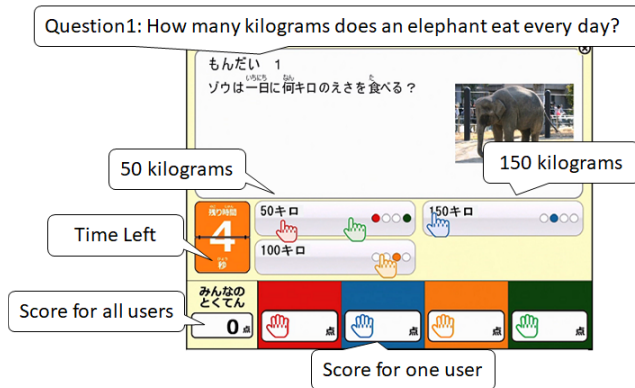


Fig. 1 Multi-Mouse Quiz (MMQ) [12]

2.3 Single Display Groupware (SDG)

A lot of ideas regarding Computer Supported Collaborative Learning (CSCL) were developed based on multiple personal computers that were connected through a network. These systems were used in educational environments where students used their own computers and sat at their own seats. However, when students needed to discuss their work with their classmates face-to-face, they often had to move to others' seats and thus leave their own computers.

Considering the importance of face-to-face collaborative learning, the SDG proposed by Stewart et al. is a framework that overcomes the previously mentioned disadvantage of connected personal computers in a CSCL environment [1]. In SDG, users share information on a single display, and every user has an input device (such as a mouse) that can control the computer. Scott et al. reported that the SDG environment shows users as being more active on the screen [11].

2.4 Multi-Mouse Quiz (MMQ) and Previous Research

MMQ is a quiz application based on the SDG concept. It enables multiple users to answer quizzes by connecting several mice to an ordinary personal computer. Figure 1 shows a screenshot of the MMQ. Four users with hand-shaped cursors controlled by their own individual mice can independently click their answer within a time limit while use only one PC. After users answer the quizzes, MMQ will show the correct answer and commentary on the next screen.

We utilized an MMQ system (including MMQEditor, a software to edit MMQ quizzes, and MMQ) to support 6th-grade children in creating and answering quizzes in an elementary school setting. The results showed that the children found it easy to operate the MMQ system and that their learning was encouraged and deepened through the mutual evaluation of the quizzes themselves created [12].

Based on these results, we carried out the similar practice, including the museum learning activity, among the 3rd-grade and 6th-grade children. This study aimed to confirm whether above results would be found among the 3rd-grade

children and to determine which kind of engagement the children would have.

Zhou et al. [2] revealed that the MMQ could be operated by 3rd-grade children and they have high engagement. However, analysis of the results shown in [2] showed good engagement of the children in the activities, but this mainly remained a quantitative study of multiple choice questions in the questionnaires. However, MMQ provided an environment different from other ICT environments for collaborative learning; furthermore, the design of the activities was complex because it combined museum-based study with quiz creation and answering across grades.

This study investigates this activity through a qualitative point of view by analyzing descriptive answers for the questionnaires, interviews with school teachers, and observations of the activities. In this study, we further examined the children's reflection on their learning and created a questionnaire analysis using the results of the free description of the questionnaires; furthermore, we examined the children's behavior when they were using the MMQ.

Sections 3 and 4 provide overviews of the practice partly reported in [2]. In Sect. 5, we analyzed the results qualitatively while referring to the quantitative results shown in [2].

3. Class Design

3.1 Purpose of Class Design: To Motivate Children's Collaboration

In this study, MMQ was used to motivate children's enjoyment in terms of engagement with the activity. The activity selected for the class was designed in accordance with the proposals of the school teachers, and the authors gave technical suggestions with regard to use of the MMQ.

The 6th-grade children used the MMQ to answer some sample quizzes that were created by our research group before they visited the museum. They were asked to create quizzes for 3rd-grade children. This step was designed to ensure that the children would carry out a study task during their visit to the museum, thus motivating them to collaborate with the 3rd-grade children by creating quizzes.

The 3rd-grade children used the MMQ to answer 10 quizzes created by the 6th-grade children before they visited the museum, and they answered all the quizzes (40 quizzes) created by the 6th-grade children after they returned from the museum. This task was also designed to motivate children to carry out a study task during their visit and thus enhance their enjoyment in remembering the knowledge they learned during the museum visit.

