

Doctor Thesis

**Effectiveness of the Multi-Mouse Quiz
System for Collaborative Learning in
Elementary Schools**

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Abstract

In elementary school education, to motivate learning is one of the key problems. Collaborative learning is one of promising methods in teaching for it, and support collaborative learning by Information and Communication Technology (ICT) is an important subject. Single Display Groupware (SDG), a Computer Supported Collaborative Learning (CSCL) model in which users have their own input devices such as mice sharing information on a single display, is a promising approach to encourage collaborative learning in ordinary classroom supporting face to face collaboration by ICT. In this paper, the author studied effectiveness of the Multi-Mouse Quiz System (MMQ System) including MMQ an application of SGD which allows several users to answer quiz questions sharing one screen and MMQ Editor a regular application of personal computer to create quiz question, through various practices of using MMQ System in elementary schools. Through these practices, the author studied usability of the system, applicable subjects and other activities, class design, and the effectiveness of MMQ on children.

This research was carried out with cooperation of Kyoto Municipal Board of Education. Introduced by the board, several elementary schools participated in the practices of using MMQ System. Before carrying out the practice in elementary schools, the author participated in classes of elementary schools to study needs of classroom, and added some functions to MMQ such as pause by keyboard to facilitate class, and developed the MMQ Editor for teachers or children to edit the quizzes. In this research, the study was conducted by asking the teachers to decide the subjects or activity to which MMQ System was applied, and to design classes along their own educational policies, and the author support teachers' work in technical aspects.

As the one of SDG's particular features, the users can communicate to others through gestures using mouse cursors as well as to communicate to the computer. However, in the present stage, most researchers restrict the number of

mice to avoid the problem that it takes time for users to distinguish their mouse cursor from the others when many mouse cursors are shown on a shared display. Further, as the practices were conducted in this research include the classes of one child hold one mouse in a small class and the classes of using groups with 2 to 8 children share one mouse in regular classes. The author observed the effects of group size sharing a mouse with MMQ through a practice that gave children with various environments of the group sizes sharing a mouse. The group sizes of using one mouse were set to 1 child to 7 children. As the result, all of the environments engaged the children and enhanced their learning. In groups with 2 to 7 children sharing one mouse, more active communication than the case of one child use one mouse was observed, and performance on learning didn't decreased.

In the practices we conducted, there were four schools which implemented the practices in regular classes of subjects 'Social Studies' and 'Arithmetic'. The practices were designed combining various activities. As the result, children was engaged the classes by using MMQ, and the engagement was higher than usual classes.

There was a school used MMQ in 'the Period for Integrated Studies'. The teacher designed the class in which the children not only answered the quizzes but also they created the quizzes to improve the performance of class. This practice showed the possibility of activity using MMQ highly encouraging children's studies not only in the classroom but also the activities outside of the school.

Through these practices the effectiveness of MMQ System supporting collaborative learning in elementary schools were shown as a conclusion.

小学校での協調学習における マルチマウスクイズシステムの有効性

周 娟

内容梗概

小学校教育では児童を学習に動機づけることが重要であり、楽しく学習できるような雰囲気を作るために協調学習という形態を用いた授業実践がしばしば見られる。このように授業へのICTの利用は重要な課題である。Single Display Groupware (SDG) は、1つのディスプレイを共有しながら複数人にマウスなどの入力デバイス进行操作できるようにした Computer Supported Collaborative Learning (CSCL) モデルである。この SDG の概念に基づき、1つの画面を共有しながら複数人が同時にクイズを答えるシステムであるマルチマウスクイズ (MMQ) とクイズを編集する機能を実装したマルチマウスクイズエディタ (MMQ Editor) からなるマルチマウスクイズシステム (MMQ System) が開発された。本研究では、小学校での様々な授業実践を通じて、MMQ System のユーザビリティ、適用できる教科、授業案設計、および授業実践の効果について、MMQ System の有効性を調査した。

本研究は京都市教育委員会の協力を得て、複数の小学校の授業において MMQ System を利用する授業実践を行った。MMQ System を用いて小学校現場で授業実践を行うに先立って、著者は参観という形で授業現場に入り、教室内の環境や教員、児童のニーズを洗い出し、それに基づき、教員が授業をファシリテーションをするために、キーボードで一時停止する機能を追加したり、教員がクイズを編集するために、クイズ編集用エディタ (MMQ Editor) を追加開発したりするなどの MMQ System の改良を行った。

本研究では、複数の小学校で複数の授業実践を行ったが、実践研究は教員が主導的に MMQ 適用する授業を決定し、授業案を設計した。研究者はその支援にあたった。

SDG の特徴の一つとして、マウスカーソルを通じて、ユーザたちがコンピュータとのコミュニケーションすることにとどまらず、ユーザ間のコミュニケーションも行われる。しかし、一つのディスプレイに大量のマウスカーソルを表示することは、ユーザが自分のマウスカーソルを識別するのに時間がかかるなどの課題があり、その対策として、マウスの数を限定することが一般的である。また、

これまでの授業実践の使い方では、少人数のクラスにおいて1人1台のマウスを与えていたが、普通のクラスサイズでは2人から8人までの児童がグループとして1つのマウスを共有していた。これらのことを踏まえて、MMQを用いて、1台のマウスを使用する人数を1人から7人までのグループサイズを設定し、それぞれの効果を実践を通じて観察した。その結果、いずれの利用環境でも、児童の関心や意欲は高く、学習的な効果も得られた。また、2人から7人までマウスを共有する利用には発話を促進する効果があり、1人で1つのマウスを用いる場合と比べて学習効果が低下することもないことが示された。

これまでの実践では、4校の教員はMMQ Systemを適用する科目として社会科、算数科を選び、様々な活動と組み合わせる授業設計が行われた。これらの授業では児童の関心意欲は普段の授業より高いことが分かった。また、MMQ Systemを総合的な学習の時間に適用する学校1つもあった。この授業実践では、クイズに回答することだけでなく、クイズを作成させる授業設計が行われ、効果を上げていた。MMQ Systemを用いた授業実践は教室内の活動への影響のみならず、児童の学校外の活動にも良い影響を及ぼす可能性も示された。

これらの授業実践から、MMQ Systemの小学校での協調学習における有効性が示されたと考える。

Effectiveness of the Multi-Mouse Quiz System for Collaborative Learning in Elementary Schools

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Chapter 1 Introduction

1.1 Background

1.1.1 Development of Collaboration Capability

Capability of collaboration is required in various social activities such as those at school and work place. As for life in school in Japan, from 3 month-old baby can attend a nursery school, and more than half student of high school get a college education (percentage of students in high school who go on to universities or junior colleges is 54.5% in March, 2015[17]). In the school, we are assigned in a class whose size is usually 30 people, and we study a long time with the same classmates accepting the scheduled education in the fixed time and fixed place with them. In order to have a smooth and successful school life, we have to establish a good relationship with the classmates, and take part in the study collaboratively. Further, as long as we live, we will always be in a continuous learning environment. Hence the school is the place that teaches us how to learn effectively and develop good study habits including ability of collaboration as well as various conceptual knowledge and skills. Elementary education, as the formative education in the compulsory education, has special roles in teaching rudimentary knowledge and developing good study habits.

The Courses of Study by the government asks the children to learn the fundamental knowledge and basic skills, and using these skills to develop children's thinking ability, judgement ability, expressiveness and other capabilities[12]. In the chapter of General Provisions of the Courses of Study, it requires consideration in designing class concerning language ability as follows.

“When teaching subjects etc., learning activities that necessitate pupils use basic and fundamental knowledge and skills should be emphasized and language activities should be enhanced by way of preparing a solid linguistic environment necessary to deepen the pupils' understanding of and interest in language and to develop their linguistic abilities, with an aim of fostering the pupils' ability to think, to judge, to express themselves and so forth.”[31]

Furthermore, as the revised point for improvement in the new Courses of

Study for elementary school, concerning enhancement of language activities the following is shown: “To enrich learning of recording, explaining, criticizing, describing, and discussing in each subject as well as the subject of Japanese Language” (translated by the author)[32].

1.1.2 Encouraging Motivation of Learning in Elementary School

Children in the elementary education period have characteristics that they prefer to pay attention only to what they are interested in. It is widely believed that they have difficulty in controlling their sentiment. Hence, how to maintain their attention as well as how to encourage the enthusiasm to learn is an important issue in education in elementary schools.

The teachers have to teach children with consideration of the development process of children, and to change their educational method flexibly. In Japanese elementary schools, normally there is a home teacher in one class from grade 1 to grade 6. The home teacher has to take care all of the children’s activity in the school, and teach almost all the subjects. Thus most of the teachers of elementary school bear a great burden of work. They teach Japanese Language, Arithmetic, Social Studies, Science, Living Environmental Studies, Home Economics, Physical education. Some teachers also teach the Music, and Art and Handicraft.

The teachers have to take care of all the children, and usually the teacher always pay attention on the lower academic ability children more in their class having different academic abilities. Hence the teachers need ways that can involve all the children in the class. However, that is not a simple matter. Akita issued that in order to understand the student motivation in school, it is necessary to stimulate interest in the subject, assure the time of learning[1]. Furthermore, children are good at learn from other children than adults[22]. The teachers usually conduct the collaborative learning in their classes to encourage children’s motivation and involve all the children.

Many teachers also encourage children’s motivation using Information and Communication Technology (ICT) environments. Nowadays, in Japan, the number of computers introduced to elementary schools has reached at one computer per 7.2 children[20], and 84.3% elementary school has at least one

electronic blackboard (large LCD display) in each classroom[18].

However, the computers for children are placed only in the computer room, and in the home classroom only one computer for teacher is equipped. It is connected to the electronic blackboard. Hence, in the home classroom, collaborative use of computers and the electronic blackboards get hard to achieve. The government carried out the project “Collaborative Education” in which each child holds a tablet computer, and they study together. However, to expand such environment to all the elementary schools may face difficulty in funding.

1.1.3 Computer Supported Collaborative Learning

Currently, the computer we used generally designed as the concept of a personal dynamic media which can be used by human beings of all ages proposed by Alan Kay[3]. The people realized that the computer can be used as a tool to support the work and study in this era. Computer Supported Collaborative Learning (CSCL) was first used in the title of an international gathering in 1989, a NATO-sponsored workshop held in Maratea, Italy[34], [38]. After that, the Internet environment was developed rapidly. A lot of ideas of supporting collaborative work were based on multiple personal computers connected through the Internet.

Most of the current ICT systems for education purposes are also based on usage of personal computers (PCs). Therefore, the ICT systems are supposed to support collaborative learning by connecting PCs to a network, with students having their own seats and computers in the classroom. However, in such environment, when students want to discuss their work with the classmates face to face, they have to move to others’ seat leaving their own computers. Considering the importance of face-to-face collaborative learning, such an inconvenience is a disadvantage in education in elementary schools. In other words, making each child use their own computer may inhibit some important aspects of collaborative process, such as the development of mutual understanding through face-to-face discussions as well as sharing information in the virtual workspace[40].

1.1.4 Single Display Groupware and Multi Mouse Quiz

The Single Display Groupware (SDG) proposed by Stewart et al. is a framework that overcomes the aforesaid disadvantage of the connected personal computers as a CSCL environment. In SDG, each of the multiple users has an input device such as a mouse and they share information on a single display[42].

Scott et al. reported that the SDG environment leads to users being more active on the screen[40]. Moraveji et al. proposed a system that supported traditional classroom practices between a remote instructor and a group of collocated students using SDG[27], [28]. After that, this group designed a version of mischief that is a space of mouse-based text entry in SDG scenarios[5]. While most researches on SDG assume a small number of interacting users, they attempted to make all students in a class to use their own mice. After these approaches, another concept, “One Mouse per Child” is proposed by Alcoholado[4]. The Exchange system designed on SDG concept was used in training to understand a triangle concept[9]. As a finger touch table system, Berkman proposed a direct touch table-top display using in the information kiosk of university[6]. The research of SDG focus on adult, as well as children. Gomez carried out the practice in pre school using the SDG systems[14]. Thus to support face-to-face collaborative learning is noticed and developed by more and more researchers. Since SDG shows all of the mouse cursors on the screen, the users can see the others’ behavior. This feature encourages communication among users[40].

As for developing environments for SDG application, the SDG Toolkit, a middleware tool that provides multiple users with an interaction environment using multiple mice and keyboards handled independently was developed by Tse[43]. Based on the aforesaid work by Moraveji et al., Microsoft also released middleware named Mischief for SDG and a plug-in for PowerPoint. Using such developing environments, SDG can be implemented on an ordinary PC only with software and several mice connected to it. It is a big advantage in practical use in elementary schools because their budget and human resources for ICT are quite limited.

The research group to which the author belongs has also focused on application of SDG in the field of education. A drawing tool was developed by

Hagiwara[15]. Multi Mouse Quiz, a quiz system was developed by Saga[39], and was improved later by the author for use in elementary schools[45], [46]. We have also promoted the development of a brainstorming tool[29]. These research activities showed that the SDG environment leads to higher user engagement and a positive impact on collaboration and motivation.

1.1.5 Using Quizzes as an Education Tool

There are also several studies designing practices of attracting children's attention through quiz study[10]. Another background issue is using quizzes as an education tool combining ICT environment. While quizzes are a common tool for learning and teaching, their use in collaborative learning has recently attracted attention, and in colleges in particular, there are many different practices of using quizzes in collaborative learning that lead to improved student performance[7], [11]. Mazur studied peer instruction using quizzes in physics[26]. Cortright reported that collaborative testing was an effective strategy to enhance learning with increased student retention of course content[11]. Rao and DiCarlo used concepts of peer instruction to enhance student involvement in a medical physiology class comprising 256 undergraduate medical students[37]. In their paper, they demonstrated that pausing three to four times during a 50-min class to allow a discussion of concepts enhanced the students' level of understanding and ability to synthesize and integrate material.

As to asking or answering quizzes, commonly used technologies are web-based systems, such as a learning management system (LMS) and clickers[25], [13]. Pollard used a web-based quiz to let students reflect on their studies by means of a web server and numerous PCs[36]. Yokomoto and Ware used an online quiz system to encourage students to engage in active learning in groups; the system could be used more flexibly in ordinary and large classrooms[44]. Both of these studies, however, required ICT resources, which is a barrier to introducing the quiz systems into elementary schools. Considering the limitation of available ICT resources in elementary schools, we chose to investigate the usage of SDG for quiz activities.

In addition to answering quizzes, quiz-editing systems are also studied. Sugi et al. made a prototype tool enabling the rapid creation of quiz data importable

to Moodle, a popular web-based open-source LMS[41].

However, as for quiz using SDG, research done so far is limited. Saga showed that the effectiveness of MMQ in an activity for children held in the university museum[24].

1.2 Research Questions and Method

In Japanese elementary school, usage of the network-based system has difficulty because network access in the classrooms may be restricted because of security reasons. Furthermore, the network coverage in home classroom of elementary schools recently reached 37.1%[19], there are still many of schools without network access in the home classroom.

This thesis discusses usage of the Multi Mouse Quiz (MMQ), an application of SDG to encourage collaborative learning in face-to-face environment in ordinary classrooms of elementary school.

1.2.1 Research Questions

Saga showed effectiveness of MMQ in an activity for children held in the university museum[24], concerning using the MMQ in more formal education in classrooms, we set the following research questions.

- Usability of the Multi Mouse Quiz System for Teachers and Children

The author investigates whether there are any difficult operations of system when the teachers and children use the system. As mentioned above, the home teachers bear a great burden of work. To clear this research point could help us to understand the needs of classroom, and how can we support or develop the system.

- Applicable Subjects and other Activities

Which subject or activity did teacher want to use MMQ System is an important issue of investigating the feature of system used in elementary school.

- Class Design using MMQ System

Study of class design focuses on the purpose of class excepted by teachers, contents of quizzes, and educational methods used by different teachers. It helps us to analysis the feature of system, and helps us to use the system

in the other schools as a case study.

- **Effectiveness of MMQ System**

This point focuses on the investigation of effect on children's study, their communication in the various environments of 1 child to 7 children using one mouse, and effectiveness of different practices based on different purpose of study set by teachers.

1.2.2 Research Method

This research was carried out with the cooperation of Kyoto Municipal Board of Education. The author introduced the MMQ System to the elementary schoolteachers on a meeting of Kyoto Municipal Board of Education. Some teachers showed that they interested in the system, and wanted to use it in the classroom. The practices reported in the following chapters were carried out with these teachers. As educational policies are different by teachers and schools, we take the following way in planing and carrying out classes.

1. The author introduces MMQ to the schoolteacher(s);
2. The schoolteachers decide the subjects or activity in which MMQ is used;
3. The teachers creates the class design and needed contents such as quizzes;
4. In class design, the author supported in technical matters;
5. Class is carried out by the teachers, and the author supported in technical matters.

The computers, electronic blackboard and projectors of schools were used in practices while the author lent wireless mice. According the purpose of each practice, the participant observation, pretest, post test, questionnaire and interview were designed and carried out by the author. Furthermore, as the recording of practice, we took video of the practices. The author and schoolteachers created the implementation plan for recording, use of acquired data and its management. Permission of the school principal was acquired showing the plan before the practice.

1.3 Organization of This Thesis

The practices reported this thesis were conducted based on the research questions mentioned above, and thesis was organized as follows.

Following this chapter as an introduction of the research, Chapter 2 will introduces the Multi Mouse Quiz (MMQ) System. As a nature of SDG, a large number of users using their own mice synchronously caused some difficulties. The author studied to use the mouse in a group instead of giving a mouse to each child. It will be reported in Chapter 3. The MMQ has been chosen to used in the Social studies and Arithmetic by schoolteachers. The class plans of such subjects were designed by the schoolteachers according their own educational concept, and the effect of these practices will be described in Chapter 4. In addition to these two formal subjects, some practices using MMQ in the Period for Integrated Studies were held at an another school. In these activities the schoolteachers can design classes in their own way, choosing the topics and contents rather freely. The teachers used MMQ as a quiz study in this class including activities of creating quizzes by children using MMQ Editor, the results of these practices will be reported in Chapter 5. Chapter 6 is the conclusion of this thesis.

Chapter 2 Multi-Mouse Quiz System

The Multi Mouse Quiz System is a SDG application for treating quizzes in a classroom or other learning environment. The system consists of the Multi Mouse Quiz (MMQ) and Multi Mouse Quiz Editor (MMQ Editor). This section describes the design and function of both the MMQ and MMQ Editor.

2.1 Design Principle of the System and Improvement

Mori et.al defined the socialized computer (SC) as a concept of computer that is multiple people work together with a computer[30]. It is different from the concept of the personal computer and similar to SDG. Saga developed the MMQ that is a system support four users answer the quizzes synchronously in 2008 based on the concept of SC and SDG, and showed its effectiveness through experiments in university museum[39]. Furthermore, the results showed that not only child but adult users enjoyed to use of MMQ, and used the mouse cursors smoothly with interesting action of playing with each other on the screen.

MMQ was developed considering design on the composition and size of computer screen and show the Kana (Japanese alphabets) and Kanjis in parallel for children to read the text easily. Further, it is developed considering use by schoolteachers in elementary school. That is, it works ordinary Windows PC, and no network connection is required. No additional hardware other than USB mice is required. However, the evaluation of system has not been taken in actual schools in his research.

Before using MMQ in classroom, the author performed a non-participant observation over a period of six months in elementary schools and took the communication to children and teachers, and analyzed the needs of children and teachers. According these feedbacks of teachers and children, the system was improved in three points following.

- Operation of the system: To set the file name, sound effects, number of quizzes, order of quizzes in MMQ were wrote in the program code by researchers in the original version. To provide a versatile system to users, the author add a dialogue window to set these items.

