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# A Survey of Middle and Upper Elementary School Students' Knowledge of Cloud Computing

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## Abstract

In this study, a questionnaire was administered to middle and upper elementary school students to evaluate their cloud computing knowledge to obtain suggestions for instructional strategies to understand and promote the utilization of cloud computing. Pictures and sentences explaining cloud computing were evaluated based on the evaluation criteria developed from the points of view proposed by Mitsui et al. As a result, we found that some viewpoints were easy to understand, and some were difficult to understand. Overall, we found that the general level of cloud computing knowledge acquisition was low. In addition, the upper grades were not necessarily more proficient, and there were differences between classes. In addition, we analyzed the relationship between the students' cloud computing knowledge and the teacher's experience. As a result, students whose homeroom teachers had limited experience and students whose homeroom teachers had extensive experience teaching students to utilize one-to-one devices were more likely to have acquired knowledge of cloud computing.

*Keywords:* Knowledge of cloud computing, Japanese elementary school, Middle and upper elementary school students, One-to-one devices.

# 1 Introduction

Cloud computing is becoming increasing ubiquitous, and various companies, e.g., Microsoft and Amazon, which occupy the top positions in the global ICT-related market, originally focused primarily on software and e-commerce solutions; however, offering cloud services has increased their revenue significantly [1].

Information literacy was positioned as a fundamental quality and ability for learning in the April 2020 curriculum for Japanese elementary schools [2]. In addition, in terms of the development of information literacy, the Ministry of Education, Culture, Sports, Science and Technology's "GIGA School Initiative" has established a one-to-one devices. Learning under the GIGA School Initiative environment defaults to cloud computing utilization. For example, in elementary school learning, many practices using cloud computing have been implemented, e.g., sharing of cross-referenced opinions through collaborative editing of spreadsheets and digital whiteboards, sharing links through chat, and exchanging opinions through comment functions [3], [4].

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Ertmer and Ottenbreit-Leftwich [5] stated that, to use technology effectively, teachers must first understand the technology itself. Regarding the teaching of information utilize skills to students, [6] stated that scientific knowledge and understanding of how information tools function and how information is used must be taught in line with development of students. Another study [7] stated that having students understand the characteristics of cloud computing through hands-on experience resulted in proactive use of cloud computing. In addition, Mitsui et al. developed seven points of view to evaluate cloud computing knowledge [8]. Here, by comparing the results of a survey of elementary school and university students, they found that the frequency of exposure to cloud computing is relatively high and that university students, who are at an advanced developmental stage, do not have sufficient cloud computing knowledge. Based on the results of the survey, they proposed that students gain more experience using file sharing and collaborative editing functions, and that some points of view are given as knowledge because they are unlikely to be fully acquired only through practical experience. Based on these previous studies, we believe that there is a need to improve students' cloud computing knowledge.

Therefore, in this study, we conducted a survey and analysis of middle and upper grade elementary school students who utilize one-to-one devices to obtain suggestions for guidance that teachers should provide when students utilize cloud computing. Here, we targeted middle and upper grade students because, in the third grade, we expect that instruction on Japanese input using a keyboard will be given in conjunction with instruction on Roman alphabetic characters in Japanese language classes, and that the utilization of cloud computing, e.g., collaborative editing and chatting, will be promoted in integrated learning time. First, we administered a questionnaire survey that asked students about their cloud computing knowledge, and then we set up criteria for each point of view defined by Mitsui et al. [8]. We then conducted an evaluation to clarify which points of view are understood by the students and to what extent (Survey 1). In addition, we analyzed the relationship between the results of Survey 1 and a survey of students' utilization of terminals and the teaching history of their homeroom teachers (Survey 2). Thus, we examined the guidance required by students to acquire sufficient cloud computing knowledge.

## 2 Purpose of the Study

The purpose of this study was to investigate and analyze the cloud computing knowledge of middle and upper elementary school students and to clarify the following two points.

1) Conduct a survey on the knowledge of cloud computing and evaluate the statements to determine the students' knowledge acquisition status.

2) To examine the guidance required by students to develop effective cloud computing knowledge, we analyze the relationships between the students' knowledge acquisition status and the utilization of one-to-one devices in their classroom relative to homeroom teachers' teaching history.

## 3 Survey 1: Knowledge of Cloud Computing

Survey 1 was conducted to determine the extent to which students possess cloud computing knowledge.

Here, the point of view related to "knowledge of cloud computing" (as defined by [8]) was created by researchers based on related books and adapted to elementary school students. Note that this may not strictly represent the mechanism of cloud computing and its general status.