3.2 Activity Details

In total, 47 3rd-grade children and 40 6th-grade children participated in this activity. The quiz creation activities were divided into three parts as follows:

1. Children answered sample quizzes using the MMQ.

2. Learning in the museum: They were told that they would have to create quizzes for the 3rd-grade children before they visited the Kyoto University Museum.
3. Creating quizzes: The 6th-grade children wrote quizzes for the 3rd-grade children. The children's created quizzes were reviewed and edited by the school teachers and ported into the MMQ by one of the authors. After they finished their quiz creation, they were required to answer a questionnaire concerning this activity.

The 3rd-grade children were asked to answer the quizzes created by the 6th-grade children. The MMQ was used for this activity because it encourages conversation among children while they are answering the quiz by sharing the display. This activity is composed of the following three parts:

1. First Time MMQ Answer: The 3rd-grade children answered 10 quizzes out of those created by the 6th-grade children with the MMQ as preparation for their study in the museum. The first questionnaire was conducted after their use of the MMQ.
2. Learning in the Museum: One week after they answered the quizzes, the 3rd-grade children visited the museum, and appreciated the exhibits in the museum.
3. Second Time MMQ Answer: One week after their visit, they answered all the 40 quizzes created by the 6th-grade children in order to review what they had learned in the museum. The second questionnaire was conducted at this point.

Three class hours (over 2 days) were allotted to each of the two 3rd-grade classes for answering quizzes used MMQ. To support the teachers and their students in using the MMQ, one of the authors participated in the activities.

4. Research Question and Method

4.1 Research Question

This study's main purpose was to support children's museum based learning during "the period for integrated studies." The school teachers often faced constant problems regarding how to change "play" into "study" and how to guide children to reflect on their study on the museum activity. Our main research question involved identifying what kind of reflection could be gained through this activity. We conducted a survey using the questionnaires, participant observations regarding the activities, and interviews with the school teachers.

The MMQ was used in higher grades in our previous practices, and it was used for the first time by the 3rd-grade children in this study. Another research question in our study involved determining what kind of behavior would be observed when the 3rd-grade children used the MMQ.

4.2 Method

The authors formulated questionnaires to conduct a quan-

Table 1 The first questionnaire for the 3rd-grade children [2]

1) Was the MMQ difficult to use?
2) Do you want to use the MMQ again?
3) Were the quizzes difficult?
4) Did you remember the quizzes?
5) Did you enjoy the quizzes?
6) What do you want to do after answering these quizzes? (multiple choice) *I want to go to the Kyoto University Museum soon *I want to try these quizzes with my family *I want to read books *I want to make quizzes *I will watch exhibit carefully when I go to the Kyoto University Museum *Others ()

Table 2 The second questionnaire for the 3rd-grade children [2]

1) Was the MMQ difficult to use? How was it difficult?
2) Do you want to use the MMQ again?
3) Were the quizzes difficult? How were they difficult?
4) Did you remember the quizzes?
5) What do you think about the quizzes created by the 6th-grade children? (multiple choice) *Great *Fine *Neither *Not so good *Bad *Useful *Useless *Taught me what I did not notice about that exhibit at the museum *I knew the answers to all of the quizzes *The questions in the quizzes were easy to understand *The questions in the quizzes were difficult to understand *The explanations for the quizzes were easy to understand *The explanations for the quizzes were difficult to understand *Other()
6) What did you do after you answered the quizzes last time? (multiple choice) *I went to the Kyoto University Museum with my family *I attempted the quizzes with my family *I read the books or surfed online *I created the quizzes *I studied well when I had to go to the Kyoto University Museum *Others ()
7) Did studying in the museum remind you of some quizzes?
8) Please write your comments freely. (Free description)

Table 3 Questionnaire for the 6th-grade children [2]