- Facilitation support: The teacher usually asks children some question to confirm the degree of comprehension in the class. The original version of MMQ was controlled only by the mice and preset timer. Considering the use of teacher, the author add some simple functions using keyboard for teacher to make a facilitation easily while the children using the MMQ, for example, the pause function and exit function.
- Support Quiz Creation: MMQ requires the data of quiz as an XML file. However the teachers of elementary school are not always familiar with the style of XML file. The MMQ Editor were designed and developed for teachers easy to make edit quizzes easily.

2.2 Multi-Mouse Quiz

MMQ is a SDG quiz application implemented with the SDG Toolkit[43], and allowing up to four players to answer quizzes simultaneously connecting several mice to one PC. As shown in Fig. 1, MMQ can treat quizzes with two to four choices. A picture can be shown with a question or an explanation texts. In addition to the score of each player, the total score of all the players is shown on the screen, which is aimed at encouraging students to answer the quizzes collaboratively. Questions are posed to the players automatically using a timer, but the teacher can pause the quiz with a key operation in order to facilitate learning. In this way, the teacher can add some words as hints or give the children more time to think deeply. Figure 1 shows the screenshots of the MMQ system. In screen (a), the teacher can choose a question file and number of questions. In (b), any user can click the start button to begin the quiz. In (c), users can choose their own color, and once a color is selected, the corresponding button disappears. Screen (d) shows a question screen where four users have to click on the answer within a prescribed time limit. In screen (e), the correct answer and commentary are shown. Finally, after answering all of the questions, the total score for all the users is shown in (f). All screens are controlled by a timer, which can be set by the teacher when editing the questions. In the actual run of MMQ, the teacher can also stop and restart the timer by pressing the space bar. With this operation, the teacher can control

the classroom experience, ask a question, or make some comments.

2.3 Multi-Mouse Quiz Editor

Multi Mouse Quiz Editor (MMQ Editor) is a quiz editor for MMQ. It is not an application of SDG, but implemented as an ordinary PC application. A screen shot of MMQ Editor is shown in Fig. 2. To make operation easy to understand,



Figure 1: MMQ

we designed the user interface of MMQ Editor to be as close to MMQ as possible. In addition to setting quiz questions, choices, and explanations, the user can select the number of choices, scores for each answer, and time limits with the MMQ Editor. The functions of the MMQ Editor are summarized as follows:

- Set a question and select a corresponding picture.
- Choose the number of choices.
- Decide the multiple-choice sentences and their correctness.
- Set a time limit for each question.
- Determine the score for each questions.
- Set an explanation for the question and select an appropriate picture.

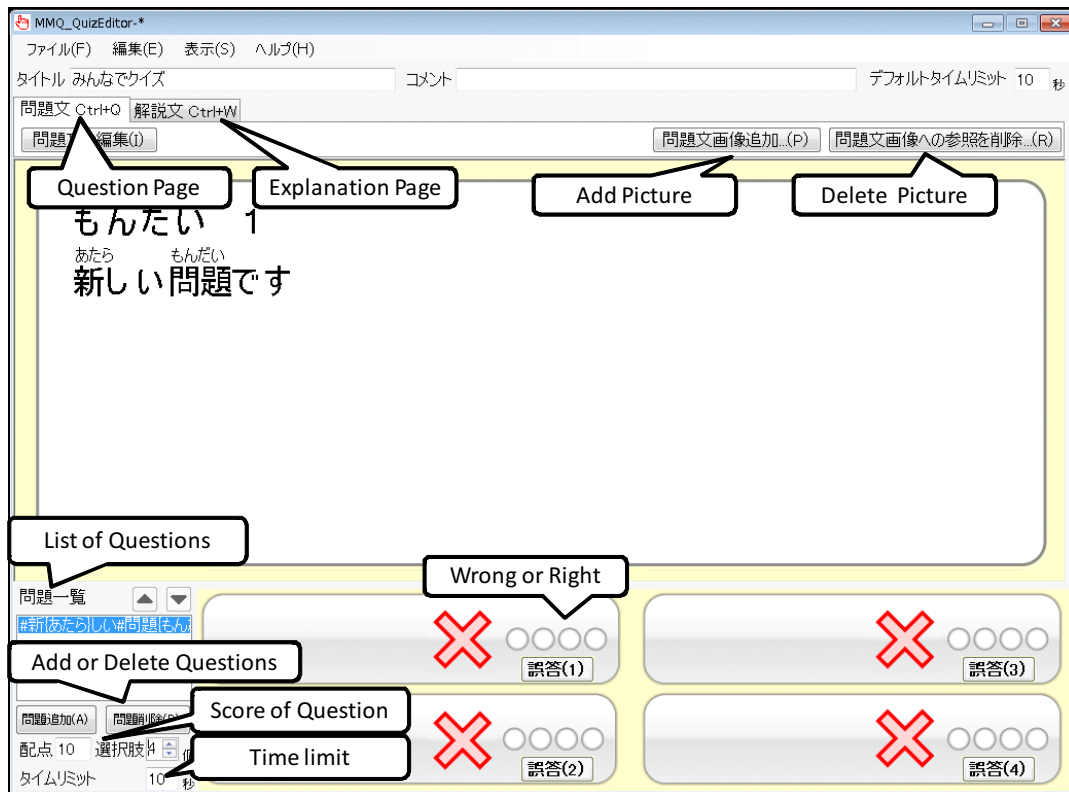


Figure 2: MMQ Editor

Chapter 3 Effect of Sharing One Mouse in a Group on Children’s Communication and Learning

As one of the SDG’s particular feature, all of users’ mouse cursors can be shown in one screen. Because of this feature, actions on screen of all the mice have to be shared, and the mouse cursors are used not only to communicate to the computer, but also to communicate to other users through gesture by mouse cursor. However, many mouse cursors move at the same time on a shared display, it takes time for a user to distinguish their mouse cursor from the others, and the mouse cursors hide background screen largely when a large number of the users using SDG. Moraveji attempted to improve it, and carried out experiments by giving mouse to each child in a classroom of an elementary school in developing countries[27], [28]. However, at the present stage, most researchers restrict the number of mice in SDG. Some research groups set their system in four input devices all the way[6], [35].

The MMQ also allows four people to answer the quiz simultaneously considering usability. The practices reported in the following chapters include the classes of one child hold one mouse in small class size and the classes of a group with 4 to 8 children share one mouse in regular class size. These classes were designed on the condition of classroom and their ICT environment. In these practices, we observed a case that some children could not focus on the activity when they released the mouse and pass the mouse to other people on one hand, and on the other hand, there were some actions that the communication of children got more active than usual by sharing a mouse.

Considering these findings of research, the practice reported in this chapter was conducted. In this practice, MMQ was used to encourage children’s motivation instead of the regular class that asked children to answer the quizzes on the paper for review of what they learnt. So as to study the effects of group size sharing a mouse with MMQ, we designed a class activity in which children would experience various setting of different group size sharing a mouse [49].

3.1 Studied Group Size Sharing One Mouse

Elementary school in Japan has to be organized up to 40 children one class by the legal regulations, and the schools are making efforts to reduce number of children to 35. In the generality of cases, there are 26 to 35 children in a class (26-30 children: 26.78%; 31-35 children in a class: 24.52%)[21]. The numbers of children in one class studied in this thesis was about 30 except one case of small size class in which only 4 children were enrolled in one grade because of a little number of children lined in the school district. Since the MMQ allows four users, in the cases studied in this thesis, a mouse was assigned to one child or a group of up to 8 children were experienced using one set of MMQ. According this, the group sizes were designed into 4 environments as follows.

- E1: An environment in which one child use one mouse (Fig. 3). Since MMQ allows four mice, totally 4 children can use MMQ with a computer. This corresponds to a case of using the MMQ in a small size class or in the computer room which has enough number of computers.
- E2: An environment in which two children share one mouse, and totally 8 children can use one computer (Fig. 4). This environment is the smallest size of group. In addition, we studied because some classes were conducted to make 2 children use one mouse as a pair and pass the mouse to another pare in a lager group.
- E4: An environment in which four children share one mouse and totally 16 children can use (Fig. 5). This corresponds to a case of using two sets of MMQ in a normal class size.
- E7: An environment in which seven children share one mouse. As the studied class size was 28, all the children of the class could use MMQ with one computer in E7 (Fig. 6). This environment is to investigate a case of using one set of MMQ in a normal size class.

3.2 Details of the Practice

3.2.1 Studied Class

The activity was conducted in an glade 6 class of an elementary school in Kyoto, Japan, in January 2012 in the third term of 2011 academic year. Most of



Figure 3: E1: 1 mouse per child



Figure 4: E2: 1 mouse 2 children



Figure 5: E4: 1 mouse 4 children



Figure 6: E7: 1 mouse 7 children

Japanese elementary school has three terms a year, and the day this activity was conducted was in the final term of the year after the New Year Holidays. In the final term, the school used many class hours for reviewing what they have learned in the year using tests and quizzes printed on papers, and children get a little bored with such class hours. The schoolteacher expected to raise children's motivation of study using MMQ substituting printed tests and quizzes. The studied class had 28 children and they experienced some classes using MMQ in the previous academic year. The quiz contents contained quizzes of Japanese Language, Social Studies, and Science.

3.2.2 Used Environment

We used two rooms having computers for activities of E1 through E7. Screen sizes and table setting were adjusted to provide children with almost same view angle of the screens.

Table 1: Schedule of Sharing Mouse Activity

No.	Time		Environment(s)
1	January 11th 2012	10:50-11:15	E1, E2, E4
2	January 11th 2012	11:15-11:40	E7
3	January 12th 2012	10:50-11:15	E7
4	January 12th 2012	11:15-11:40	E1, E2, E4
5	January 13th 2012	10:50-11:15	E1, E2, E4
6	January 13th 2012	11:15-11:40	E7

3.2.3 Schedule of Activity and Assignment of Children to the Environments

Class practice using the designed activity was held in three class hours. One class hour having 50 minutes was divided into two sections. In one section, all the children played in E7 environment, and the other section, children played in the assigned environment E1 through E4 in parallel. The schedule of the activity is shown in Table 1. For environments E2, E4 and E7 assignment were formed by the schoolteacher so that scholastic abilities of the groups became as even as possible. Children assigned to E1 are selected by the teacher because a few children had difficulty in operation of MMQ alone because of their scholastic ability or Japanese ability.

3.2.4 Used Quizzes

The quizzes were created in subjects of Japanese Language, Social Studies and Science by the schoolteacher. The quizzes were created so as to they have same degree of difficulty level. The number of quizzes in the 3 subjects was same and the question's order and order of alternative answers in a quiz were ordered by the author.

3.2.5 Questionnaire and Test

The research group where the author belonged to operated the MMQ in the conducted activity and also they carried out participant observation. The activity all the environments were also recorded with video. We also conducted questionnaire survey to the children. The questionnaires were answered by children

Table 2: Questionnaire of Sharing Mouse Activity

1. What environment are you used?
2. Did you have fun?
3. Do you want to use it again?
4. Did you try your best to answer the quizzes?
5. Please let me know the reason who choose “yes” or “maybe yes”.
6. Did you talk with your friends in your group?
7. How did you feel when the members of the group answered correctly?
8. How did you feel when the members of the group answered wrongly?
9. Did you want to give any advice to your members of the group?
10. Did you have any benefit from different group’s answers?
11. How did you feel when other groups answered correctly?
12. How did you feel when other groups answered wrongly?
13. Did you want to give any advice to other groups?
14. Did you want to get higher score than other group?
15. Including the environment you did not used, which environment did you like most? Why?
16. Which environment did you like most according your experience? Why?

after using MMQ class in all the three classes. The questionnaire was designed so as to investigate children’s interest and motivation. There were 16 questions in the questionnaire as shown in Table 2. From questions 2 to 14 were asked children in every class. The questions 15 and 16 were asked only in the final class. Questions 2 to 4, 6, 9, 10, 13 and 14 required children to provide rankings according to the five-grade evaluation system: “yes”, “maybe yes”, “neither”, “maybe no”, and “no”. Free descriptions were required in questions 1, 15 and 16. Questions 7, 8, 11 and 12 required the children to provide rankings according to the five-grade evaluation system: “happy”, “maybe happy”, “neither”, “maybe regret”, and “regret”. Question 5 was a question of multiple selection type.

To evaluate children’s performance on the learning, children were asked to

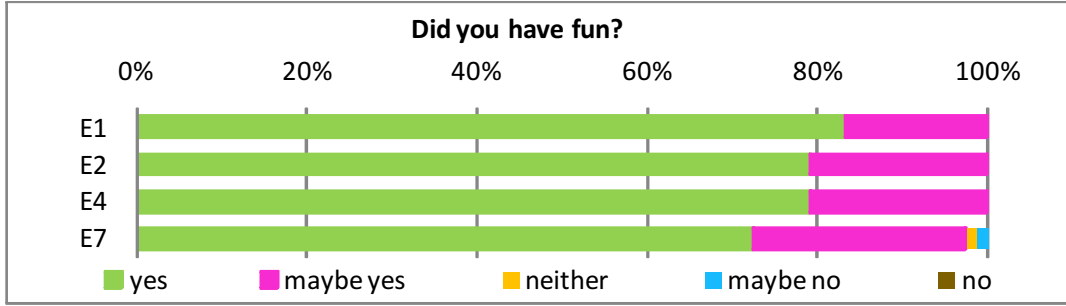


Figure 7: Results of question "Did you have fun?"

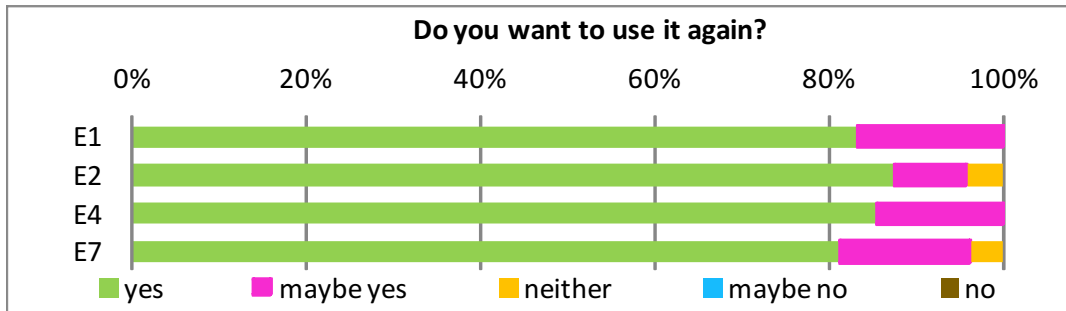


Figure 8: Results of question "Do you want to use it again?"

answer the pretest that asked 7 questions, a half from those posed in the MMQ questions before they used MMQ, and answered post test that asked 14 questions all asked in the MMQ questions. We collected the result of pretest and post test, and analyzed.

3.3 Results

At first we investigated interests and engagement of children through question 2 and 3 of the questionnaire. In response to the question "Did you have fun?" almost all the children answered yes in the all environments. Furthermore, in response to "Do you want to use it again?" there was no negative answer recorded in all the environments (Figures 7, 8).

3.3.1 Reaction of Children Concerning Inside the Groups

Some questions in the questionnaire were asked to investigate the consciousness of group of sharing a mouse. Fig. 9 to Fig. 12 are the results of how children thought to their members in the same group. The data does not include E1 because there is only one child used one mouse. All of the data shows that there

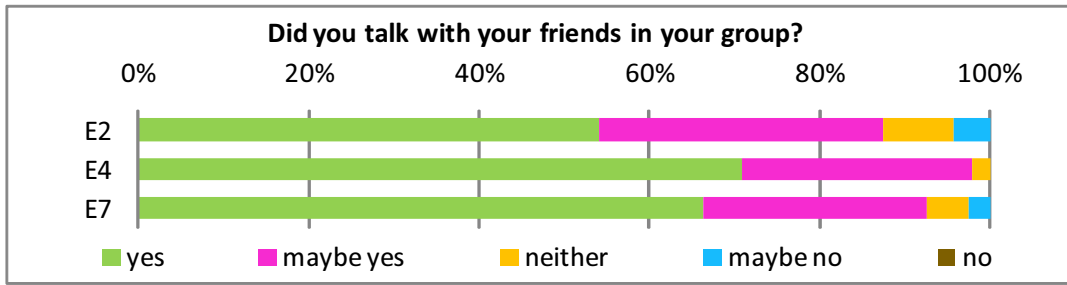


Figure 9: Results of question “Did you talk with your friends in your group?”

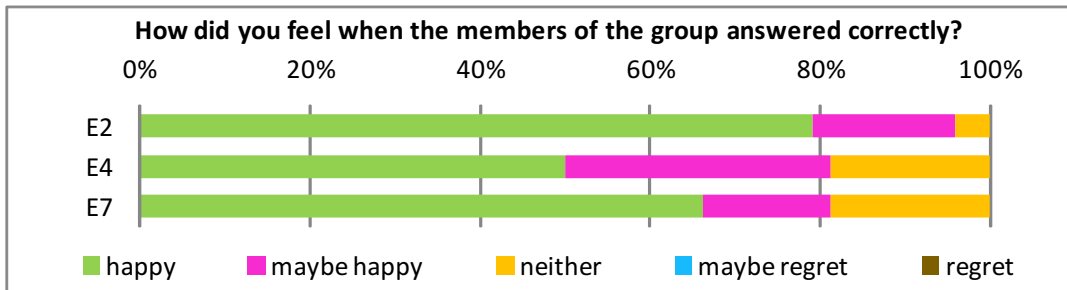


Figure 10: Results of question “How did you feel when the members of the group answered correctly?”

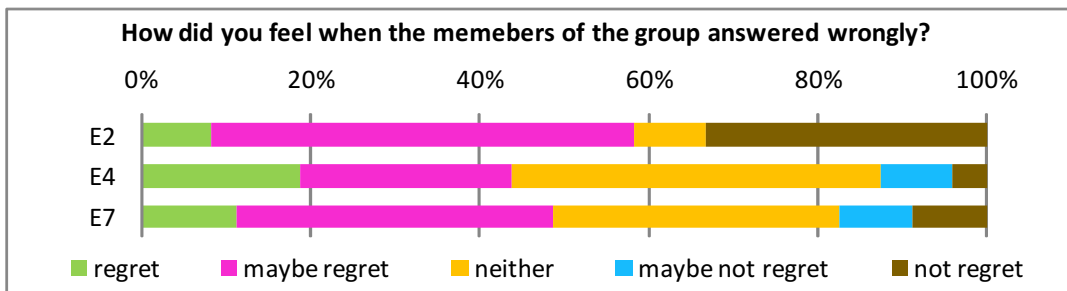


Figure 11: Results of question “How did you feel when the members of the group answered wrongly?”

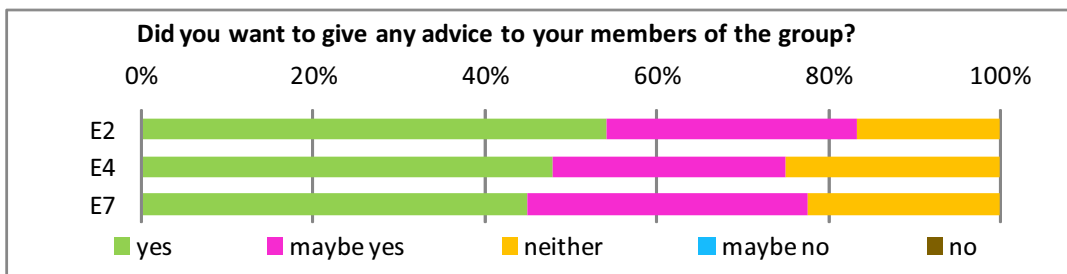


Figure 12: Results of question “Did you want to give the advice to your members of the group?”

were some difference in E2 compared with the answer on E4 and E7 which were rather similar. To evaluate their talking, we asked the question “Did you talk with your friends in your group?” In response to this question, more than 50% of children answered “yes” in the E2. This is less than E4 and E7. The results of “yes” and “maybe yes” are also less than E4 and E7 (Fig. 9).