### 3.1 Survey Scope and Time Period

Survey 1 was conducted in classrooms after obtaining permission from both the homeroom teachers and school principals. This survey was conducted from December 2020 to January 2021. The questionnaires were mailed and returned after the survey was administered.

The survey was conducted in nine classes [9]; however, six classes were considered in the analysis (excluding one junior high school class and one class where one-to-one devices were not in place, one class had a mean score of 0 (*SD* = 0) with all students scoring 0).

In this study, a total of 172 students were targeted for the questionnaire survey, and 162 valid responses were obtained, for a valid response rate of 94.2% for Surveys 1 and 2 (Table 1).

Table 1: Grades, number of students, and number of valid answers for each class

| Class | A | B | C | D | E | F | Total |
|---|---|---|---|---|---|---|---|
| Municipality | A Pref.E-town | B Pref.E-city | B Pref.B-city | C Pref.G-city | D Pref.H-city | B Pref.B-city | - |
| Grade | 3 | 4 | 4 | 5 | 6 | 6 | - |
| Number of students | 24 | 32 | 31 | 27 | 34 | 24 | 172 |
| Number of valid answers | 18 | 31 | 31 | 27 | 33 | 22 | 162 |

### 3.2 Questionnaire Survey for Students

In Japanese elementary schools, systematic instruction on cloud computing has not yet been provided. In this study, we conducted an exploratory survey of students' knowledge of cloud computing. Therefore, the questionnaire was designed with a single question asking the students to describe what their current knowledge using words, sentences, pictures, and/or diagrams.

After the first author developed the questions, the second, third, and sixth authors checked and reviewed the questionnaire. In reviewing the questions, the authors, who had experience as elementary school teachers, determined that even third graders could adequately answer the questions, which were set as follows. An example response was also provided.

*Please write whatever you know about "the Cloud"." You may use words, sentences, pictures, or diagrams. You may write about what you think "the Cloud" is like, or just mention words that are related to it. If you can write in detail, please try to write in detail, e.g., "Can be used when connected to the Internet."*

In this paper, "knowledge of cloud computing" refers to the answers to the above question. Note that respondents were elementary school students who have just begun using cloud computing; thus, the responses do not represent their cloud computing knowledge in the strict sense, which is an identified limitation of the current study.

### 3.3 Points of View and Evaluation Criteria to Assess Knowledge

The points of view used to assess cloud computing knowledge were created by Mitsui et al. [8]. These points of view are defined in Table 2. The evaluation criteria used in this study were developed for each of these points of view [10].

First, the following three levels were established: "S: well understood," "A: somewhat understood," and "B: not understood." Note that levels S and A are defined as "understood." Then, we established the evaluation criteria for each viewpoint based on the contents confirmed when all statements were extracted and counted [9]. Then, the results were reviewed and confirmed.

The evaluation criteria are also shown in Table 2.

Table 2: Points of view and evaluation criteria to assess cloud computing knowledge

| | Point of view | Description | S: Well understood | A: Somewhat well understood | B: Not understood |
|---|---|---|---|---|---|
| (1) | Understands that devices are always communicating | Words Sentences | Always connected<br>Always exchanging data<br>Data come and go | Internet/Wi-Fi required<br>Must be connected to the Internet to use | (No description) |
| | | Picture | Always connected<br>Always exchanging data<br>Data back and forth<br>One arrow in both directions (↔)<br>Two arrows in both directions (⇄) | Internet/Wi-Fi required<br>Connected by a line or one-way arrow<br>Must be connected to the Internet<br>Marked with X when offline | (No description) |
| (2) | Understands that the data (application) are not in the device, but in | Words Sentences | Data are in the cloud/server<br>Data are not on the device | Can use various applications<br>Can store/place data/files | (No description)<br>Individual app name |
| | | Picture | Data are in the cloud/server<br>Data are not on the device | Can use various apps<br>Can store/place data/files<br>Cloud or server in a separate location from the device | (No description)<br>Individual app icons/screens |
| (3) | Understands that the exchange between devices is via a server | Words Sentences | Data go through the cloud and servers<br>Data go to the cloud once and reaches the other party | Data are not sent directly. | (No description)<br>Devices and people are connected to each other |
| | | Picture | Data go through the cloud and servers<br>Data go to the cloud once and reaches the other party<br>Arrows and lines from devices/people are connected through servers and cloud | Devices and people had not connected each other with line or marked with X | (No description)<br>Devices and people connected each other with line |
| (4) | Understands that the same data can be accessed on different devices by logging in with the same account | Words Sentences | Log in with ID and password to connect to the cloud and servers | Connect to PCs, smartphones, and tablets<br>Connect on different devices/PCs | (No description) |
| | | Picture | Log in with ID and password to connect to the cloud and servers | Connect to PCs, smartphones, and tablets<br>Connect on different devices/PCs<br>Different types of devices are connected to the same cloud/server | (No description) |
| (5) | Understands that different accounts can access the same data if they are authorized to do so | Words Sentences | View and edit other people's data with permission/configuration<br>Data can be shared with select people<br>Data cannot be viewed without sharing | Data can be shared<br>Other people can see the data<br>Collaborative editing can be performed<br>Everyone can be in a single application<br>Can comment<br>Can receive comments | (No description)<br>Can share/send data via chat<br>Can summarize opinions via Jamboard/slides<br>Can share screen in online class<br>Can discuss/teach each other via chat (etc., only single app mentioned) |
| | | Picture | View and edit other people's data with permission/configuration<br>Data can be shared with select people<br>Data cannot be viewed without sharing<br>Indicates shared permissions by opening and closing keys | Data can be shared<br>Other people can see the data<br>Collaborative editing can be performed<br>Everyone can be in a single application<br>Can comment<br>Can receive comments | (No description)<br>Can share/send data via chat<br>Can summarize opinions via Jamboard/slides<br>Can share screen in online class<br>Can discuss/teach each other via chat (etc., only single app mentioned) |
| (6) | Understands that the same data can be accessed on different networks | Words Sentences | Connecting to the same data on different networks/at school/at home/anywhere | Connecting to the server different networks/at school/at home/anywhere | (No description)<br>Connecting at a distance |
| | | Picture | Connecting to the same data in the cloud/server from different locations (school or home) | Connecting to the cloud/server from different locations (school or home) | (No description)<br>Connecting at a distance |
| (7) | Understands that an account is required | Words Sentences | Account required | Enter with ID and password<br>Logged in | (No description) |
| | | Picture | Account required | Enter with ID and password<br>Logged in | (No description) |