1) Which quiz did you create?
2) Why did you create that quiz? (multiple choice) **The content was very interesting *The impression of the exhibit was deep *It was useful for the 3rd-grade children *I liked it *It was easy for the 3rd-grade children *It was difficult for the 3rd-grade children *Others ()
3) Did you consider the potential answerer when you created the quizzes?
4) What have you done to develop your quizzes for the 3rd-grade children? **I wrote the phonetic characters (Hiragana) *I made the text easy to understand *I researched online and by using reference books *I drew a picture to make it easy to understand *I discussed with friends *I reviewed the photos or the notes *Others ()
5) What reaction do you want from the 3rd-grade children who answered your quizzes? (multiple choice) **They should answer with interest *They should answer correctly *They should not answer correctly *They should remember the knowledge *They should find the quiz difficult *They should not be able to answer *They should find the quiz easy *They should be able to read other reference books *They should be able to study well in the museum *Whatever *Others ()
6) Are you satisfied with your quizzes? Why are you satisfied?
7) Did you find it difficult to create the quizzes for the 3rd-grade children? Why did you think so?
8) Did you enjoy creating quizzes for the 3rd-grade children? Why did you think so?

titative and qualitative analysis of children's engagement, evaluation, and feedback.

The study utilized three kinds of questionnaires. Table 1 shows the first questionnaire, which was administered to the 3rd-grade children after they used the MMQ for the first time (before they visited the museum). Table 2 is the second questionnaire for the 3rd-grade children, which they answered after they used the MMQ for the second time (after they had visited the museum). Table 3 shows the questionnaire administered to the 6th-grade children after they created the quizzes. In addition to analyzing the questionnaires, we also interviewed the teachers to evaluate the activities.

5. Results and Discussion

Zhou et al. [2] found that the 3rd-grade children were able to operate the MMQ by themselves without any special assistance and that the children had a high sense of enjoyment and engagement. Furthermore, we figured out the reason for their feelings by analyzing the responses to the questionnaire (comparing the responses to the first questionnaire and the second questionnaire)[†]. Furthermore, the results of the participant observations regarding the activities and the interviews with the school teachers regarding the reflection of the children's learning were as follows.

A total of 42 3rd-grade children participated in both the first time MMQ activity and the second time MMQ activity. As some of the answers were considered invalid data, the following data analysis was based on data collected from 35 3rd-grade children. Regarding the data of the 6th-grade children, the results used data from 40 children.

5.1 Children's Engagement and Usability of the MMQ

Okada examined the developmental changes in terms of motivation with regard to cooperative learning during childhood (from the 3rd to the 6th grade) over four years; growth curve analyses revealed that intrinsic motivation decreased with higher grades [13]. Okada also mentioned that educators should focus on the importance and pleasure of cooperative work to motivate children's cooperative work.

The responses to the question "Do you want to use the MMQ again?" in both activities was more or less the same. Almost all the children chose a positive choice. Two or three children changed their answer from "Yes" to "Probably Yes" and "Neither." However, no negative responses were provided for this question (Fig. 2).

The 3rd-grade children were asked the same question ("Was the MMQ difficult to use?") both during the first MMQ activity and the second MMQ activity. More than 60% of the children answered, "Probably no" or "No." Figure 3 shows that the number of children who selected "Prob-

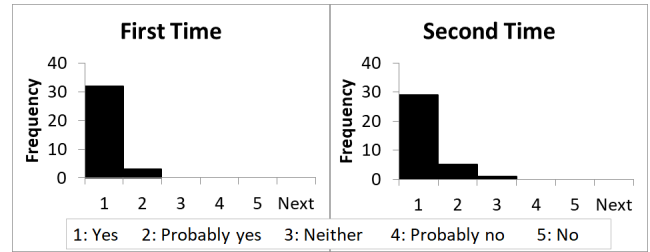


Fig. 2 Histograms of responses to the question "Do you want to use the MMQ again?"

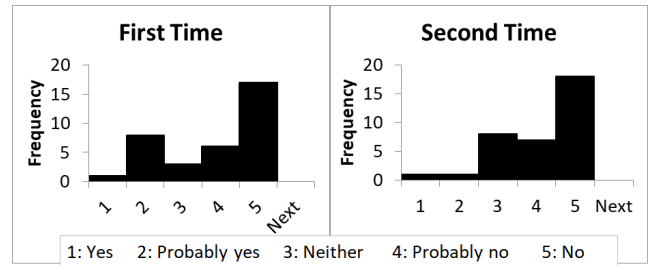


Fig. 3 Histograms of responses to the question "Was the MMQ difficult to use?"

ably yes" the first time decreased the second time. During the second round, a higher number of children selected the "Probably no" and "No" responses compared to the first round.