In response to the question “How did you feel when the members of the group answered correctly?” Almost all children answered “happy” or “maybe happy” in the E2 (Fig. 10). Compared with this, such answers in E4 and E7 were less than E2, and about 80% children answered “happy” or “maybe happy”. In the question “How did you feel when the members of the group answered wrongly?”, we also got some interesting data. Same as above, the results of E2 were also different from E4 and E7. The children who felt “regret” or “maybe regret” is most in E2, some children chose “not regret”, a little children chose “neither”. In E4 and E7, the children chose the “neither” more than E2 (Fig. 11). The next question is “Did you want to give any advice to your members of the group?” In response to this question, more than 80% children of E2 answered “yes” and those in E4 and E7 were less. Whatever, in response to this question no negative answers were recorded in all the environments (Fig. 12).

For statistic analysis, we used Pillai, Wilks, Roy, Hotelling-Lawley test in our multivariate analysis of variance (MANOVA analysis) to compare group means on questions. There is no significant result in these questions about inside group.

3.3.2 Reaction of Children among Groups

The result of how they reacted to the different groups will be described in this session. In response to the question “Did you have any benefit from different group’s answers?” More than 60% E1’s children answered “yes” or “maybe yes”. E2, E4 and E7 are less than those (Fig. 13). Even some children chose “maybe no” in E1, no one chose “no”. In the E2, more than 30% children answered “no”, in the E4 and E7 nearly 20% children answered “no”.

In response to the investigation about children’s reaction to different groups, in E1, there is almost 50% children felt “maybe regret” when other groups

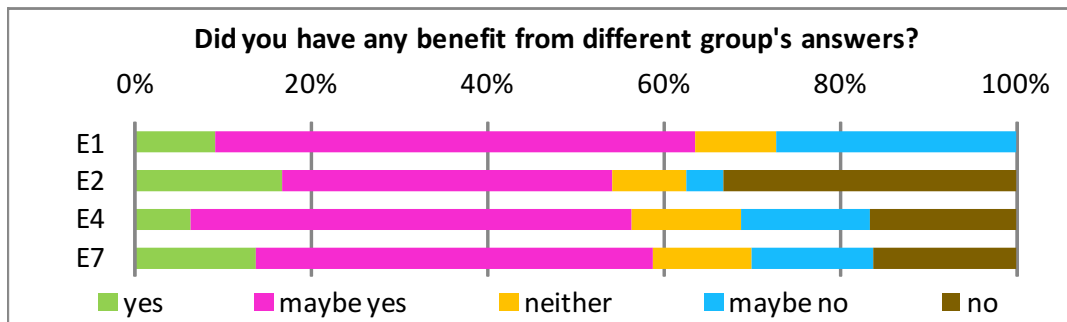


Figure 13: Results of question “Did you have any benefit from different group’s answers?”

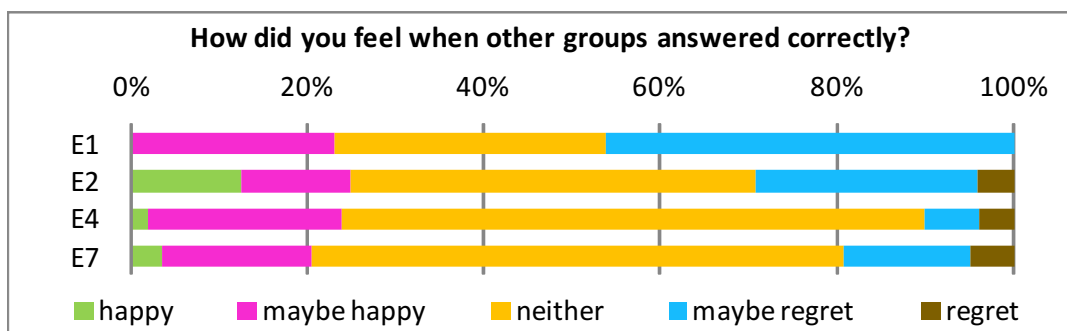


Figure 14: Results of question “How did you feel when other groups answered correctly?”

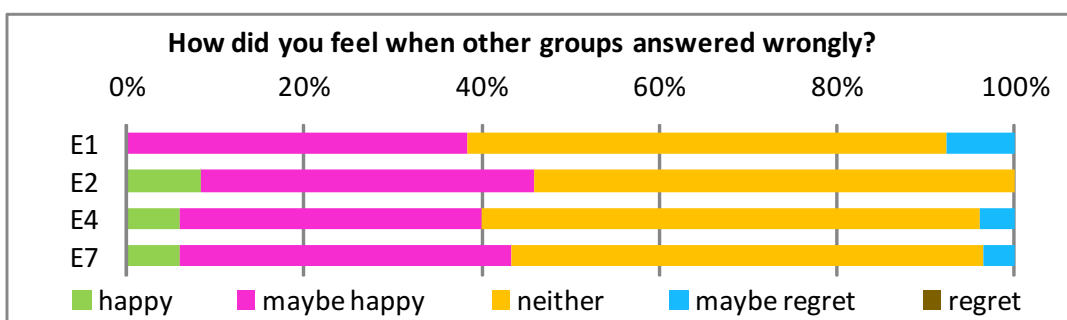


Figure 15: Results of question “How did you feel when other groups answered wrongly?”

answered quizzes correctly. There are about 30% children answered “maybe regret” or “regret” in the E2. About 20% children answered “maybe regret” or “regret” in the E7. The lowest was E4, there are 10%. However, there are 20% children answered “happy” or “maybe happy” in all the environments (Fig. 14). In response to question “How did you feel when other groups answered wrongly” about 40% children answered “happy” or “maybe happy” in every environment. Also fewer children answered “maybe regret” or “regret” in E1, E4 and E7. Only in E2, there are no children felt “maybe regret” or “regret” (Fig. 15).

In response to the question “Did you want to give any advice to other groups?”, comparing E1 to other environments, only 10% children answered “yes” and 10% children answered “maybe no”, and about 80% children answered “neither” in E1. The children answered “neither” are the lowest in E2. More than 50% children answered yes and almost 20% children answered no. In E4 and E7 the answerers were both less than in E2. Half of the children answered “neither” about 40% children answered yes, and more than 10% children answered no (Fig. 16).

In response to question “Did you want to get higher score than other group?” more than 80% children answered “yes” or “maybe yes” in the every environment. E2 is the most (Fig. 17). Relating to this question, we asked the children who answered “yes” or “maybe yes”, “Why they try their best to answer the quizzes” (Table 3 and Fig. 18). This question was a multiple select question. In the E1, E4 and E7 the largest answer was “Confirming the knowledge”. Just E2 in the all of the environment was different, and more children chose the “Don’t want to lose” (9 out of 23). In E4, the second ranking is “On behalf of my team” (13 out of 44), the third ranking was “Don’t want to lose” (9 out of 44). In the E7, the second ranking was “Don’t want to lose” (22 out of 75) and the third ranking was “On behalf of my team” (18 out of 75). The children did their best to answered quizzes for confirming the knowledge except E2. From the above, in the E2, children pay their attention more to winning or losing the game.

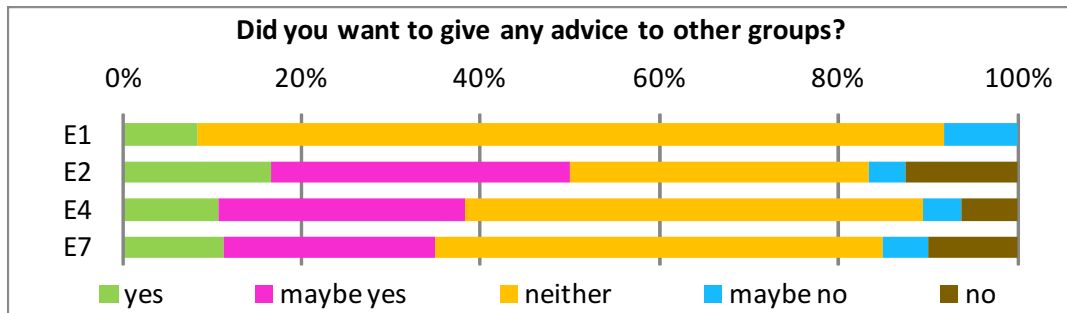


Figure 16: Results of question “Did you want to give any advice to other group?”

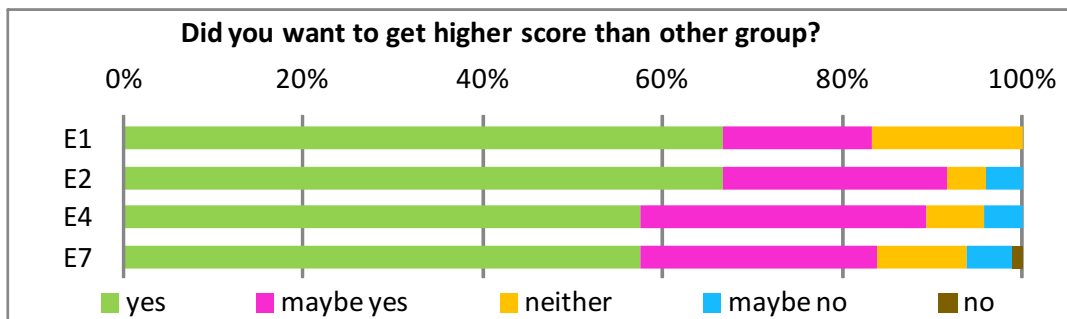


Figure 17: Results of question “Did you want to gain higher score than other group?”

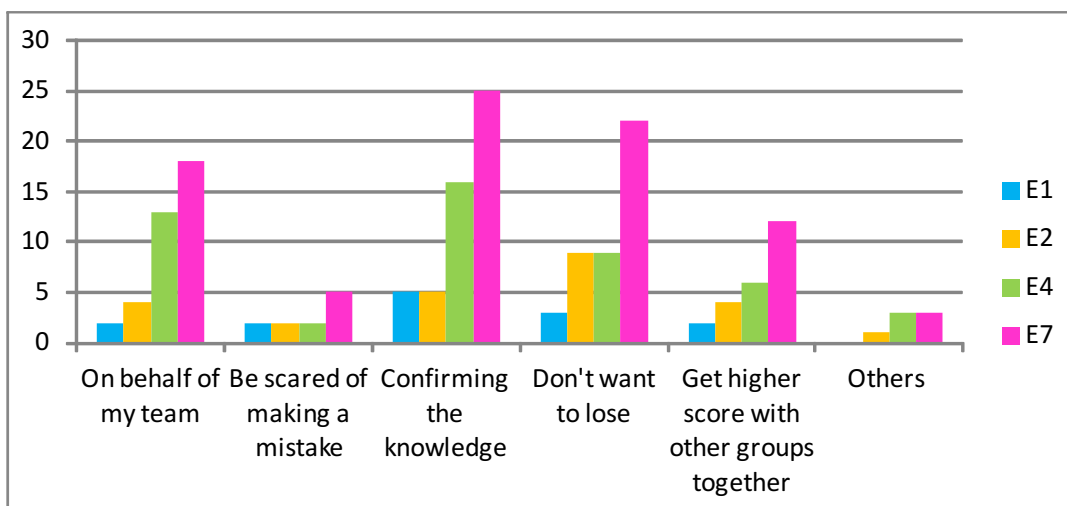


Figure 18: Results of question “Please let me know the reason who choose ‘yes’ or ‘maybe yes’.”

Table 3: Results of Question “Please let me know the reason who choose ‘yes’ or ‘maybe yes’.”

	E1(11)	E2(23)	E4(44)	E7(75)
On behalf of my team	2	4	13	18
Be scared of making a mistake	2	2	2	5
Confirming the knowledge	5	5	16	25
Don’t want to lose	3	9	9	22
Get higher score with other groups together	2	4	6	12
Other	0	1	3	3
The number of respondents	11	23	44	75

3.3.3 Analysis of Utterance Using Video

We focus on the children’s communication and mouse operation in each environment. In each environment, children use the mouse cursor to point the question and choice, putting their own cursor on the other children’s cursor were also observed. In the E1, most children spoke in low murmur, and even when they talk to each other, they kept watching the screen instead of looking at their faces each other. In this activity, we aimed to investigate communication in the same group and among different groups. As the result of questionnaire, E4 and E7 were similar and there is no sense of same group in E1, we focus the video analysis of environments E2 and E4.

So as to avoid the effects on experience of MMQ, we choose the video data from the first day. The data were collected of 4 children of 2 groups in E2 and 4 children of 1 group in E4, because of the number of children is different inside group of E2 and E4. As shown in Table 4, E2 spent 8’24”, E4 spent 6’22” from question 1 to 14 posted by MMQ. Children also affected the time lose even the MMQ were set the time limit default. The reason was considered on the speed of mouse click by all of the users. On the explanation page, if all of the users click the “I know” button before default time limit, the next question page will be shown faster than the default time.

We counted phrases as single utterance, regardless of the length of the

phrases. The total utterance in E2 is 71 times and less than that in E4 of 101 times while E2 spent longer time. In E2, the rate of children talk to their friends inside the group is 18%, talk to outside of group is 46%, and the rate of murmur is 35%. Compared to this, in E4, the children mainly talk to each other inside the group (85%), and they talked to the children outside the group only by 8%, talked in murmur was little (7%).

With our observation, in E2, the children talked quietly near their friend's ear when they talk inside group. About the communication of outside the group, they put their mouse cursor on others' cursors or put the cursor on the content of questions. Then all of the children are laughing or talking about it. They also talked about the question they did or they did not asked it in the pretest. In their murmur, they look at the screen and talk murmur aloud, such as, "I don't know." "I did it before."

In the E4, more children talk to their friends inside group, and they talk to each other with eye contact. As you can see in the Table 4, the communication inside the group was 85% of 101 utterances. Communication outside the group was also observed while its percentage stayed at 8%. We found that they talk to each other about the answer of question such as telling their friend to choose the correct answer, and teaching their friend that their choices were wrong. In contrast, the communication they had outside the group was the reaction of different group's action on the screen. E4's communication was 1.4 times more than E2 in utterance. As stated in the above, we observed the children teach each other in the same group in E4, and an example is shown in the following. Child A, Child B and Child C are in the same group.

- (A quiz was shown in screen)
- Child A: "I know this. I know this."
- Child B held the mouse and chose the answer.
- Child A: "No, No, No"
- Child B: "The left?"
- Child C shook his hand to the left.
- Child B changed her choice.
- Child A and Child C smiled to Child B.

Table 4: Results of Video Analysis

	E2	E4
Operation time	8'24"	6'22"
Utterance token	71	101
Inside group	18%	85%
Outside group	46%	8%
Murmurs	35%	7%

3.3.4 Performance in Tests

We collected the data from the pretest and post test of the practice. There were two children who couldn't answer the quiz questions independently in this class. The teacher did not assigned them to the E1 considering their learning. The data doesn't include their score. Furthermore, there were 2 children who were late in the class in the practice 3 and 4, and they did not answered the pretest. Hence, these 2 children's scores were not to be used.

Figures 19, 20, 21, and 22 are the scatter plots of pretest and post test on E1, E2, E4, E7. Figure 19 shows that the scores in E1 stuck to the top. It means the score of post test were good, for both the children with high and low scores in pretest. Most of the children in E1 had pretty good scores also in pretest. Concerning this, it maybe related to the consideration of children's ability when the teacher assigned the children to the environment as mentioned above.

There were some children stayed at the lower score both in pretest and post test in E2 (Fig. 20). E4 and E7 were similar, it totally stuck on the top, but a few children can not gained the result of higher scores in the post test (Figs. 21, 22). There are also some children who with lower scores in the pretest got very good scores in the post test.

Table 5 shows the percentage of questions answered correctly in the pretest and the post test. The score of pretest shows that E1 was the highest one. However, in the post test, E1 was not the highest and E7 was the highest one. Even in the pretest or post test, E2 was the lowest one. The pretest was set to

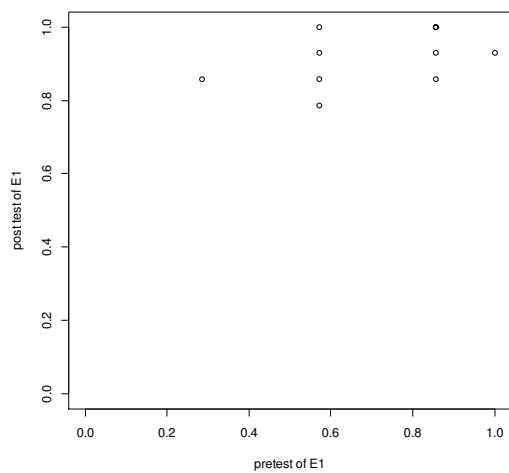


Figure 19: Scatter plot graph of E1

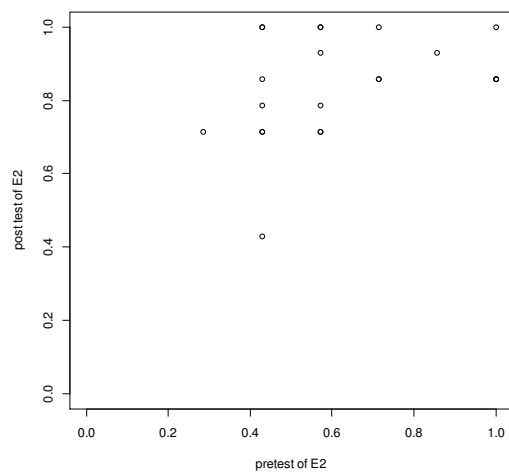


Figure 20: Scatter plot graph of E2

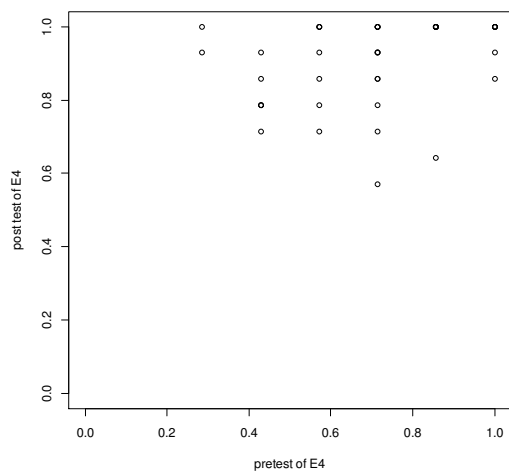


Figure 21: Scatter plot graph of E4

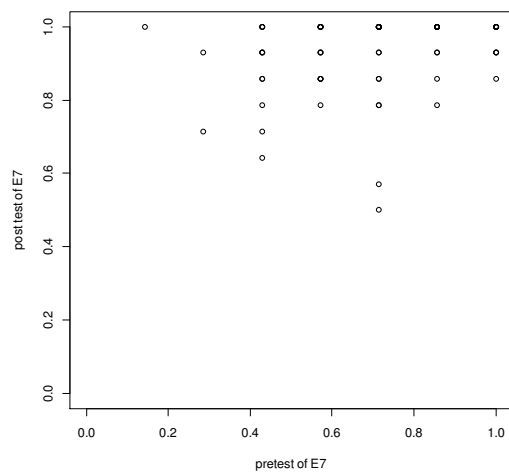


Figure 22: Scatter plot graph of E7

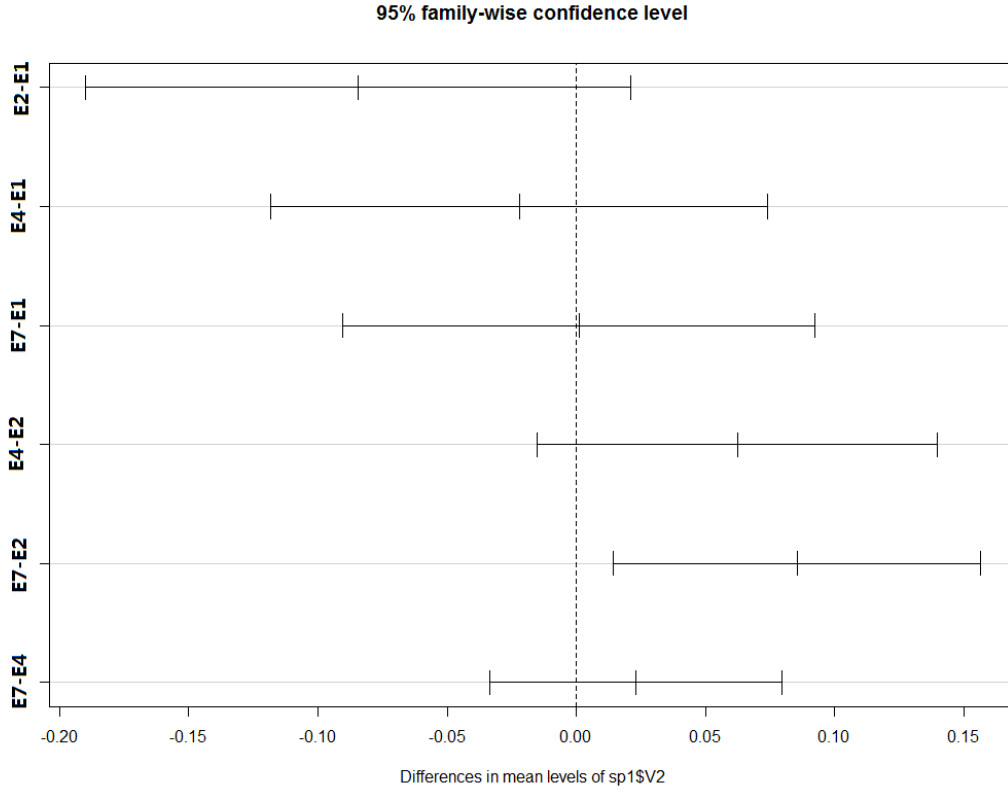


Figure 23: Multiple test of E1-E7

compare children's study ability in each environment. Shown in Table 5, the median data is also different, E1 was the highest one, and E2 was the lowest. Anyway, there was no significant difference in the pretest when we applying a statistical test. Contrary to this, significant difference were shown in the post test. E2 was the lowest, and E7 was the highest. To compare the differences of pair environments (i.e. E1-E2; E1-E3) of the same children, we used Tukey-Kramer's method that are test for correspondence data with multiple factor (Fig. 23). The result shows that there was a significant difference between E2 and E7 because the crossbar was not across the vertical dotted line.

The post test score of E2 was the lowest in all the environments. There were some children remained the lower score in both pretest and post test (Fig. 20), and the variance still larger than other environments even it better than pretest

²⁾ The score was set to 1, if all the answers were correct.

²⁾ E1, E2, E4, E7 used Welch Two Sample t-test because of the alternative hypothesis that true ratio of variances is not false were dismissed.(i.e. unequal variance)

Table 5: Results of Pretest and Post Test

Environment	pretest ¹⁾			post test			p value ²⁾
	Mean	Variance	Median	Mean	Variance	Median	
E1	0.7262	0.0425	0.8571	0.9286	0.0056	0.9286	$p < 0.05^*$
E2	0.6234	0.0496	0.5714	0.8441	0.0202	0.8571	$p < 0.05^*$
E4	0.7041	0.0422	0.7143	0.9065	0.0136	0.9286	$p < 0.05^*$
E7	0.6917	0.0425	0.7143	0.9295	0.0114	1.0000	$p < 0.05^*$
	$p > 0.05$			$p < 0.05^*$			

in E2. However, the scores of all of the environments were lower in the pretest and got higher score in the post test. In addition, Table 5 shows the significant differences in pretest and post test in all the environments.

3.4 Discussion

From the results described in the previous section, it was shown that interaction of children inside group and outside group were different by the environment they used.

About the reaction inside group, children's behaviour in E2 showed some differences from those in E4 and E7. They showed higher tension in answering than others environment. They felt happy when their members answered quizzes correctly, felt regret when their members answered wrongly. They also wanted to give some advice to their members more than E4 and E7. Similar data was also observed from Table 3. They tried their best to answered quizzes and they did not want to lose. Video analysis showed that the total of utterances made in E2 was less than E4. In the E2, children talked more out of group, and they murmured aloud. Children in the E2 showed higher emotion to their members, pay their attention to the content less than the other environments. They felt they did not want to lose points. According this, the children in the E2 felt like playing a game than learning using MMQ.

The performance of learning showed similar result. The scores of the post test in E2 was the lowest in all of the environments. The variance of the post test was also larger than others. It shows that the improvement range is the

smallest in all the environments. However, the significant difference in pretest and post test were shown, the learning effect were shown even in the E2 using MMQ.

The E4 was opposed to E2, children talked more inside the group. It maybe related to the children's number in a group. As we know, there are 4 children in a group. As our result of questionnaire, the children in E4 and E7 think they are representatives of their team. Because of this responsibility, they have to care about their member's feelings or their answers. On this point, the author thinks it was same in the E7. It is also related to the result of E4 that the utterances made more inside group. They talked to their members to ask the questions or confirm the answers or point the different answers. The score of the post test in E7 was the highest among the environments, and there were significant differences in the 4 environments. Furthermore, comparing the environments pair wisely, a significant difference was shown between E2 and E7. From a viewpoint of study, E7 might be better than E2. It maybe related to the number of children. More children posed more ideas, and they talked their answers in the group more like E4.

The children's reaction to outside group in the E1 was more than the other environments. They could accept information about quizzes only from different groups. They saw the answers of different groups on the screen. They have to chose the answer by themselves and be responsible to their own choice, because the score shown in the screen was their own score. It was different from the other environments. In E2, E4, and E7, the total of score shown on the screen was not a single child's score but 2 to 7 children's score.

MMQ showed 2 types of the scores, one was for each participant, the other was total of all the participants. They could compete to each other in getting higher score and also could collaborate to each other in getting the higher total score. However, in this practice, we found that the collaboration was only from the screen when one child control one mouse. More than 60% children got benefit from different group's answers. This result was similar to the other environments. More significant results were shown in the reaction outside group. A lot of children in E1 feel regret when the different group answered correctly.

This was most in the all of the environments. When we asked the question of “Did you want to give any advice to other groups?”, almost 80% children chose the “neither” in E1. These results of questionnaire supported this viewpoint. The author has a bold guess whether there was more collaboration if they shared something physically.

Especially in Fig. 14, the children’s reaction when the different group answered quizzes correctly. In every environment, 20% children felt “happy” or “maybe happy”. However, the children felt “regret” or “maybe regret” were different depending on the environments. E1 was the most, E2 was ranked in the second, E7 was the third, and E4 was the lowest. Maybe the discussion and the action in the group were more active so that they could play less notice of other groups.

According to the aim of MMQ of making children cooperate together in answering the quizzes, the result suggests that E4 would be the most suitable environment in school.

3.5 Conclusion

SDG is the technology in which multiple users can control their own device to work together sharing one display. The previous research found that the users felt uncomfortable if many users use SDG simultaneously. We studied the practice using MMQ to investigate the effect of children’s reaction and learning when a group of children share one mouse or a single child controls one mouse. We observed the following results:

- All of the environments engaged the children, and enhanced their learning using MMQ. Especially in E7.
- E2 engaged children and they had more emotion to their members inside group while the effect on children’s learning using MMQ in E2 is observed, compare of the other environments, the performance was poorer than the other environments.
- The children in E1 had some competitive emotion to other children control a mouse. This was different from the other environments. In E2, E4 and E7, children had collaborative emotion to children even outside group.

Furthermore, in E4 and E7, children talked inside their group almost.

According the results, maybe the E4 and E7 would be the most suitable usage when using it to discuss some quizzes in classroom in elementary schools. Considering the number of opportunity to answering quizzes by a child, E4 would be good for children and teacher because they can answer more quizzes than E7. The teacher also can use the MMQ with E1 environment to let children remember some knowledge than discuss something. The teachers have to pay attention on children's action and led them to concentrate the contents of quizzes if 2 children sharing one mouse.

When the MMQ was designed, the standard definition of screen was XGA (1024×768 pixels). Based on this situation, MMQ was designed for 4 users to use. Screen with higher definition has gotten common recently, it is possible to increase the flexibility of operation by extending the number of users of MMQ for a class of about 30 children.

Chapter 4 Effect of Multi-Mouse Quiz for Subject Classes

In the study of using MMQ in elementary school, the schoolteachers applied MMQ to subject classes of Social Studies and Arithmetic. This chapter describes these cases, and effectiveness of the MMQ in these cases [48].

4.1 Subjects Applied Multi-Mouse Quiz

According to the Courses of Study of Japan, elementary schools have to teach Japanese Language, Social Studies, Arithmetic, Science, Living Environmental Studies, Music, Arts and Crafts, Home Economics and Physical Education as subjects. In addition, Moral Education, Foreign Language Activities, the Period for Integrated Studies, and Special Activities have been established as a part of curriculum. In Japanese elementary schools, most of the home teachers teach all of these subjects. As mentioned in Section 1.2.2, the subjects to which MMQ was applied were selected by the teachers. There were four schools implemented the practices in the regular subjects ‘Social Studies’ and ‘Arithmetic’, and one school used MMQ in ‘the Period for Integrated Studies’. In this chapter, the practices of MMQ applied to the regular subjects are studied. The author focuses on the design and effectiveness of class, as well as to find the reason of using MMQ in the subjects of Social Studies and Arithmetic.

4.2 Purpose of Research

There are many practices that studying mathematics through game playing on computer[8][23]. Hennessy pointed that it is helpful to children’s learning objectives when teachers were developing and trialing new strategies specifically for mediating ICT supported learning[16]. Also study with quizzes provides students an opportunity to self-assess their current level of knowledge. It also provides feedback, helping students determine how to adjust their behavior to ensure acquisition of the missing knowledge. Study by quiz was widely used with a variety of methods, such as to amuse children so as to maintain the attention as well as to encourage the enthusiasm to learn. Pollard, J.K. used a

Table 6: Class Practices using MMQ System

No.	School	Grade	Subject	Class Size	times
1	H	5 th	Social Studies	28	2
2	S	6 th	Social Studies	32	2
3	T	6 th	Arithmetic	27	1
4	N	4 th	Arithmetic	4	2

Web-based Quiz to let student to reflect their studies[36].

In this chapter, the research questions were set as following:

- To investigate children’s engagement is the first research question. It was studied through the questionnaire survey to the children and interview to the teachers.
- To evaluate the effectiveness and the points of improvement of each practice. The author participated all the practices for observation, and took the video to discuss it with other researchers and teachers.
- To compare the subjects to which MMQ was applied and to get the points of usage for use of MMQ in future.

4.3 Cases of Using MMQ in Subjects “Social Studies”

Table 6 shows the list of practices. Class subjects were Social Studies (such as geography and history) and Arithmetic, and they were held in grade 4 to 6 classes.

4.3.1 Practice in H Elementary School

In H elementary school, MMQ was used for grade 5 class of 28 children in Social Studies in November and December 2010. The teacher divided the class into two parts, and set MMQ to each part. Hence, 3 or 4 children shared one mouse to answer the quizzes. The practice conducted 2 class time of 45 minutes. The first one was preliminary practice to prepare the second one.

As described before, 2 set of MMQ were used in this practice, it corresponds to E2 discussed in the previous chapter (Figs. 24, 25). In the H school, the teacher focused on encouraging writing ability. A lot of teachers are stumped



Figure 24: The children on the left in Figure 25: The children on the right in
classroom classroom

about how to improve children's writing ability, and seeking good methods to lead children to writing more. This teacher designed the class to improve children's engagement about contents of learning first, then, facilitated better communication among the children using the multiple choices quizzes and finally let children write an essay on the paper.

The framework of posing quizzes was also an important point in this practice. There were 21 quiz questions in the MMQ. Up to question 15, there were basic questions that children could find their answers on the textbook. Questions 16 to 19 were a little difficult questions regaining and combining the knowledge learnt before with the knowledge not shown in the text book, such as knowledge learnt from news, or the word heard somewhere. Question 20 was a question have no choice, and the children had to write the answer on the paper as a group work. Finally, the children had to write their own essay to a paper on Question 21 that related to Question 20. Questions in Japanese is shown in Appendix2 (Table A.1). As the result, the teacher reviewed that he had surprised that the children could write essays more than usual, and the content of the essays showed the children's comprehension of the asked questions.

4.3.2 Practice in S Elementary School

In S elementary school, MMQ was used for a grade 6 class of 32 children in 'Social Studies' in November and December 2011 (Fig. 26). Two class hours were used. One MMQ set was used, and a mouse was shared by a group of 8



Figure 26: The children of S elementary school

children. The teacher tried class management so as to make children feel class was fun. Along with this policy and so as to raise concentration of children that share mice in rather larger group, he tried to ask children to make quizzes by themselves. First, after experience of answering quizzes with MMQ, the children were asked to create quizzes and write them on paper.

Then the teacher collected and reviewed them before entering them into the MMQ system. Finally the children answered the quizzes made by them with MMQ. In answering quizzes they made, the children concentrated more on the contents of quizzes keeping high motivation compared with answering quizzes made by the teacher.

In the S school, the teacher emphasized good atmosphere of classroom. In other words, the rhythm of class and whether children enjoyed the class were the point when the teacher designed the class. Using MMQ to enhance children's engagement and communication and let children learn with self-motivated were the objective of the practice. Because only one electronic blackboard was available, the teacher divided a class into 4 groups, and 8 children shared one mouse. Further in this practice, children used a mouse in a pair among each group. Hence it likes E2 rather than E7 discussed in the previous chapter.

In the first preliminary practice, MMQ was used with the quizzes created by the teacher. However, the teacher found the few children could not focus on the contents of learning. Hence the teacher let children create the quizzes and perform it on the MMQ to make children concentrated on the contents of

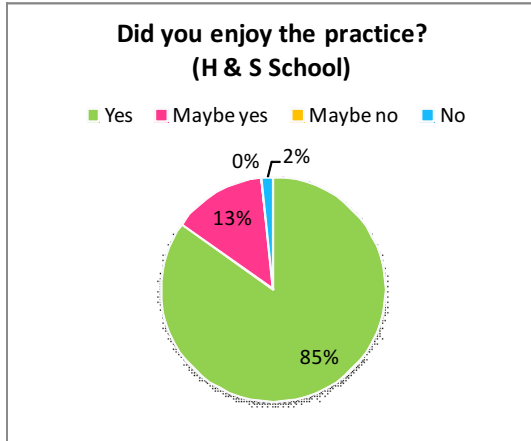


Figure 27: Response to “Did you enjoy the practice?” in H and S schools

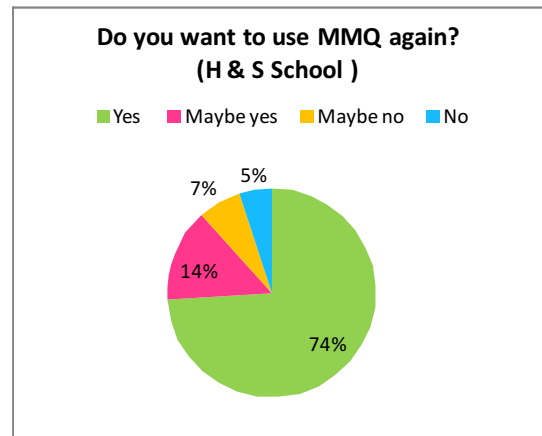


Figure 28: Response to “Do you want to use MMQ again?” in H and S schools

learning.

4.3.3 Engagement of Children in H and S school

In these practices, we collected the total 119 answers of questionnaire, because a child answered leaky on some questions (Figs. 27 and 28). There were 98% children who answered “yes” or “maybe yes” to the question “Did you enjoy the practice?” in the two schools (Fig. 27). There were 2% children who chose “no”. To examine the causes of these, we investigated their free description. In their description, they wrote “Because of quizzes were answered with friends, the practice was fun. I enjoyed it” and “I want answer more questions using this system, it is fun”. Thus, their choice might be mistakenly answered.

The result of the question “Do you want to use MMQ again?” showed that 87% children answered “yes” or “maybe yes”. There was 5% children who chose “No” as shown in Fig. 28. To examine reason of this, the free description were investigated:

- The MMQ likes regular quiz game, so fun. (S school)
- The MMQ is good for memory the knowledge when review the class of Social Studies, because we talk together, work as a team. I am happy if I can use it in other subjects, like Arithmetic. (H school)
- I enjoyed so much. I’d like to do it one more time. I want use it in subjects Arithmetic and Japanese Language. I studied through quizzes using MMQ.

Table 7: Results of Tests After Using MMQ

	H first	H second	S first	S second
Number of Children	28	28	32	32
Mean ¹⁾	0.8328	0.8515	0.8379	0.7852
Standard Deviation	0.2150	0.1868	0.1392	0.1595

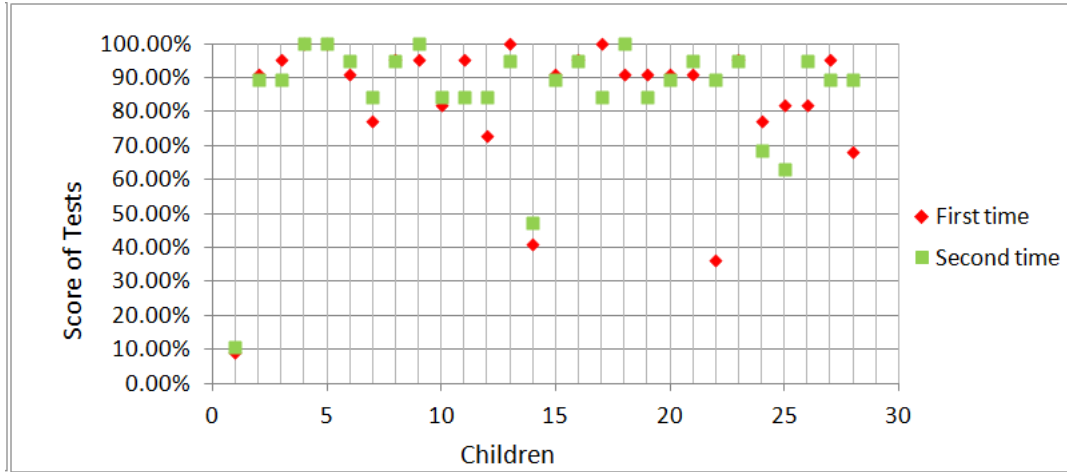


Figure 29: Score in two class hours in H elementary school

(H school)

Obviously, even the children chose “Maybe no” or “No” they also evaluated the MMQ was good for study, and want to use it more. There is no negative answers in the free description.

4.3.4 Result of Learning

The tests were conducted after classes using MMQ in S school and H school. Table 7 shows the result of the tests. After using the MMQ, all of the data shows that correct rate were about 80% . Because the contents of the question were different, we could not compare the data each other.