The difficulty of using the MMQ may have been reduced in the second activity. However, when the Wilcoxon signed-rank test was carried out, no significant differences were observed between the two groups.

One of the authors observed that the children seemed to use the MMQ successfully without any apparent difficulty in operating it. The vice principal said, "The atmosphere of the class is different compared to what it is when the higher-grade students use MMQ. Everybody looks very happy. Maybe the lower grade children expressed their enjoyment with more gestures. The visuals of the class of 3rd-grade children using the MMQ with high engagement should be shown to the 6th-grade children. The 6th-grade children will be happy." For example, when the children answered the quizzes correctly, they said "Yeah!" with a victory pose.

The children used the MMQ smoothly; there were even a few children who thought that the MMQ was difficult to operate, but the more they used it, the more familiar they became with the MMQ. Furthermore, in the case of the children who felt that the MMQ was difficult to operate, it had no negative effects on their engagement. Compared with the previous research conducted among the 6th-grade children, the 3rd grade children were more active with their gestures compared to the older children.

[†]We used the data shown by Zhou et al. [2]; however, the figures were replotted as histograms because we wanted to know the difference between the first class that answered the MMQ and the second class that answered the MMQ.

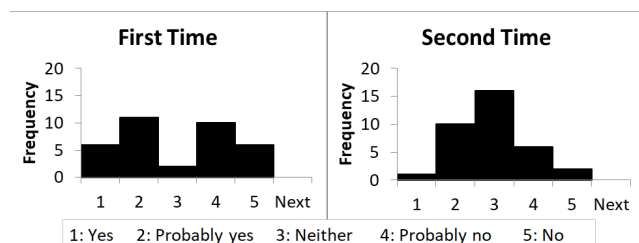


Fig. 4 Histograms of responses to the question “Were the quizzes difficult?”

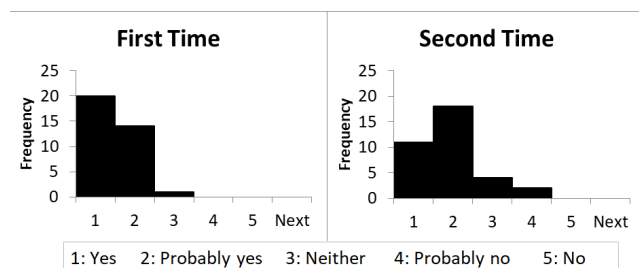


Fig. 5 Histograms of responses to the question “Did you remember the quizzes?”

5.2 Answer the Quizzes Using MMQ

5.2.1 The Result of the Questionnaire

For responses to the question “Were the quizzes difficult?,” about half the children chose the “Yes” or “Probably yes” option, and the other half chose the “No” or “Probably No” option in the first round. Only two children selected “Neither,” but during the second time, about 15 children chose “Neither.” Furthermore, the number of children who chose the other choices decreased during the second time (Fig. 4).

The responses regarding the free description of the children who selected “Neither” reveal some of the reasons for this. “Even though I did not know the answer to the quizzes, my classmate and I answered it together. It was very good.” “It would be better if they could create some quizzes on what I saw in the museum” “It is good that the quizzes taught me what I did not notice” This showed that, when the quizzes dealt with things that the children did not see or did not notice in the museum, the children could not provide a proper evaluation for whether the quizzes were difficult.

Another important question was, “Did you remember the quizzes?” Compared to the first time, the number of children who chose “Yes” decreased during the second time. There were also some children who chose “Probably No.” This was related to the number of quizzes. There were 10 quizzes during the first time, and there were 40 quizzes during the second time.

The results above show that all the children thought that they would be able to remember the contents of the quizzes and they would be able to evaluate the difficulty

level as easy or difficult before they visited the museum. Because they had the knowledge that the questions are referring to, they think that the quiz was easy. If they could not answer, they would think the quizzes were difficult. However, after they visited the museum, some of the children had no confidence in whether they could evaluate the quizzes as easy or difficult because of the possibility that the contents of the quizzes were not difficult or that they had not noticed a particular exhibit in the museum that the quizzes are referring to. The children began to evaluate the quizzes based on their experience of visiting the museum. We can see the change in their evaluation of the quizzes before and after they visited the museum. A kind of reflection after visiting the museum is observable.