Figure 29 is the results of children’s scores in two class hours, the abscissa axis is children, the vertical axis is their scores in two class hours. There were three special children we have to consider. Through the interview to the teacher, we found that children H1 and H15 were the children who could not understand

¹⁾ The score was set to 1, if all the answers were correct.

Japanese adequately, and could not understand document well. The teacher took special care of them in teaching his classes.

H22 is also a student with lowers scholastic ability. At the first practice in H school, she didn't touch the mouse even when it was her turn. She just watched her friend answering the quiz. But in the second practice, she got the mouse when her friend released the mouse, and answered the quiz. We observed she was very interested in the quiz. After watching friends playing in the first practice, she looked confident and active. She asked questions about quiz to her friend confirmed her reply, and got the advice from her friend. Her score in the test after the class was improved largely in the second practice (89.47%) from the first one (36.36%) as shown in Fig. 29. The teacher said that her score in the second practice was higher than usual.

4.4 Cases of Using MMQ in Subject “Arithmetic”

4.4.1 Practice in T Elementary School

In T elementary school, MMQ was used for a grade 6 class of 27 children in Arithmetic in December 2011 (Fig. 30). We used two MMQ sets of 8 mice in total, and children learnt in 8 group of 3 or 4 children. It likes practice in H school, and corresponds to E4 in the previous chapter. This class aimed to solve difficult arithmetic problems through discussion in group as a course unit of “Attempt to challenge a variety of issues”.

The following are examples of the asked questions:

Question 1: How many kinds of possibility to choose 3 people from 6?

Choices: A: 20 B: 60 C: 120 D: 18

The activity was held in one class period of 45 minutes. Eight quizzes were asked in the class. All the questions in Japanese are shown in Appendix2 (Table A.2). For each quiz, first the teacher showed the quiz written in a large sheet of paper on the blackboard, and let one child read it. The each group was asked to discuss how to solve in. Ideas proposed by the group members were written on a white board given to each group. Then, the question screen of MMQ was shown and the groups answered their solutions. After explanation screen was shown on MMQ, the teacher paused the MMQ and let children explain their



Figure 30: The children of T school



Figure 31: The children of N school

choice using whiteboard to the whole class.

The home teacher of the class evaluated that this was a good practice, and felt the MMQ affect to the children who didn't like Arithmetic. He said that if this lesson was held in a traditional way with printed hand out, children of higher scholastic ability might achieve more, but children of lower scholastic ability might feel difficult, and give up to work. This class was shown to other teachers in the school, and opened to teachers of other school can as a program of the education board. One of the teachers from the other schools said that he was impressed that children could concentrate in these difficult arithmetic quizzes, and all of the children didn't give up until the time limit.

4.4.2 Practice in N Elementary School

In N elementary school, the MMQ was used for a grade 4 class of four children in Arithmetic in December 2011 (Fig. 31). This school area was small, and the class of the four grade has only four children.

The practice were carried out in a course unit of "What is the original number?", it aims to make children to understand the concept of relationship diagram to find the value of a variable from the given condition. An example question is as following:

Question1: I bought six notebooks of a same price. Then I also bought a bottle of juice, it cost me 100 yen. I spent 940 yen in total. So how much is the price of one notebook.

Figure 32 is a sample of the used diagram (translated to English by the author). It shows the relationship of forward and inverse calculation to assist

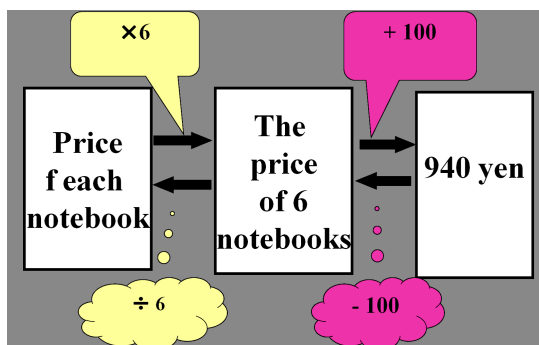


Figure 32: Diagram of Question

Figure 33: Question2 on MMQ

children to decide the asked value. This class held in connected 2 periods of 45 minutes each without break. In the first period, the teacher explained the arithmetic rules to calculate question 1 as showing above using the relationship diagram. She gave one page handout to each child on which a similar question, say question 2 is printed, and give them a few minutes to let them think about how to calculate. In the 2nd period, the children wrote down the relationship diagram, arithmetic formula, and the solution of question 2. Then, the teacher started up the MMQ let every child has a mouse when they finished writing. The teacher made 5 quizzes about the relationship diagram and one quiz for arithmetic formula which treat question 2 in step-by-step manner. Figure 33 is a translated example of the question on MMQ. As well as asking children to answer in MMQ, the teacher paused the MMQ, and let children explain not only the reason of their choice, but also the reason of the choice they did not chose.

The teacher evaluated operation of MMQ Editor was not difficult, and they used MMQ to support their pedagogical study in Arithmetic. She said that the children used the MMQ with high motivation because they designed this practice with two class periods. She worried about the engagement of a child having difficult moods in the class, but he could concentrate in this practices. Different from other practices of MMQ, we observed each child chose different choices along with their ideas, while in other practices, children often followed others' choices. The teachers opinion on it was that the

class size was so small, and children might not be afraid of making mistakes in front of their classmates.

4.5 Discussion

4.5.1 Subjects Chosen to Apply MMQ

There was one case in which the children created the quiz, and the teacher set it to the MMQ Editor, in the other cases the quizzes were created by teachers. Since the knowledge of the regular subjects have to be given to children correctly, asking children to answer the quizzes made by the teachers were natural. Contrary to this, the practice of quizzes making by children was conducted in the Period for Integrated Studies will be reported in the next chapter. To engage children's motivation were the purpose of practice from schoolteachers.

Because the Social Studies requires to remember many facts and concepts, the quiz system fits to this subject. Furthermore, the teacher made effort to encourage deeper comprehension by creating quizzes become more difficult gradually, and to encourage children's ratiocination ability to the question they had not learnt in the school and writing an essay finally.

In the both Arithmetic studies, the MMQ was used to help children to understand the difficult contents. It is necessary to understand the contents step by step when a child solves a complex problem in Arithmetic. The MMQ was excepted to use as a tool to help children's comprehension step by step through the quizzes.

4.5.2 Combination of Activities in Practices

In the studied practices, various activity were combined with answering quizzes with the MMQ along with the class subject and teaching aims:

- Group discussion (all the schools)
- Oral explanation of children's ideas (H and N schools)
- Writing descriptive answer (H school)
- Quiz Creation and Mutual Appreciation (S school)

It should also be noted that the teachers select media that fit for the activities. Both the teachers and children used paper as well as the computer.

In these activities, quiz creation is interesting because children engaged in learning both in the quiz creation phase and the quiz appreciation phase. Even in answering quizzes, children concentrated more because the questions were made by their classmates.

4.5.3 Collaboration among Schoolteachers and Researchers

All of these practices, class plans were designed mainly by the teachers. Then, the researchers discussed with the teachers to confirm implementation of their plans, and necessary support in carrying out the classes. We revised the MMQ such as introducing pause function and improvement of stability of the system on computers in the schools. Further, the researchers also recorded the data of these practices using questionnaires, interview, voice and video recording, and analyzed them. We think such continuous interaction and collaboration among schoolteachers and researchers are important for both school teaching and academic research.

4.6 Conclusion

According to the studied activities, we found the following:

- The schoolteachers and children could use the MMQ without particular difficulty, and they enjoyed the practices.
- In all of the practices, the teachers evaluated effectiveness of the MMQ in encouraging children's motivation to study in the classes. Also the result of questionnaire showed the same tendency.
- It is also an important finding that using MMQ encouraged participation of children of lower scholastic ability. Both usage of the computer for interaction and study in group might be the reason of such involvement. It also should be noted that oral communication was encouraged in these practices. This might also the effect of using the MMQ developed as an application of SDG.
- The teachers used the MMQ for classes of subjects of the Social Studies and Arithmetic. Even though the contents of activity were different, the focus points of system for teachers had some common ones. They used MMQ to improve engagement, involvement, and motivation of children.

- In almost all the activities, the teacher used not only MMQ but also some other methods depending on their own education concept.
- Concerning the contents of quiz questions, teachers arrayed the quizzes considering difficulty level from easy ones to difficult ones in the H, N, T schools while MMQ were applied to the different subjects. The teacher designed the quizzes in this order so as to gave children confidence in answering the questions, and gradually attack more difficult ones through discussion in group.
- The pause function of MMQ were often used by the teachers aiming at control of the progress, giving hints, and combining other activities such as discussion in group, oral answering, and writing on paper or whiteboard.

Chapter 5 Quiz Creating using MMQ and MMQ Editor in Period for Integrated Study

In the studied cases of using MMQ System, as well as subject classes of Social Studies and Arithmetic, there are some practices that used the MMQ in the Period for Integrated Studies. These cases had a common characteristics of the usage, that is the children not only answered the quizzes, but also they created the quizzes.

In this chapter, we describe two activities of using MMQ Editor and MMQ in an elementary school. One is the case where grade 6 children were asked to design quizzes using MMQ Editor and then evaluated them mutually using MMQ. Another one is the activity including two different grade classes. The grade 6 children were asked to create quizzes after their study in a museum. Then, the grade 3 children were asked to answer these quizzes using the MMQ before and after their visit of the museum.

5.1 The Period for Integrated Studies

“The Period for Integrated Studies” (“Sogoteki-Na-Gakush-No-Jikan”) is a general learning class required in the national curriculum for elementary school in Japan [47]. Elementary school has to conduct 70 class hours every year from grade 3 to 6 as this program. It aims to develop children’s abilities of finding the problem, learning, and thinking by themselves, to build up children’s attitude of activeness, creativity, collaboration [33]. As for this program, every elementary school can design their activity considering its regional situation and its educational plan. Using computer and learning of regional matter are common subjects in the design of the Period for Integrated Studies.

5.2 Purpose of Research

The author studied this activity with the aim of investigating the usability of the MMQ Editor for children, and examining the effects of using MMQ Editor and MMQ on learning in the Period for Integrated Studies. It focused

on the following points:

- Possibility of MMQ Editor usage using by children.
- Engagement of children in the activities. The activities reported in the following include a challenge of asking the third grade children to operate the MMQ. It was the youngest grade to which the MMQ was applied.
- Children’s behavior in using MMQ Editor and MMQ.
- Design of study contents and activities.
- Evaluation of quizzes created by the children on number of quizzes and refection by themselves.
- Influence of quizzes through the actives.

5.3 Case of Studying Regional History

5.3.1 Outline of the Activity

The quiz learning activities using the MMQ System took place in an elementary school in Kyoto, Japan, in February 2012. The study was conducted in two grade 6 classes of the school as a part of the course “Period Integrated study”. The numbers of children were 25 and 27, with a total of 52 children participating in the activities [50].

5.3.2 Class Design

In this classes, children learned regional history, and they intended to go “orienteering” to visit historical places in the town. Activities using the MMQ System were designed as preparation to the orienteering by studying the regional history content in the classroom. The activities were held in the computer room of the school. They consisted of 3-hour classes held over 3 days for each class. To support teachers and children in using the MMQ system, two researchers including the author took part. The quiz learning activities were divided into three parts: creating quizzes, discussing them, and answering them:

- On the first day, each child individually created quizzes using the MMQ Editor (Fig. 34).
- On the second day, the whole class was divided into groups comprising of three or four children. Children shared their created quizzes with others



Figure 34: Creating quizzes



Figure 35: Answer quizzes

in the group and exchanged opinions in order to improve them. In Class A, they revised their questions, while in Class B, they merged the created questions into one quiz file with the group's name.

- On the third day, all of the children used the MMQ in their groups in order to answer the questions created by other groups (Fig. 35) by visiting the other group files.

5.3.3 Method of Study

The teachers who held these classes wanted to know the effectiveness of MMQ as the learning environment as well as us. They expected that children would be able to learn from their friends and improve their own performance in the collaborative environment using MMQ.

To conduct a quantitative and qualitative analysis of the making quizzes, responding to them, and engagement of the children, we made a questionnaire as shown in Appendix1 (Table. A.1). Children answered to the questionnaire after the third class.

There were 17 questions in this questionnaire. Questions 1) to 4), 8) to 11), and 13) required students to provide rankings according to the five-grade evaluation system: “yes”, “maybe yes”, “neither”, “maybe no”, and “no”. Free description was required in questions 7), 12), and 17). Questions 5), 6), 14), 15), and 16) were multiple choice questions.

In addition to the questionnaire, we also interviewed the teachers to evaluate the activities. Furthermore, the researchers observed the classes, and the activities were recorded by video. Due to the space limit of the computer

room and requests from the teachers, we recorded the classes using three cameras throughout the activities.

5.3.4 Result

Analysis of the videotapes, questionnaire survey, and interviews revealed that the children were positively engaged in the quiz making and answering activities.

MMQ Editor Usage Through participant observation by the researchers, the children were seen to use the MMQ Editor successfully, without apparent difficulty in operating it. In the two classes, the following questions were asked by the children in relation to the function of the software:

1. Place to save the file;
2. Naming of the file;
3. Difference between the file menus “save” and “save as”;
4. Way to change the font size of the question text.

The first two questions needed clearer instructions from the teacher, while the third is common to Windows Graphical User Interface. As to the final question, the specification of the MMQ Editor does not allow change of the font size, so we asked the children to summarize the sentences within the space limit.

In the interview with one of the teachers, she said,

“The children were familiar with the operation of the MMQ Editor. I didn’t think they found anything difficult.”

After the activities, the children answered the questionnaire about the MMQ Editor. Some questions related to MMQ Editor usage. In response to the question “4) Can you use the MMQ Editor by yourself from now on?” almost 90% of children from both classes answered that could use it independently (Fig. 36); no negative answers were recorded. However, we also observed some differences between the two classes. Answers in Class A were slightly more positive compared with those in Class B (24 out of 25 children in class A; 22 out of 27 children in class B). This difference was perhaps influenced by the time spent operating the MMQ Editor. Class A spent longer in creating the quiz questions individually using MMQ Editor than Class B over the

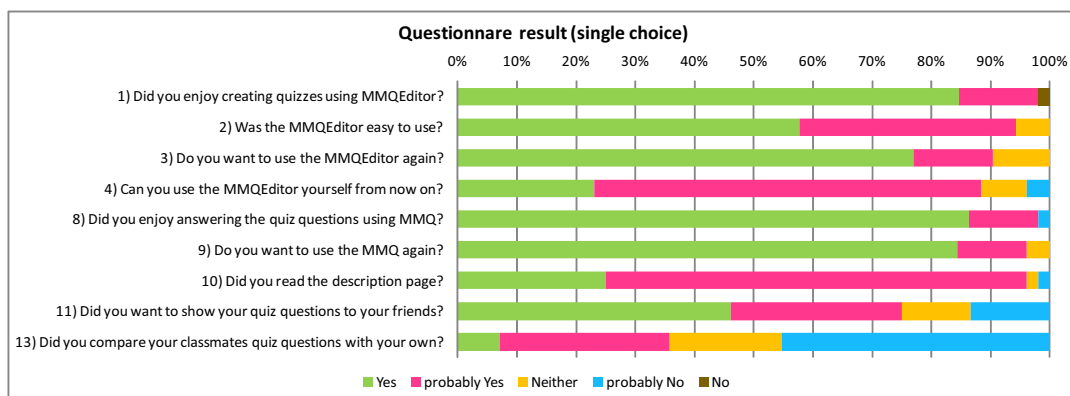


Figure 36: Results of single option questions in questionnaire survey to children

course of 3 days (Class A: 66 min 30 sec; Class B: 33 min 29 sec). In Class B, the MMQ Editor was used both individually and in group. More than 90% of children in both classes evaluated the MMQ Editor as easy to operate in response to the question “2) Was the MMQ Editor easy to use?” (Fig. 36).

We added many functions to the MMQ Editor. To evaluate these functions, we asked the question “6) What did you do to improve the questions?” In the multiple-choice answers, many children answered that they devised the commonly confused responses (25 children) and made the question easy to understand (20 children). In addition, some children carefully read the textbook (17 children) or made the explanation easy to read (11 children) (Fig. 37). Thus, the children tried to make the questions better in their own ways. The author observed that children returned to their classroom to look at their textbooks when the teacher asked them to put content on the explanation page. In other words, writing an explanation encouraged the children to read their textbooks. In response, one teacher noted, “Such behavior showed children’s engagement in creating quiz questions.” The time limit and score settings can be assessed through the quiz files created by the children. Some chose to set different time lengths and scores for the quiz questions. However, it was observed that the children could not estimate how long the answerers might need to read the questions.

Engagement of Children Children’s engagement in the activities was assessed by analyzing the videotapes, questionnaires, and interviews with

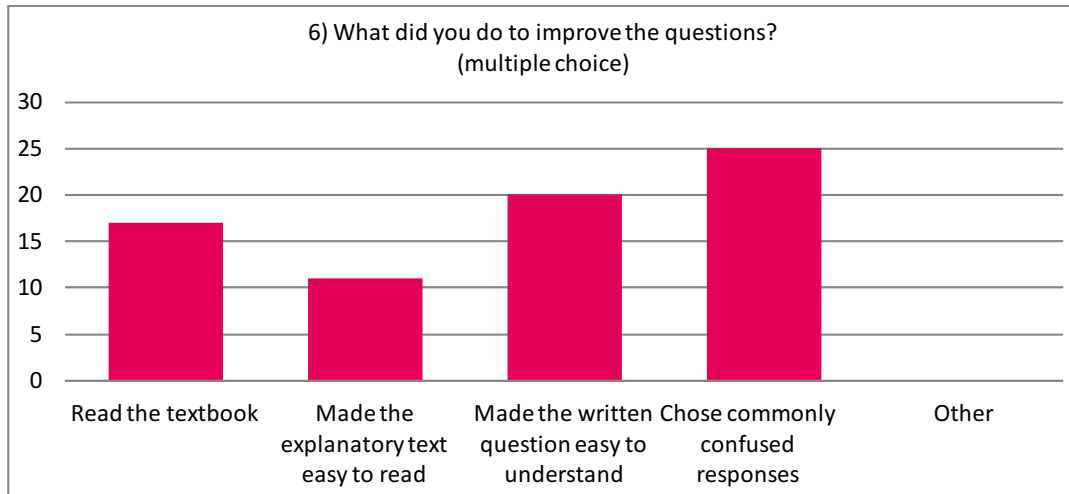


Figure 37: Results of question “6) What did you do to improve the questions?”

teachers. In the questionnaires, we asked children “1) Did you enjoy creating quizzes using the MMQ Editor?” and “2) Do you want to use the MMQ Editor again?” Almost all of the children (51 out of 52) enjoyed using the MMQ Editor, and more than 90% said that they wanted to use it again (Fig. 36).

In the interview, one teacher said,

“Almost all the children liked to work on the computer. In the activities using the MMQ Editor to create the quiz questions, the children with a high scholastic ability were able to create quiz questions one after another. The children with a low scholastic ability or low writing ability were also able to work faster than usual. I think children obtained a sense of satisfaction in different ways. For children with a low scholastic ability, in particular, the MMQ Editor supports them in creating quiz questions at the same starting line as other children. They felt satisfied when they finished completing the work.”

Table 8 shows the statistics of the number of questions children created and Fig. 38 is a histogram of the number of questions made by each child. All of the children created at least one quiz. As to the number of quizzes, the highest in frequency was two, although a few children created more than four, with the largest being eight.