5.2.2 The Result of the Observation

Regarding the children’s use of the MMQ, observations showed that, sometimes, the children answered the quizzes and changed their choice according to their friend’s choice, and sometimes, they stuck to their own choice.

One case was as follows. Three children used the MMQ together, and one of them (a boy we will call X) chose “B,” while the other two children (two girls we will call Y and Z) chose “A” during the first time. However, Boy X said, “I know this. It is B.” Girl Z said, “I think it is A.” Girl Y showed some hesitation and changed her answer to “B.” Two seconds later, she changed again and chose “C.” (Girl Y said something, but we could not catch it because of the vocal noise from the other children.) As a result, when A was revealed to be the correct answer, these three children (including girl Z) were very disappointed.

For the next question, Boy X read the question and chose B, saying, “Absolutely B, it is ‘Canid’.” During the same time, Girl Y chose “A,” and Girl Z chose “B.” After 2 seconds, Girl Y asked X and Z “Really?” and changed her answer to “B.” When the correct answer was revealed to be “B,” these three children looked very happy and talked about it.

The abovementioned case showed that, even though they could see the others’ answers, they also thought about which one was correct and did not just follow the other children’s answers. Girl Z stuck to her answer and tried to lead the other children to choose the correct answer. Boy X also chose the answer that he thought was correct. Girl Y changed her answer during both rounds, but she also had her own opinion because she did not just follow the other children’s answer; rather, she ensured that they had no doubts about their answers before she changed her choice.

The children’s conversations were observed when they were using the MMQ. They talked to each other, and in the abovementioned case, children taught each other which option was correct and tried to convince the other children regarding their choice. These kinds of conversations probably would not have occurred if they were unable to see the other children’s choices. In other words, showing everyone’s answer gave the children the chance to talk about their answers

Table 4 The category of the 3rd-grade children's free description

Engagement	26
Quiz-related Knowledge: Remember or Understand	17
Evaluation of the Quizzes	9
Museum	8
System(Multi-Mouse Quiz)	5
Collaboration	2

to each other. We also think that this action was a kind of study activity in the children's perspective.

Another point is related to the design of the MMQ. The MMQ not only showed every user's score but also showed the collective score for all the users. This may be one of the reasons why, even though Girl Z answered the first quiz correctly, she looked disappointed when the other children (X and Y) answered it wrong. The children cared about other children's answers and wanted to get the correct answer together.

Although quantitative evaluation or more persuasive evidence is our future work, from such observations, we think that MMQ promoted the interaction between children, encouraged active discussion and also gave an opportunity to rethink about their answers.

5.3 Reflection through the Activities

After the 3rd-grade children finished providing their second time MMQ answer, we asked the following: "(8) Please write your comments freely. (Free description)." While answering this was not mandatory, all the children wrote about what they felt in their own words. Table 4 showed the results, which we categorized based on the children's answers. It was labeled by the author. Table 4 showed that the "Engagement" was mostly found in their feedback. Some example comments were as follows: "I am very glad to attend this activity." "It was really lots of fun." "I want to try this again."

The second rank was accorded to "Quiz-related Knowledge: Remember or Understand." Many children were satisfied in their answering of the quizzes and gained important knowledge. "I am happy to know the types of leaves and the types of elephants that I did not know"; "I am glad to answer the quizzes about things I did not notice in the museum."; "The quizzes were difficult, but I enjoyed it."

The third rank was accorded to "Evaluation of the Quizzes." For example, one child wrote, "It was good because it was easy to understand, and sometimes, hints were also provided with the quizzes."

Many children's opinions showed that they developed an interest in the museum after this activity. Some children wrote comments such as "I want to know more about the museum" and "I want to go to the museum more than 3 times so that I can answer the difficult quizzes."

Some of the feedback was related to the system: "It is a great system, and it can let four people answer the quizzes together" and "I like to click the choice to answer the quizzes." Furthermore, some children were satisfied

with the collaborations: "I think it was good to answer the quizzes that I did not know with my friends" and "I realized the importance of collaboration for answering quizzes."

Children's engagement and motivation were also observed in their free description. They enjoyed the activity because it involved using the MMQ, gaining knowledge, or collaborating with their friends.

5.4 Reflection in the Museum and in the Classroom

In the interview with one of the school teachers, she evaluated the activity, explaining that the first time activity is useful for increasing children's familiarity with the contents of the museum. She heard that the children had discussed the quizzes when they visited the museum. These results were also reflected in the questionnaire. More than 90% of the 3rd-grade children (who chose "Yes" or "Probably yes") answered that they remembered some quizzes that they had completed before they visited the museum [2]. Not only did the first-time activity have an effect on the children in their next study but studying in the museum also affected the children during the second time MMQ activity. One of the authors observed that children made statements as follows when they answered the quizzes with the MMQ after the visit of the museum: "I know this quiz; we saw it in the corner (of the museum)" and "Is this that game (shown in the museum)?".

5.5 Reflection by Creating Quizzes and Evaluating the Quizzes of 6th-Grade Children

5.5.1 Creating Quizzes

About 80% of children thought that creating a quiz for the 3rd-grade children was a difficult thing. The results of the free description related the following: "It is hard to make the question easy to understand for 3rd-grade children" and "It is hard to make a quiz that can increase the knowledge of 3rd-grade children and also help them understand quizzes easily."

The 6th-grade children felt that it would be difficult to create quizzes for answerers who were younger than them; thus, difficulty level was also a thing that they worried about. This was also related to the results of the questionnaire. In total, 22 children made the text easy to understand, and 10 children wrote the Japanese phonetic characters[†] in the quizzes.

5.5.2 Evaluating Quizzes

The 6th-grade children who created quizzes reflected through their evaluation of the quizzes, and 60% of children were satisfied with the created quizzes.

[†]Hiragana is a Japanese syllabary; it is learned in the first year of elementary school. The younger children were more familiar with it.

Regarding the reasons for their satisfaction, some children thought that their quizzes were good because they considered the answers when they created the quizzes: “The quiz I created is useful for the 3rd-grade children,” “The quiz I created is not too easy and not too difficult for the 3rd-grade children. It generates useful knowledge,” “My quiz can increase knowledge that the 3rd-grade children did not learn before,” and “I created quizzes that were easy to understand for the 3rd-grade children.”

Some children were satisfied with their efforts. They wrote statements such as the following: “By carefully considering the answer, I tried my best to create the quizzes,” “I surfed the net perfectly,” “I surfed the net to confirm certain things of my interest,” “I checked the notes that I had written when I went to the museum and confirmed whether there were any mistakes or not,” “I wrote the commentary for the quizzes,” and so on.

Some children experienced satisfaction because of the difficulty, simplicity, or enjoyment of the quizzes: “I thought that my quiz was very interesting when I read my quiz again,” “The quiz I created is very easy to understand,” and “I created a difficult quiz.”

Some children pointed out some drawbacks in their quizzes, even though their evaluations of their quizzes were great: “I am not sure whether the 3rd-grade children understand the ‘the Chugoku regional,’ so I should have explained it more” and “The context may not have been right.”

Only 2 children were not satisfied with the quizzes they had created. The reasons were pointed out as follows: “I am not sure the answer is correct” and “I created my quizzes with support from my friends (I did not create the quizzes by myself).”

Nearly 30% of 6th-grade children evaluated their quizzes with “Neither.” The reasons for this were many: “Some quizzes are good, but creating the quizzes is difficult.” Some children chose the “Neither” option because they had no confidence about their quizzes: “I created the quizzes without considering the need of the 3rd-grade children.”

These results show that the 6th-grade children felt that creating quizzes for younger children was a difficult thing. However, most of the children were satisfied with the quizzes that they created by themselves. The reasons for this were that they cared about the fact that the answerer was a younger child, so they made some efforts to make the contents easier for the 3rd-grade children.

5.5.3 Engagement with Regard to Creating Quizzes

On the other hand, more than 80% of the children stated that they enjoyed the activity. They also provided the reasons for their enjoyment. Some children mentioned that they were looking forward to the 3rd-grade children answering their quizzes using the MMQ. They thought that the 3rd-grade children would be happy to answer the quiz: “Because I am looking forward to the 3rd-grade children answering the quizzes happily” and “When I think this quiz will let the

3rd-grade children increase their knowledge, I feel happy.”

There were also some children who wrote about their enjoyment in relation to gaining knowledge: “Because it is useful for studying by myself,” “Because I was able to find out something that I did not know before,” “I investigated the related knowledge using a computer,” “I gained new knowledge while I was creating the quizzes,” “I gained new knowledge,” and “I learned about some contents in more detail by creating the quizzes.”