Table 8: Statistics of the Number of Quizzes Made by the Children

Total	147
Mean	2.83
Standard Deviation	1.17
Max	8
Min	1

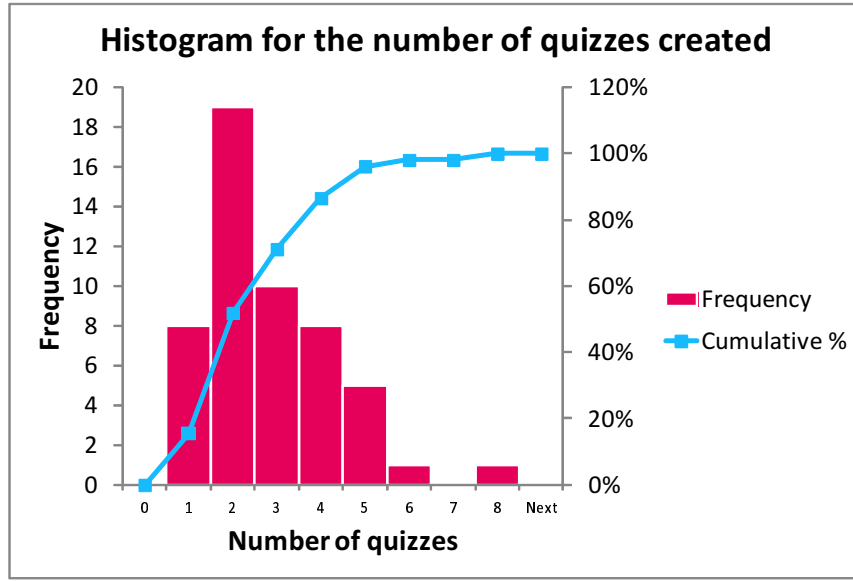


Figure 38: Histogram for the number of quizzes created

Children's engagement in the activities can also be assessed in terms of the amount of off-task behavior they exhibited as recorded on the video. The behavior of three children was recorded in each class. These children spent more than 20 minutes using the MMQ Editor on the first day, with an average off-task time of 11.85% out of 23 min 36 sec in Class A and 7.46% out of 21 min 5 sec in class B. Off-task behavior may be considered as anything not associated with Class activities (e.g., looking around the room or taking a short break). However, the video analyses revealed that the off-task behavior included looking up from the screen when asking their classmates some questions, or borrowing textbooks. Thus, children showed their engagement in the quiz-making activities.

We also asked the children about the MMQ in the questionnaire when

they finished the activity after 3 days. The questions “8) Did you enjoy answering the quiz questions using MMQ?” and “9) Do you want to use the MMQ again?” aimed to examine the engagement of children when using the MMQ. As shown in Fig. 36 most children enjoyed answering the quizzes except for one child. Another positive result is that the majority wanted to use the MMQ again (50 out of 52). In response to the question “11) Did you want to show your quiz questions to your friends?” more than 70% children wanted to share their questions. The reasons for their choice were following:

1. I wanted to know how other people answered my quizzes.
2. Because I created a good question.
3. Because I did my best in creating the questions.
4. I wanted to have their evaluation after they answered the questions.
5. We can learn by answering others’ questions.

The remaining students either did not want to share their questions with others or answered that they did not consider it. The reasons for not wanting to show their questions to others were as follows:

1. I thought about the question in a hurry, so the questions were not very good, although they might not be so bad.
2. My questions are not very good.
3. I worry about my questions being too difficult or too easy.

We can therefore see that the children who were confident about their questions wanted to know others’ reactions, while those who were not confident did not want to share their questions.

Behaviors Observed The following behaviors were observed for the children throughout the study. On the first day, children designed their own quiz questions using the MMQ Editor along the original schedule. While the activities on that day did not include group work, we observed much interaction among the children.

We also analyzed the behaviors of exceptional off-task time and time spent using the MMQ Editor. We found that the children liked to talk to each other and to watch each other’s screens. When they had difficulties, they looked at another screen nearby. They also pointed to their own screens, while asking

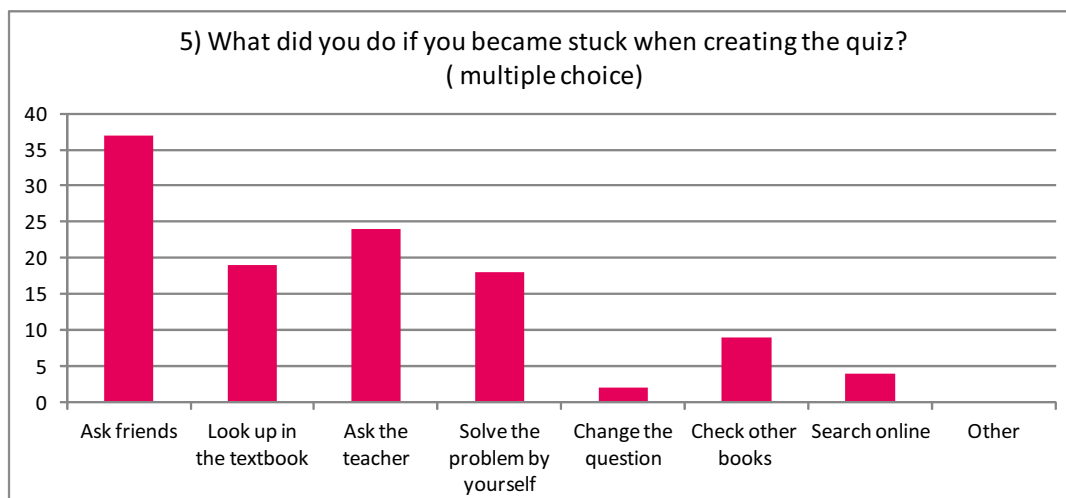


Figure 39: Results of question “5) What did you do if you became stuck when creating the quiz?”

friends for some feedback. Some groups of three or four children shared one screen and discussed the questions. They also talked about how to create quizzes, and asked questions about the system, lesson, or textbook.

These results were reflected in the answers to questionnaire; in question “5) What did you do if you became stuck when creating the quiz?” (multiple choice), the most common responses were to “ask friends” (37 children) and “ask the teacher” (24 children) (Fig. 39).

When the children answered quizzes with the MMQ, they usually looked at the same screen while talking to each other. When they answered quizzes correctly, they smiled and looked happy. In our previous research in another school[46], children often followed other students’ choices when using the MMQ. However, even though the children could see others’ answers, they still kept their own choice, choosing what they thought to be the correct response. Associated with this behavior, the questionnaire included the question “10) Did you read the description page?” with more than 90% of children responding positively (50 out of 52) (Fig. 36).

Reflection on Their Own Quizzes In the answers to the question “13) When you answered your classmates’ quiz questions, did you compare them with your own?” more than 60% children answered they did not make a

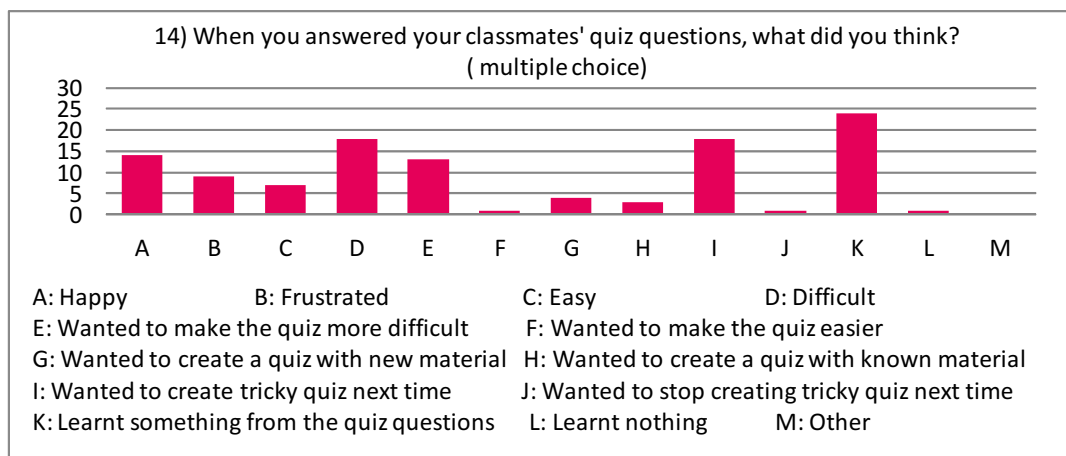


Figure 40: Results of question “14) When you answered your classmates’ quiz questions, what did you think?”

comparison, while less than 40% did (Fig. 36).

However, as to the question “14) When you answered your classmates’ quiz questions, what did you think?” (multiple choice), the most common response was that they learnt something from the questions (24 children). The next most common response was that they wanted to create tricky questions next time (18 children). Many children also felt that the questions were difficult (Fig. 40).

Concerning the question “15) When classmates answered your questions correctly, what did you think?” 19 children wanted to make the questions more difficult next time (Fig. 41). Some felt happy when others people gave the correct answer (16 children), although others felt frustrated (12 children). In addition, many children wanted to create tricky questions (13 children).

As to the question “16) When classmates gave the wrong answer to your questions, what did you think?” the most frequent response, “Feel happy,” represented an extremely high percentage of responses, with more than 70% of children (37 out of 52) (Fig. 42). The number of people who selected “What you aimed for” was also high (13 children).

One of the purposes of this activity was to let children reflect on their own learning through answering their classmates’ questions. We can see from the above that approximately half of the children (24 out of 52) felt that they

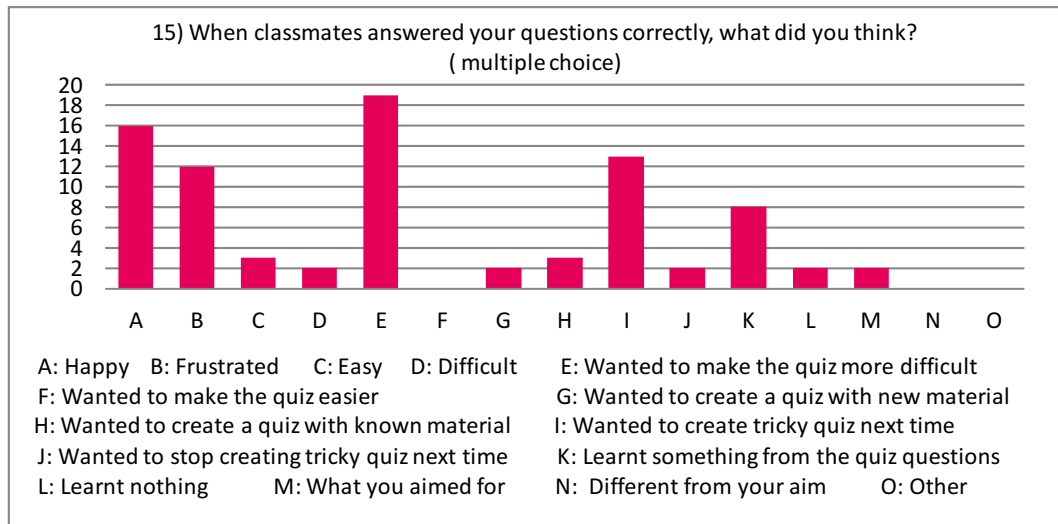


Figure 41: Results of question “15) When classmates answered your questions correctly, what did you think?”

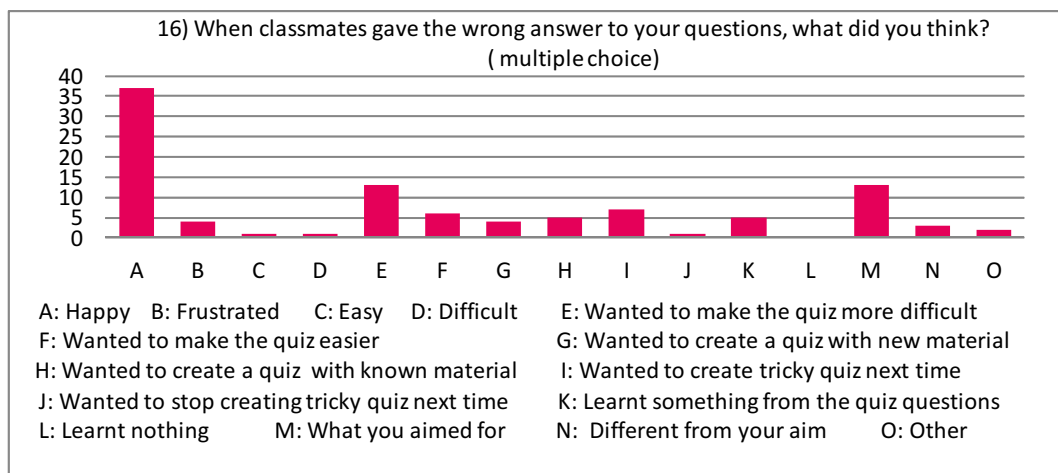


Figure 42: Result of “16) When classmates made wrong answers to your questions, what did you think?”

had learnt something from the quizzes, and wanted to create tricky questions next time. In the interview, one teacher noted that it was a good reflective exercise using the MMQ which allowed four children to answer quizzes on one screen. This teacher said, “Some children found it difficult to create a quiz, while others found it easy. Some perspectives may be gained through answering the quizzes created by others. I think if there is a good model, they can learn about how to create better quizzes next time. Furthermore, as four children could answer the quizzes together, the conversation among them was natural. This type of communication is a very important aspect of learning. That is, students not only learn to create quizzes, but they can also improve their knowledge using the quizzes when they answer others’ questions”.

General Impression of Teachers We conducted interviews with the teacher of Class B and the school’s vice-principal who coordinated this activity from the planning stage. Because of personal reasons, we could not interview to the teacher of Class A. The following are the general impressions of the teachers concerning this activity.

In the interview to the teacher of Class B, she said,

“Children had to think about ‘how to make the quizzes better’ when they created the quizzes. When they answered the questions, they could respond to many of them in the group. They could talk about the quizzes within the group, and learn from their own quizzes. It is better than the traditional learning style. The children were able to make more quizzes in the class than usual. Children who would normally create one quiz using paper in an ordinary class made three or four in this activity. I usually pay a lot of attention to two children who find it hard to understand lessons in class. However, in this activity, I was surprised at their involvement and that they had a sense of satisfaction. It was amazing.”

In the interview with the vice-principal, she said,

“Usually, classes in the computer room, the children in front of computers interact with the computers in silence. If they have a question,

they perhaps ask their friend nearby. However, in this activity, you showed a new method of using computers for learning, that is, four children sharing one screen, and learning through communication is fun and better than usual. In addition, the Multi-Mouse Quiz system has a beautiful design, and children felt happy to create quizzes. This is because they are always in a position to answer quizzes when watching TV shows. The situation of creating quizzes was as though they were making games. The beautiful design also made them engage in creating the quizzes. However, there was still an inconvenience. Teachers always want to know the achievements of children. In this system, the teacher can glance over the data. But if there is a function for reviewing the activities of all children, teachers will find it helpful.”

5.3.5 Discussion

Creating Quizzes with the MMQ Editor From the results described in the previous section, it was shown that the MMQ Editor could be operated by children without any special assistance from the researchers. Teachers and most of the children evaluated the MMQ Editor as easy to operate. Furthermore, they were also confident about their ability to operate the MMQ Editor alone in the future.

Describing the explanation page was an important activity for engaging the children to read the textbook. In writing of the explanations, children also tried to make the document easy to read, and it increased their chances of examining the document. It also allowed children to consider their audience when creating a document.

In using the MMQ Editor to create quiz questions, children showed a greater interest in the activities than usual. In general, they were able to concentrate on their work in this study. In terms of the numbers of quizzes, the teacher said that they were able to create more than usual. Regarding children’s study, using the MMQ Editor had good influence on their learning.

Engagement Children had a high sense of enjoyment and engagement when using both the MMQ Editor and MMQ. A large percentage (more than 70%) of children wanted to publish their quizzes to allow others to

answer them, while some did not want to show them to others (more than 10%). The motivation for sharing the quizzes was that the children wanted to know whether others could provide the correct answer to a given question or how their classmates answered the questions. They were also motivated by the desire for everybody to learn something from the quizzes. On the other hand, if the children were not confident about their quizzes, it affected their mood and they hesitated in showing the quizzes to others.

Reflection One of the reasons why children wanted to show their questions to other children was to know how other people answered them. They felt happy about other people doing their quizzes regardless of whether the answer was correct (question 16 in the questionnaire). When others gave the correct answer, they felt a little frustrated and wanted to make the quizzes more difficult with trickier questions. If their classmates gave the wrong answer, more children were happy. Because the children felt they had succeeded in making their classmates choose them over the others. Furthermore, children were able to reflect on their own quizzes and knowledge by answering the quizzes created by others.

Activity As to the teachers' evaluation, we observed that the MMQ System promoted the children's involvement in the activity. In school education, many teachers pay more attention to children with lower scholastic abilities. Our study achieved good results as the activity can support the children regardless of their scholastic ability.

As the MMQ allows up to four children to answer the quizzes simultaneously, the communication among them was active, and they enjoyed answering the quizzes. In the practice discussed in the previous chapter, a teacher wanted to emphasize the children's writing abilities while combining the MMQ and written work on paper. In this practice, children could reflect on their learning through both creating and answering quizzes.

We also found some differences from our previous research. In the present study, children read the description page carefully, whereas in the previous study, they hurried onto the next question. The description page is an important aspect in learning. Teachers always want children to read this page

carefully and memorize the information. In this study, we found that the children naturally read the description page carefully. The reason for this behavior may be that the quizzes were created by their friends, not by their teacher. They were curious to know how the other children designed quizzes, so they paid more attention to the contents of the quizzes as opposed to competing with other players for a higher score.

5.4 Case of Studying in Museum

5.4.1 Outline of the Activity

This activity of using MMQ was conducted in the same elementary school same with the previous case from February to March 2013, as a part of the Period for Integrated Studies. 42 children in two grade 6 classes, each of 21 children and 45 children in two grade 3 classes of 22 and 23 children participated in the activity.

5.4.2 Class Design

This activity of using MMQ to support learning in museum across two grades in an elementary school. In this study, the grade 6 children were asked to create quiz questions after visit of the Kyoto University Museum. The grade 6 children wrote quizzes on paper instead of using MMQ Editor because of class schedule. Then, the grade 3 children were asked to answer a part of the quizzes created by the grade 6 children with MMQ before visit of the museum. They were also asked to answer all the quizzes after their study in the museum.

The quiz creating activities in two grade 6 classes were divided into two parts: learning in Kyoto University Museum, and creating quizzes on paper. Collected quizzes were edited by the schoolteachers to correct wrong words and to shorten words to meet the limit of the MMQ. The edited quizzes were set to the computer by the author.

The quiz learning activities in two grade 3 classes were divided into three parts: answering quizzes with the MMQ as preparation of study in the Kyoto University Museum, visit of the museum, and answering quizzes with the MMQ to review of learning in the museum. Three class hours over 2 days

were used for each grade 3 class for MMQ. To support teachers and children in using the MMQ system, the author took part in the activities.

1. The children answered 10 quizzes with the MMQ before they went to the museum. We call it “Prior Activity” in the following.
2. One week after they answered the quizzes, they visited the museum, and appreciated the exhibits in the museum. We call it “Learning in Museum”.
3. One week after the visit, they answered all the 40 quizzes created by the grade 6 children to review the learning in the museum. We call it “Posterior Activity” in the following.

5.4.3 Method of Study

To conduct the quantitative and qualitative analysis of the quiz making, quiz answering, quiz responses, and engagement of the children, we used the questionnaires as shown in Appendix1 (Tables A.2, A.3, and A.4).

There are 8 questions in the questionnaire for quiz making children (Table A.2). Questions 3) and 6) through 8) asked children to answer rankings according to the five-grade evaluation system: “yes,” “probably yes,” “neither,” “probably no,” and “no.” Free descriptions were also asked in questions 1) and 6) through 8). Questions 2), 4) and 5) are multiple choice questions.

There are 6 questions in the questionnaire to evaluate the activity of quiz answering after Prior Activity (Table A.3). Questions 1) through 5) required children to provide rankings according to the five-grade evaluation system: “yes,” “probably yes,” “neither,” “probably no,” and “no”. Question 6) is a multiple choice question. We call it “Prior Questionnaire” in the following.

There are 8 questions in the questionnaire to evaluate the activity of quiz answering after Posterior Activity (Table A.4). Questions 1) through 4) and 7) asked children to provide rankings according to the five-grade evaluation system: “yes,” “probably yes,” “neither,” “probably no,” and “no”. Question 5) and 6) are multiple choice questions. Free description was required in Questions 1), 3) and 8). We call it “Posterior Questionnaire” in the following.

In addition to the questionnaire, we also interviewed the teachers to evaluate the activities.

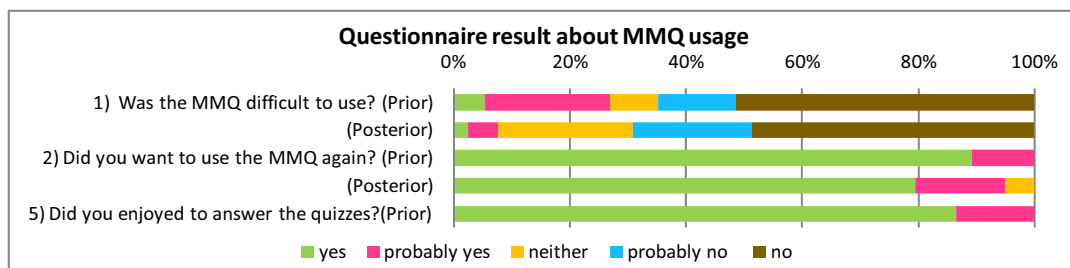


Figure 43: Result of usage in questionnaire for the grade 3 children

5.4.4 Result

MMQ Usage In our practices before, the MMQ were applied to classes of grade 4 or higher, and it was the first time we use the MMQ for the grade 3 children. Through participant observation by the researchers, the children were seemed to use the MMQ successfully, without apparent difficulty in operating it. One of the teachers said “The atmosphere of the class is different from the higher grade students using MMQ. Everybody looks very happy. Maybe the lower grade children expressed the enjoyment with more gestures.”

In this practice the grade 3 classes used the MMQ twice. After each activity, the children were required to answer the questionnaire about the MMQ usage in the Prior Questionnaire (Appendix1 Table A.3) and Posterior Questionnaire (Appendix1 Table A.4). As response to the question “1) Was the MMQ difficult to use?” in the Prior Questionnaire, more than 20% children answered “yes” or “probably yes”. Compared to this, in the response to the same question in the Posterior Questionnaire, the children who think the MMQ difficult to use has decreased about 20% (Fig. 43). Although, there are also less than 10% children think MMQ is difficult to use. However, the response to the question “2) Do you want to use the MMQ again?” almost all of the children want to use the MMQ again, no negative answers were recorded both in the Prior and Posterior Questionnaires. Most worthy has to be mentioned, all of the children answered “Yes” or “probably yes” in the question “5) Did you enjoy answering the quizzes?” (Fig. 43).

The grade 3 children were required to evaluate the quizzes designed by the grade 6 children in the question “3) Was the quiz difficult?” in the Prior

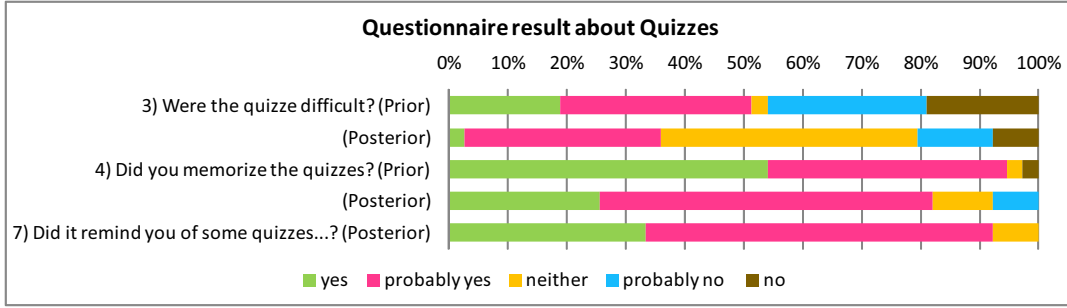


Figure 44: Result of question for evaluation of quizzes

Questionnaire and Posterior Questionnaire. Figure 44 shows more children choose the “neither” after they come back from museum. Both the positive answer and negative answer are decreasing than the data from Prior Questionnaire. However, almost 40% children agreed the quizzes are difficult, more than 40% children chose the “neither”, with 20% children left they do not think the quizzes are difficult eventually.

In the interview to one of the teachers, she said, “This activity is useful to let children feel familiar with the contents of museum. I heard they said ‘We did this, we did this (quizzes)’ when they studied in the museum.” These results are also reflected in the questionnaire. In question “7) Did it remind you of some quizzes when you studied in the museum?” most children evaluated they remembered the quizzes when they visited the museum as shown in Fig. 44.

The Evaluation of Quizzes Not only the Prior Activity had affect on the children in their study next step, but studying in the museum also had effects on the children in the Posterior Activity. One of the authors observed that children said “I know this quiz, we saw it in the corner (of the museum)”, “Is this that game (in the museum)?” etc. when they answered the quizzes with MMQ after visit of the museum.

Comparing the result of “Q.4) Did you remember the quizzes?” between the Prior Questionnaire and Posterior Questionnaire. The number of children who think they remembered the quizzes has decreased. The reason of this result may be related to the numbers of the asked quizzes. Before the visit of the museum we provided them with 10 quizzes, but after the visit, we

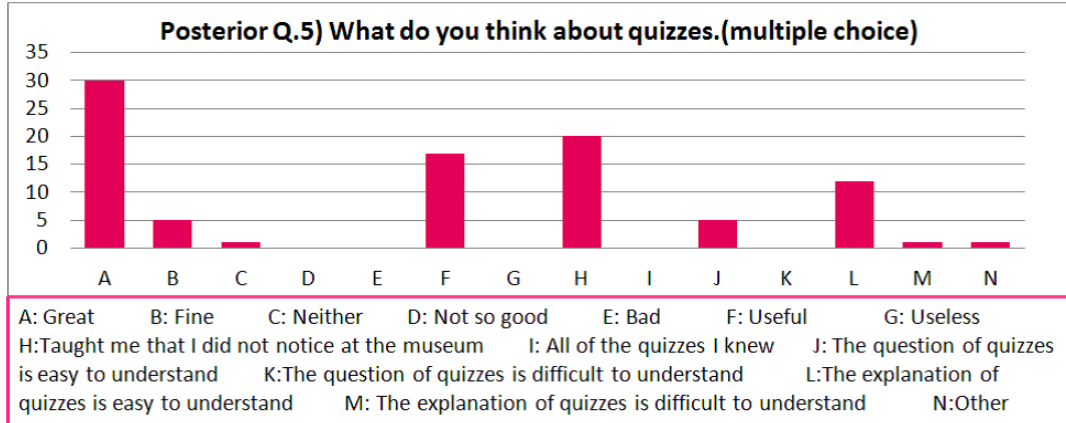


Figure 45: Results of question “What do you think about the quizzes?”

asked them 40 quizzes. Although this is a substantial increase, more than 80% children answered they remembered the quizzes.

In the Prior questionnaire, we asked children “5) Did you enjoyed the quizzes?”. The result is all of the children answered “yes” or “probably yes” in this question as shown in Fig. 43. In multiple choice question “5) What do you think about the quizzes from the grade 6 children?” the most common responses were “Great” (30 children), “Taught me that I did not notice at the museum” (20), “Useful” (17), thus they evaluated the quizzes in the positive side while we also see. “The explanation of quizzes is easy to understand” (12) as shown in Fig. 45.

The Action of Children through Activity The purpose for setting the quiz study before the children go to the museum aims to encourage children’s interest in the museum. The question “6) What do you want to do after answer these quizzes?” in Prior Questionnaire aimed to examine the encouragement of children after they use the MMQ. The question “6) What did you do after you answered quizzes last time?” aimed to examine the action of children after they answered the quizzes using the MMQ.

In Fig. 46, the most common responses were “Want to try these quizzes with my family” (22 children), “Will look carefully in the museum” (19 children). Also 17 children chose they want to go to the museum soon. Compared with these results, we found that the most children studied well

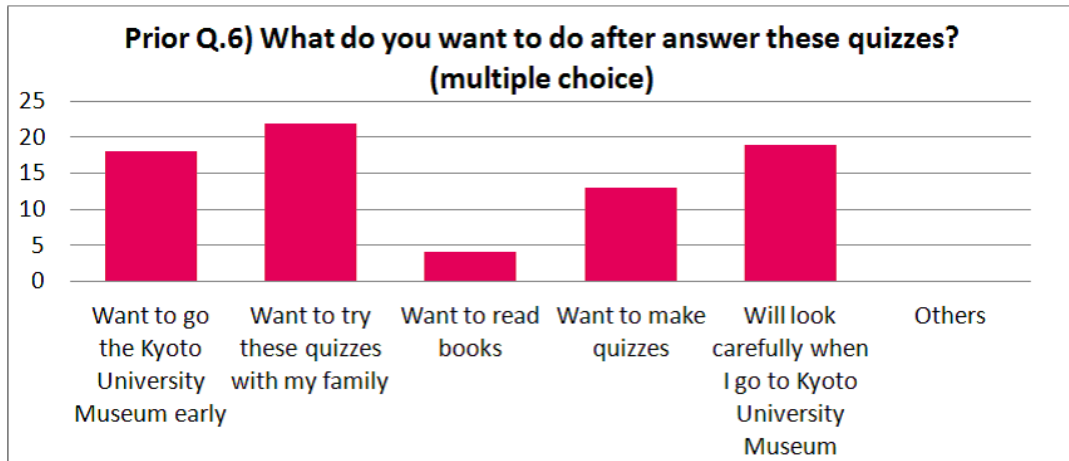


Figure 46: Results of question “What do you want to do after answer these quizzes? (multiple choice)”

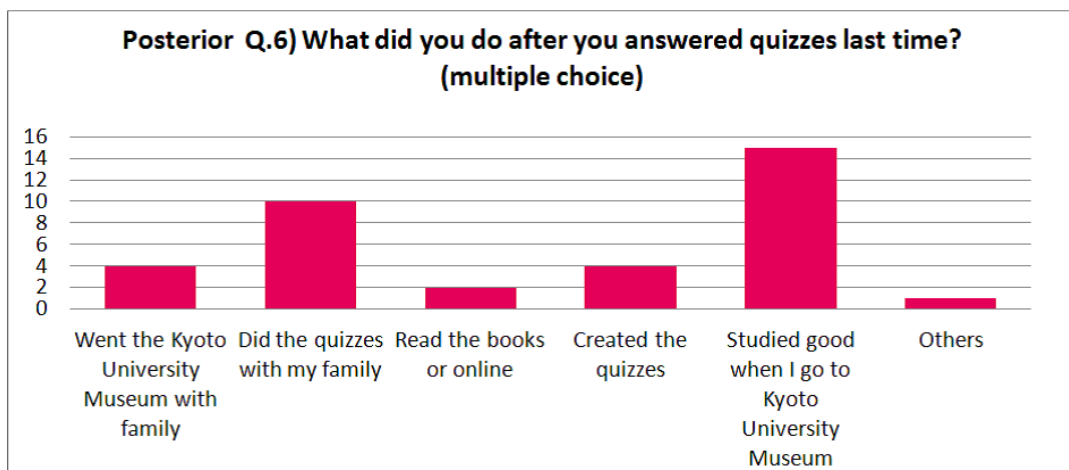


Figure 47: Results of question “What did you do after you answered quizzes last time? (multiple choice)”

in the museum when they went to the museum as shown in Fig. 46 (15 children). The children also did the quizzes with their family (10 children). There also 4 children gave responses to the choice “Went to the museum with family” (Fig. 47).

Consideration of Quiz Answerer The grade 6 children who created the quizzes are required to answer the questionnaire after they finish their quizzes creating.

From the response to question “3) Did you make consideration for an-

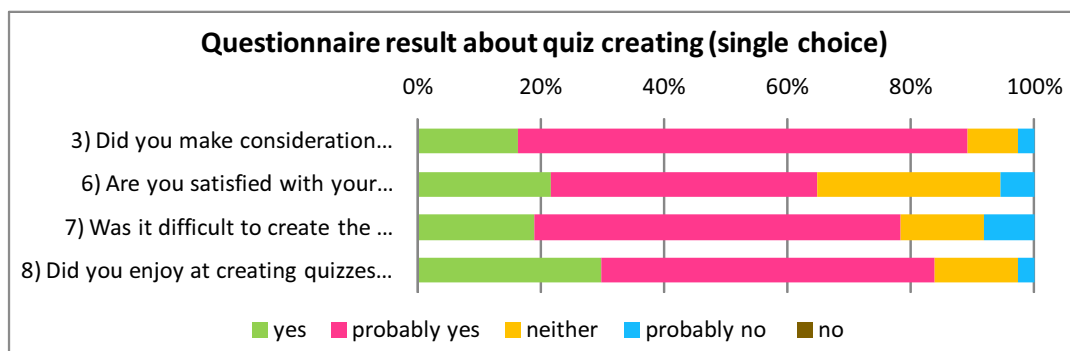


Figure 48: Questionnaire result about quiz creating (single choice)

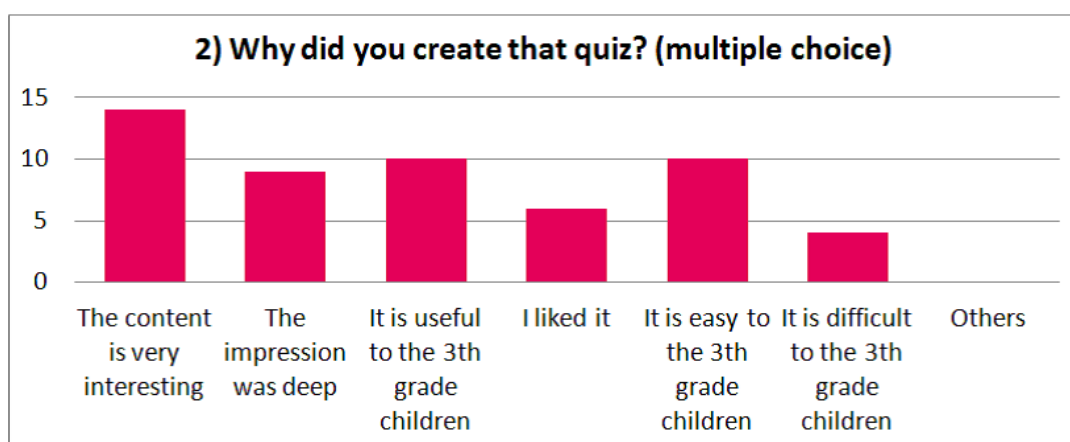


Figure 49: Results of question “Why did you create that quiz? (multiple choice)”

swerer when you create the quizzes?” almost 90% children made consideration for answerer shown in Fig. 48. A response to another question “2) Why did you create that quizzes?” some children created quizzes because they think the contents are interesting (14 children) as shown in Fig. 49. There were also some children considered that their quizzes were useful (10 children) or easy to the grade 3 children (10 children).

Engagement in Creating Quizzes We also asked the children to evaluate this practice. In Fig. 48, close to 80% children thought that it was difficult to create quizzes to the grade 3 children from the response to question “7) Was it difficult for you to create the quizzes to the grade 3 children? Why?”. But at the same time, more than 80% children enjoyed this practices

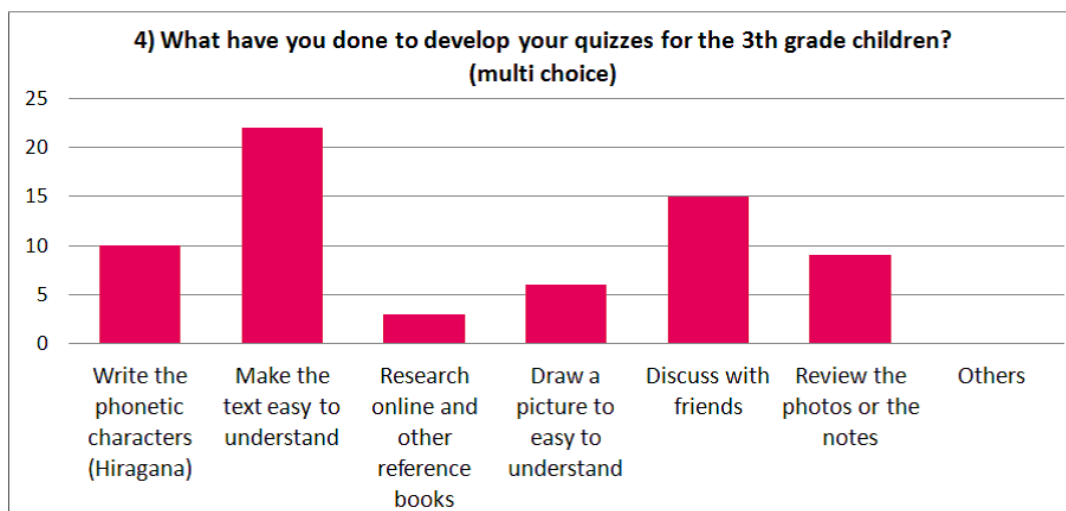


Figure 50: Results of question “What have you done to develop your quizzes for the grade 3 children? (multiple choice)”

in the response to the question “8) Did you enjoy at creating quizzes to the grade 3 children?”.

Reflection of Creating Quizzes In response to the question “4) What have you done to develop your quizzes for the grade 3 children?” 22 children made the texts easy to understand, 15 children discussed the quizzes with their friends, a lot of children wrote the phonetic characters with quizzes (10 children), also some children reviewed the photos or the notes they took in the museum as shown in Fig. 50. More than 60% children satisfied with their quizzes in the question “6) Are you satisfied with your quizzes?” as shown in Fig. 48.

Figure 51 shows the response to the question “5) What reaction do you want from the grade 3 children who answered your quizzes?” 22 children wanted they remember the knowledge, 16 children wanted they answered with interest, also some children wanted they could study well in the museum.

5.4.5 Discussion

Engagement Both the grade 6 children and the grade 3 children had a high sense of enjoyment and engagement when creating the quizzes and answering the quizzes using the MMQ. Although the children who created the quizzes felt difficulty in creation of the quizzes, but they enjoyed this activity.