Some children stated in their evaluations that they had enjoyed the collaborative learning: “I am glad to think about the quizzes with my many friends” and “I talked about the quizzes with my friends.”

The children reflected on the experience of creating quizzes. By creating quizzes, they affirmed their efforts in creating quizzes and increasing their knowledge. They were satisfied that the 3rd-grade children could gain knowledge by answering their quizzes, and they reflected on areas where they felt inadequate.

The abovementioned data analysis of the 6th-grade children’s free description showed various benefits associated with the use of MMQ. Many children stated in their evaluations that they felt that creating quizzes would be a difficult task, but they enjoyed it because they were looking forward to the 3rd-grade children answering their quizzes using the MMQ. One of the aims of this class design was to motivate the 6th-grade students. Our experimental results demonstrated that the 6th-grade children had a strong awareness of the 3rd-grade children and that they expected to interact with them.

6. General Discussion

6.1 Children’s Behavior

This was the first time that we conducted classroom practice using the MMQ for 3rd-grade children. The 3rd-grade children were able to operate the MMQ smoothly and did not need others’ help [2]; similar results were found in the previous studies (6th-grade children).

The MMQ aimed to support children’s collaborative learning by engaging them in conversations with each other. Through an analysis of the observation and interview results, we found some differences in the 3rd-grade children compared to the higher grade children. That is, the 3rd-grade children not only talked to their friends but also preferred to use body language to express their emotions; this tendency made the whole class atmosphere very active when they were using the MMQ.

The main benefit of the “sharing” feature of the MMQ was that it allowed for sharing one screen, and consequently, students could see each other’s answers; this, in turn, prompted dialog among the students and encouraged them to pay attention to the questions (activity such as reading the questions aloud, reading the choice option, or self-asserting the answers). This may have aided the children in focusing on the question itself.

6.2 The Reflections of the 3rd-Grade Children and the 6th-Grade Children

The 3rd-grade children reflected on their learning in different ways through the two MMQ classes. The first MMQ answer class made children carry a task to visit the museum, and it made them recall the quizzes when they were visiting the museum. For the second MMQ answer class, the experience of visiting the museum was recalled when they answered the quizzes. The 3rd-grade children reflected on the quizzes when they were visiting the museum and reflected on their museum learning in the second MMQ answer class.

It is reported that creating the quizzes had a positive effect on students' learning [14], [15]. One purpose of this activity was to make the 6th-grade children consider the fact that the answerers of the quizzes were younger than them. 3rd-grade children had less knowledge compared to the 6th-grade children. Therefore, when they created the quizzes for the 3rd-grade children, they wanted to choose easy words or explanations that were easy to understand. Thus, they were required to develop a better understanding of the knowledge and use their own words to express it in their quizzes. Thus, this could be a good educational method for helping children gain a deeper understanding of the content and also to help them memorize the knowledge.

The children who created the quizzes also reflected on their learning in their own way. They paid attention to the answerer. Concerning the reason for their satisfaction and enjoyment, they felt happy because someone had answered the quizzes they had created. They felt that their quizzes were good because, when they were creating the quizzes, they had considered the fact that the answerers were younger in age. Therefore, we can say that the 6th-grade children paid attention to the answerers when they created the quizzes.

We investigated the reasons for children's satisfaction. Concerning the reasons for satisfaction, many children felt satisfied because they had shown care toward the 3rd-grade children when they were creating the quizzes. Furthermore, the children who chose the "neither" option stated that they had been worried about whether the 3rd-grade children could understand their quizzes.

The children expressed clearly in their own words that what they studied provided a good reflection. For improving their quizzes, the children tried their own methods; some children made the text easy to understand, and some children reviewed the notes. Eventually, a good number of the children felt satisfied with their quizzes.

7. Conclusion

Many elementary schools utilize social educational facilities such as museums in their class design for the "period for integrated studies." However, school teachers often face problems with regard to children's learning reflection in these activities. We studied collaborative quiz learning by using

the MMQ model in a museum learning setting.

The school teachers evaluated this activity as successful. That is, they felt that this activity helped all the children to learn well through both quiz answering and quiz creation; thus, both activities encouraged students to have a successful reflection. We observed the following results:

1. MMQ encouraged the 3rd-grade children to use communication to collaborate with each other. The 3rd-grade children were more willing to use body language to express their emotions while using the MMQ.
2. The MMQ learning model inspired the 3rd-grade children to carry along a study task to the museum.
3. The MMQ learning classes were recalled when the 3rd-grade children visited the museum. They reflected their quiz-based learning (the first MMQ learning class) when they visited the museum.
4. The 3rd-grade children reflected their museum-based learning when they carried out the second MMQ learning class.
5. Creating quizzes for younger children, the 6th-grade children reflected on evaluating the quizzes that they had created and tried, in many ways, to create a good quiz.
6. This activity helped teachers to turn the museum-based learning from "play" into "study."

As for future work, the authors aimed to utilize the same class design in other schools to confirm children's behavior and the reflection on study identified in this practice.

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References

- [1] J. Stewart, B.B. Bederson, and A. Druin, "Single display groupware: a model for co-present collaboration," *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pp.286–293, ACM, 1999.
- [2] J. Zhou, M. Mori, H. Kita, and K. Watagoshi, "Quiz creating and answering activities of across grades using multi-mouse quiz system in the period for integrated studies in an elementary school," *2013 Second IIAI International Conference on Advanced Applied Informatics*, pp.172–177, IEEE, 2013.
- [3] "Ministry of education, culture, sports, science and technology, japan." http://www.mext.go.jp/component/a_menu/education/micro_detail/_icsFiles/afieldfile/2018/05/07/1387017_14_3.pdf.
- [4] T. Kotani and N. Tomoyuki, "A case study of science learning in a museum from two viewpoints," *Journal of Science Education in Japan*, vol.26, no.1, pp.20–32, 2002.
- [5] S.-W. Hsieh, Y.-R. Jang, G.-J. Hwang, and N.-S. Chen, "Effects of teaching and learning styles on students' reflection levels for ubiquitous learning," *Computers & Education*, vol.57, no.1, pp.1194–1201, 2011.
- [6] J.R. Ward and S.S. McCotter, "Reflection as a visible outcome for preservice teachers," *Teaching and teacher education*, vol.20, no.3, pp.243–257, 2004.
- [7] E.M. Boyd and A.W. Fales, "Reflective learning: Key to learning

from experience,” *Journal of humanistic psychology*, vol.23, no.2, pp.99–117, 1983.

- [8] K. Yatani, M. Onuma, M. Sugimoto, and F. Kusunoki, “Musex: A system for supporting children’s collaborative learning in a museum with pdas,” *Systems and Computers in Japan*, vol.35, no.14, pp.54–63, 2004.
- [9] Y. Hirazawa, T. Matsukawa, T. Kawata, and M. Kominami, “Development and evaluation of ipad guide system for museum exhibits,” *Japan journal of educational technology*, vol.36, pp.89–92, 2012.
- [10] A. Yishiyama, K. Muratsu, S. Kato, T. Sakiyama, F. Kusunoki, S. Inagaki, and T. Terano, “Stamp-on: Prototyping and a preliminary evaluation of support system for museums,” *JSSE Research Report*, vol.28, no.7, pp.45–48, 2018.
- [11] S.D. Scott, R.L. Mandryk, and K.M. Inkpen, “Understanding children’s collaborative interactions in shared environments,” *Journal of Computer Assisted Learning*, vol.19, no.2, pp.220–228, 2003.
- [12] J. Zhou, M. Mori, H. Ueda, and H. Kita, “Quiz making activities using the multi-mouse quiz system in an elementary school,” *International Journal of Distance Education Technologies (IJDET)*, vol.11, no.4, pp.45–62, 2013.
- [13] R. Okada, “Developmental changes of motivation for cooperative learning during childhood,” *The Japanese Journal of Personality*, vol.26, no.3, pp.194–204, 2018.
- [14] Y. Hirai, A. Hazeyama, et al., “A collaborative learning support system based on question-posing by learners and effectiveness of its application to an actual university course,” *The Special Interest Group Technical Reports of IPSJ (Computer in Education)*, vol.2009, no.15 (2009-CE-98), pp.9–16, 2009.
- [15] A. Nakano, T. Hirashima, and A. Takeuchi, “An intelligent learning environment for learning by problem posing,” *The Journal of the Institute of Electronics, Information and Communication Engineers D*, vol.83, no.6, pp.539–549, 2000.



display groupware.

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