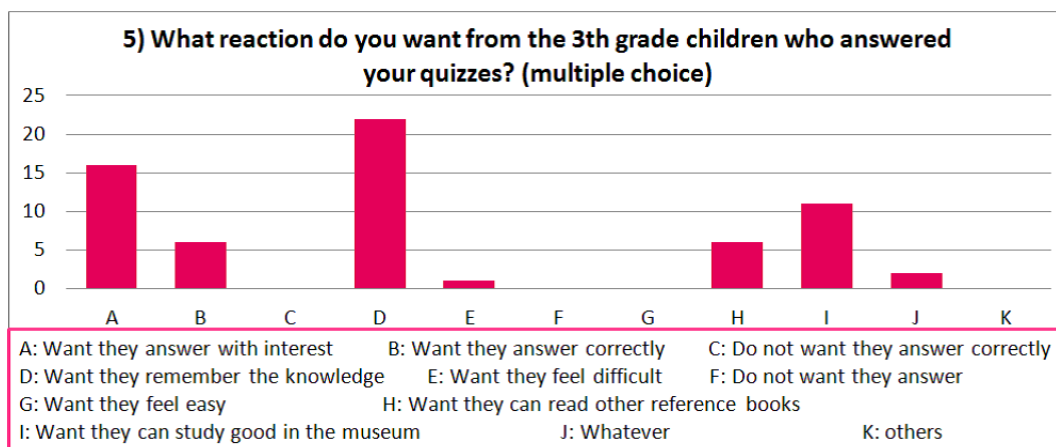


Figure 51: Results of question “What reaction do you want from the grade 3 children who answered your quizzes? (multiple choice)”

Reflection on the Quizzes The grade 3 children who answered the quizzes were reflected in different ways through the two MMQ classes (3 class hours). At first they answered the 10 quizzes about learning in the museum, and most children remembered the quizzes (Q.4 in Prior Questionnaire). Teachers evaluated that answering the quizzes could let children feel familiar with the contents of the museum. One of the teachers also observed that children talked about the quizzes in the museum. The same result also reflected by the question 7) in the Posterior Questionnaire. Most of the children answered the museum reminded them to think about the quizzes that they answered before. After they came back from the museum, the second MMQ learning inspired reflection that studied in the museum. Children evaluated these quizzes were useful and taught them that they did not notice at the museum from the response to the question 5 of Posterior Questionnaire.

The children who created the quizzes also reflected in their own way. Firstly, from the response of question, they paid attention to the answerer. Children expressed clearly in their own words what they studied was a good reflection of study. For making the quizzes better, the children tried their own way, some children made the text easy to understand, some children reviewed the notes. Eventually, a lot of children felt satisfied with their quizzes.

Activity As to the result of questionnaire, we found some cases that this activity cause the children's studies outside the school. Before grade 3 children went to the museum we asked them to answered 10 quizzes created by the grade 6 children. We can actually say that answering these quizzes encouraged them to go to the museum soon, and also some of them went to the museum with their families actually. In addition, most of children studied well in the museum.

5.5 Conclusion

We studied two activities using the MMQ and MMQ Editor to support quiz answering and quiz creation in the Period for Integrated Studies in an elementary school. In the Period for Integrated Studies, the children were expected to learn the contents more actively. We therefor think that the combination of quiz creation and answer is an effective usage from this point of view. In the studied activities, we observed the following results:

- The MMQ Editor could be operated by children themselves without any special assistance given by the researchers. The MMQ could be operated even by the grade 3 children without any special assistance.
- Class was designed combining various activities such as classes held outside the school, asking to create questions, and combining two grade classes.
- The MMQ system highly engaged children in the class activities. Children reflected on their learning in both quiz making and quiz answering using the MMQ system.
- The activity highly encouraged children's studies not only in the classroom but also classes held outside the school.
- We also observed that the children liked to talk to each other while looking at their friend's screen.

Chapter 6 Conclusion

In this thesis, the author focus on the Single Display Groupware (SDG) from a viewpoint of utilization in a home classroom in an elementary school among the ICT to support collaborative learning. As an application of SDG, the Multi-Mouse Quiz System was studied in the various classes of several elementary schools, and its effectiveness was investigated.

6.1 Effectiveness of Multi-Mouse Quiz System

As the results of this research, the effect of children's reaction and learning when a group of children shared one mouse or a single child controlled one mouse were discussed in Chapter 3. The MMQ was applied to classes teaching Social Studies and Arithmetic as subjects. The result of these classes and the design of classes were discussed in Chapter 4. In addition to the subject classes, the MMQ and MMQ Editor were used in the Period for Integrated Studies to support children answering the quizzes and creating the quizzes, these results were described in Chapter 5.

In this chapter, the author summarizes the findings of research along the research questions set in Chapter 1.

6.1.1 Usability of Multi Mouse Quiz System

In all of the practices, the teachers evaluated effectiveness of the MMQ in encouraging children's motivation to study in class. One of the teacher mentioned that all of the children seemed to feel happy to use the computer. With our observation, teachers and children of grade 3 to 6 could use MMQ without particular difficulty.

The MMQ Editor was developed based on the needs of elementary schools. It also used by the children in a studied case. The result showed that the MMQ Editor could be operated by children without any special assistance from the researchers. Teachers and most of the children evaluated the MMQ Editor as easy to operate. Furthermore, they were also confident about their ability to operate the MMQ Editor alone in the future.

6.1.2 Applicable Subjects and Activities

The teachers used the MMQ for class subjects of Social Studies and Arithmetic. It was also applied the practices of periods for integrated studies. In one of these practices, the teachers designed the class to use MMQ Editor in addition to MMQ. Considering Social Studies requires to memorize many facts and concepts, it may be reasonable that teachers chose this subject. In the both practices for Arithmetic, the teachers wanted that children could comprehend difficult contents through discussion in a group and encouraging participation using the MMQ. MMQ was used in the Period for Integrated Studies where children learn more actively along with the theme set by the teachers. Class design that made the children create quiz questions with MMQ Editor, and then appreciate them mutually with the MMQ was successful.

6.1.3 Class Design using MMQ System

Following activities were combined with the MMQ along with the class subject and teaching aims:

- Group discussion (all the schools)
- Oral explanation of children's ideas (H and N schools)
- Writing descriptive answer (H school)
- Quiz Creation and Mutual Appreciation (S and F schools)

In a class teaching Social Studies, a teacher set his goal to improve children's writing ability. He focus on how to encourage children's discussion through order of the quizzes. The quizzes were arrayed from easy ones to difficult, and the last quiz had no choice to answer, and the teacher asked children to write descriptive answer on a sheet of paper.

In the Arithmetic, a teacher used MMQ in a difficult unit for grade 4 class. MMQ was used in every steps of a complicated arithmetic process so as to let children comprehend the complicated process easily. The other teacher also used MMQ in a difficult unit of grade 6 class, and let children discuss in a group, and encourage the participation and preventing giving up.

In the Period for Integrated Studies, both teacher designed the class with combination of quiz answering and quiz creating to encourage more active children's learning.

We found a common strategy from the content created by schoolteachers, that is teachers arrayed the quizzes considering difficulty level from easy ones to difficult ones in the H, N, T school. The teacher designed the quizzes in this order so as to gave children confidence in answering the questions, and gradually attack difficult ones through discussion in group.

6.1.4 Effectiveness of MMQ System

Effectiveness of the MMQ observed in the studied class can be summarized in the following points of view.

Function of MMQ The pause function of MMQ were often used by the teachers aiming at control of the progress, giving hints, and combining other activities such as discussion in group, oral answering, and writing on paper or whiteboard.

In the activity using MMQ Editor, describing the explanation page was an important activity for engaging the children to read the textbook. In writing of the explanations, children also tried to make the document easy to read, and it increased their chances of examining the document. It also allowed children to consider their audience when creating a document. Furthermore, the time limit and score table settings also functioned well.

Engagement In the activity using MMQ, oral communication was encouraged. This might also the effect of using the MMQ developed as an application of SDG It is also important issue that using MMQ encouraged participation of children even of lower scholastic ability. Both usage of the computer for interaction and study in group may be the reason of such involvement.

Communication among Children The oral communication and non-verbal communication were active when 4 or 7 children share one mouse to answer the quizzes using MMQ. Furthermore, the practices showed that the children asked their friends questions about quizzes, and gave their friends

advises or explanations about which was correct answer spontaneously when they shared a mouse.

Children's Study When a group with 4 children or 7 children share one mouse using MMQ, the children talked to each other inside group more. Our research showed that they have some kind of competitive emotion to other children when one child control one mouse. The questions the children answered in pre test is around 50% or 60% accuracy rate, and in the post test they obtained around 80% or 90%. Either cases 4 or 7 children used one mouse, the performance on study showed high accuracy rate in post tests. Even the children in the environment that 2 children shared one mouse showed a little lower results on learning while there were around 80% accuracy rates can be confirmed.

In the case of using the MMQ in the Period for Integrated Studies, we observed various behaviors of children, that is, children reflected the knowledge on reading the text book again, asking teacher or friends, making the quizzes to their family, investigating in the museum with their family through creating of the quizzes.

According to the interviews to teachers, the learning task was taken deeper by children than usual class, for example, they wrote the essay longer and deeper, created the quizzes more.

Class Design by Teachers The author studied various practices with the teachers in elementary schools. The teachers designed the class in their own way according their own teaching policies. In addition to using the MMQ System, they adopted various educational methods, like oral presentation, writing description answers, explanation of ideas and so on. It can be argued that the MMQ System gave some free space of design to teachers, and engage teachers' motivation to design classes in a variety of ways.

6.2 Subjects of Future Study

In this research, the children's motivation to study was engaged by using Multi Mouse Quiz System in elementary schools. Regarding the future work

of using Multi Mouse Quiz System and Single Display Groupware, the following subjects can be listed.

- Improvement of MMQ. Such as increase the number of mice more than 4 to allow more flexible use in classroom usually having around 30 children.
- Investigation of effectiveness of the MMQ System on other subjects.
- Development other applications on SDG.
- MMQ was developed base on SDGToolkit, a middleware which provides only fundamental functions. It can be expected that the development of applications will be more efficient by improving the middleware based on the SDG is actual class activities such as this study.

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Appendix1: Questionnaires

Table A.1: Questionnaire of Creating/Answering Quizzes

1) Did you enjoy creating quizzes using MMQ Editor?
2) Was the MMQ Editor easy to use?
3) Do you want to use the MMQ Editor again?
4) Can you use the MMQ Editor by yourself from now on?
5) What did you do if you became stuck when creating the quiz? (multiple choice) * Ask friends * Look up in the textbook * Ask the teacher * Solve the problem by yourself * Change the question * Check other books * Search online * Others
6) What did you do to improve the questions? (multiple choice) * Read the textbook * Made the explanatory text easy to read * Made the written question easy to understand * Choose commonly confused responses * Other
7) If you have any requests, suggestions, or comments about the MMQ Editor, please let us know. (Free description)
8) Did you enjoy answering the quiz questions using MMQ?
9) Do you want to use the MMQ again?
10) Did you read the description page?
11) Did you want to show your quiz questions to your friends?
12) Tell us why. (Free description)
13) When you answered the quiz questions created by your classmates, did you compare them with your own?
14) When you answered your classmates' quiz questions, what did you think? (multiple choice) * Happy * Frustrated * Easy * Difficult * Wanted to make the quiz more difficult * Wanted to make the quiz easier * Wanted to create a quiz with new material

Table A.1: Questionnaire of Creating/Answering Quizzes

* Wanted to create a quiz with known material
* Wanted to create tricky quiz next time
* Wanted to stop creating tricky quiz next time
* Learnt something from the quiz questions * Learnt nothing * Other
15) When classmates answered your questions correctly, what did you think? (multiple choice)
* Happy * Frustrated * Easy * Difficult
* Wanted to make the quiz more difficult * Wanted to make the quiz easier
* Wanted to create a quiz with new material
* Wanted to create a quiz with known material
* Wanted to create tricky quiz next time
* Wanted to stop creating tricky quiz next time
* Learnt something from the quiz questions
* Learnt nothing * What you aimed for * Different from your aim * Other
16) When classmates made wrong answers to your questions, what did you think? (multiple choice)
* Happy * Frustrated * Easy * Difficult
* Wanted to make the quiz more difficult * Wanted to make the quiz easier
* Wanted to create a quiz with new material
* Wanted to create a quiz with known material
* Wanted to create tricky quiz next time
* Wanted to stop creating tricky quiz next time
* Learnt something from the quiz questions
* Learnt nothing * What you aimed for * Different from your aim * Other
17) Please write your comments freely. (Free description)

Table A.2: The Questionnaire for Children Who Created Quizzes

1) Which quiz did you create?

2) Why did you create that quiz? (multiple choice)

*The content is very interesting *The impression was deep *It is useful to the grade 3children *I liked it *It is easy to the grade 3children *It is difficult to the grade 3children *Others ()

3) Did you make consideration for answerer when you create the quizzes?

4) What have you done to develop your quizzes for the grade 3children?

*Write the phonetic characters (Hiragana) *Make the text easy to understand *Research online and other reference books *Draw a picture for easy to understand *Discuss with friends *Review the photos or the notes *Others ()

5) What reaction do you want from the grade 3children who answered your quizzes? (multiple choice)

*Want they answer with interest *Want they answer correctly *Do not want they answer correctly *Want they remember the knowledge *Want they feel difficult *Do not want they answer *Want they feel easy *Want they can read other reference books *Want they can study well in the museum *Whatever *others ()

6) Are you satisfied with your quizzes? And why do you think so?

7) Was it difficult for you to create the quizzes for the grade 3children? And why do you think so?

8) Did you enjoy creating quizzes for the grade 3children? And why do you think so?

Table A.3: The Questionnaire for Quizzes Answering before Visit of the Museum

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

Table A.4: Questionnaire for Quizzes Answering after They Come Back from Museum

1) Was the MMQ difficult to use? How is difficult?
2) Do you want to use the MMQ again?
3) Was the quiz difficult? How is difficult?
4) Did you remember the quizzes?
5) What do you think about the quizzes from the grade 6children? (multiple choice)
*Great *Fine *Neither *Not so good *Bad *Useful *Useless *Taught me that I did not notice at the museum *All of the quizzes I knew *The question of quizzes is easy to understand *The question of quizzes is difficult to understand *The explanation of quizzes is easy to understand *The explanation of quizzes is difficult to understand *Other()
6) What did you do after you answered quizzes last time? (multiple choice)
*Went the Kyoto University Museum with family *Did the quizzes with my family *Read the books or online *Created the quizzes *Studied good when I go to Kyoto University Museum *Others ()
7) Did it remind you of some quizzes when you studied in the museum?
8) Please write your comments freely. (Free description)

Appendix2: Quizzes in Japanese

Table A.1: Quizzes of Social Studies in H school

問題 1、成田国際空港の貨物とりあつかい額は？ 日本で 2 位 アジアで 2 位 世界で 2 位
問題 2、なぜ、成田空港は貨物とりあつかい額が高額なのでしょう？ 世界中から荷物が来るから 高額なものをあつかうから 日本中の品物が集まるから
問題 3、その高額なものとは何？ 半導体やカメラ マグロなど高級食材 宝石や高級な服
問題 4、税関の仕事でないものは？ カスタム君の宣伝 犬を使って麻薬を見つける 特別な品物に税金をかける
問題 5、たくさんの魚やエビの輸入が多いため成田空港は〇〇とよばれる？ 成田空港 成田漁港 成田漁業
問題 6、日本に石油（原油）を最も多く輸出している国は？ アラブ首長国連邦 イラク サウジアラビア
問題 7、鉄鉱石を日本に輸出している国は？ アメリカ オーストラリア オーストリア
問題 8、日本に最も多く小麦を輸出している国は？ アメリカ オーストラリア カナダ
問題 9、現在、日本が最も多く輸出している品目は？ 鉄鋼（てっこう） せんい品 機械類
問題 10、日本の貿易（輸出）相手国のナンバー 1 は？ オーストラリア アメリカ 中国
問題 11、現在、日本の貿易（輸出）相手国のナンバー 2 は？ オーストラリア アメリカ 中国
問題 12、輸出相手として、最近伸びてきている地域は？ アジア アフリカ ヨーロッパ
問題 13、海外に輸出するだけでなく、その他に.... 海外を支配しようとしている 海外に工場を作っている 海外の工場を買い取りしている

Table A.1: Quizzes of Social Studies in H school

問題 1 4、なぜ海外に工業を作るのでしょうか？間違っているものを選ぼう。 発展を手助けするため 支配するため 技術を伝えるため
問題 1 5、貿易とは？ 品物の交かん 豊かさのこうかん お金の交かん
問題 1 6、先進国とはどんな国？ 最近、発展してきた国 これから発展する国 工業技術や文化の進んだ国
問題 1 7、B R I C s とは、発展のいちじるしい国ですが、どこの国？ 中国・韓国・ドイツ・ベルー ブラジル・ロシア・インド・中国 オランダ・ブラジル・中国・ロシア
問題 1 8、日本の工業の自まんは？ アイデアと技術力 値段と品質 根性と努力
問題 1 9、A P E C とは何？ アジアペキン経済協力 アジア太平洋経済協力 アジア協力機構
問題 2 0、貿易まさつとは何か。説明しよう。
問題 2 1、貿易まさつを防止するためにどうすればいい？

Table A.2: Quizzes of Arithmetic in T school

問題 1、翔太君と柊稀くんがじゃんけんをしました。一度で勝負が決まる組み合わせは何通りあるでしょう。 4 通り 9 通り 6 通り 12 通り 解説：翔太くんが勝つ場合が 3 通りあります。(グー・チョキ・パー) 柊稀くんが勝つ場合も同じだけあるので、答えは 6 通りになります。太郎くんと花子さんの 2 人であっち向いてホイをします。勝ったものは指で右か左を指す。
問題 2、1 回目のじゃんけんで勝負が決まる組み合わせは何通り。 4 通り 9 通り 6 通り 12 通り 解説：太郎くんが勝つ場合を考える。じゃんけんで勝つ場合が 3 通り、その後に、太郎くん《右》指さし、花子さん《右》向き、太郎くんが【左】指さし、花子さん【左】向きの計 6 通りが 1 回で勝負がつきます。
問題 3、4 人の中から 2 人を選ぶ組み合わせは何通り。 12 通り 6 通り 20 通り 8 通り 解説：$4 \times 3 \div 2 = 6$ わる 2 は、選ばれた 2 人の組み合わせ (2 通り) に順番がないために行う。
問題 4、6 人の中から 3 人を選ぶ組み合わせは何通り。 20 通り 60 通り 120 通り 18 通り 解説：$6 \times 5 \times 4 \div 6 = 20$ 6 人の中から 3 人選ぶので ($6 \times 5 \times 4$) ですが、選ばれた 3 人の組み合わせ (6 通り) に順番がないので、わる 6 をします
問題 5、上り始めてから何秒後に 8 階までたどり着ける？ 96 秒 112 秒 84 秒 128 秒 解説：まず、1 階から 4 階までは 3 つ階を上っているので ($48 \div 3 = 16$) で 1 階上るのに 16 秒かかることが分かる。したがって 1 階から 8 階まで 7 つ階を上るので、(16×7) となり、答えは 112 秒になる
問題 6、一辺の長さが 6cm, 3cm, 2cm の三角形の面積は？(超早押し問題) $6cm^2$ $18cm^2$ $12cm^2$ 答えが出せない 解説：短い方の 2 本の辺の長さの和が残された一辺の長さよりも短い場合、三角形はできません。

Table A.2: Quizzes of Arithmetic in T school

問題 7、面積が 20cm^2 の正方形の各辺の真ん中の点と各原点を結びました。AB の長さを求めよう。

2cm 4cm 3cm 5cm

解説：小さな三角形を移動すると、小さな正方形が 5 つできる。だから、小さな正方形 1 つ分の面積は $\langle 20 \div 5 = 4\text{cm}^2 \rangle$ となるので、一辺の長さが分かる

問題 8、一辺の長さが 20cm の正方形の各辺の真ん中の点と各原点を結びました。色のついた部分の面積を求めよう。

50cm^2 120cm^2 80cm^2 200cm^2

解説：先ほどと同じ様に考えると、 $\langle 20 \times 20 \div 5 = 80\text{cm}^2 \rangle$ となる。