## 3.4 Evaluation

We evaluated the students' responses using the criteria described in Section 3.3. The following is an evaluation of "S: well understood," "A: somewhat understood," and "B: not understood," with corresponding examples of the students' responses.

For the student's answer to point of view (1), if the responses mention that they are communicating, e.g., "The cloud needs the Internet," it is evaluated as A. If the student's response indicates that they are always communicating, e.g., "anytime," it is evaluated as S.

In the figure/picture, if a person or computer and cloud computing are connected by a line or a single arrow, or these entities are marked with an X when offline, as shown in Figure 1A, then it is designated as A. In addition, if the response indicates that the exchange is bidirectional, as shown by the arrow on the right side of Figure 1B, or if the line is accompanied by a word such as "all the time," it is evaluated as S.

Note that the left side arrows in Figure 1B, which are drawn for illustrative purposes, were not evaluated. In addition, lines or arrows connecting people or devices that signify the movement of data, etc., were not evaluated.

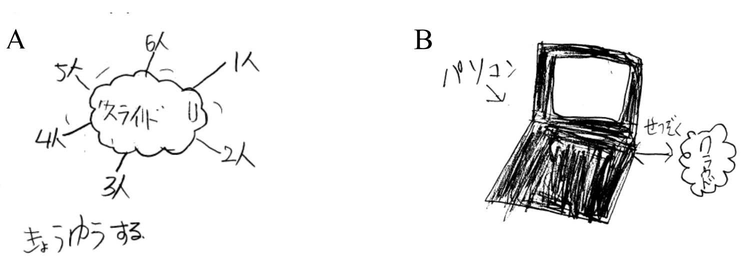


Figure 1: Sample answers

The B grade was assigned to student responses that included incorrect perceptions (e.g., "It is not available in foreign countries"), confusion with functions other than the cloud (e.g., "You can get information by looking it up"), impressions (e.g., "Using the cloud makes the class go faster"), irrelevant answers (e.g., "I don't know"), or blank responses.

In this survey, although we did ask the respondents to answer in detail, if possible, we did not ask the respondents to write as much as possible. In addition, we only gave a single example response; thus, it is possible that the students' answer focused on only one concept or topic. Note that 17 students provided responses that focused on only one thing, and these answers were excluded because we could not determine a robust summary of their knowledge.

Eight other cases were not included in the evaluation. These cases consisted of responses that stated, "can be used when connected to the Internet" and "can only be used when connected to the Internet," which is the same meaning of "can only be used when connected to the Internet," which was described in the example given in the questionnaire.

## 3.5 Evaluation Results

The evaluation was conducted by two researchers who had previously worked in elementary schools and were specialized in the informatization of education. Here, the researchers reevaluated the areas of disagreement and adjusted the points of the evaluation. The agreement rate was 97.2% (141/145 cases), which was adjusted to 100% after the reevaluation and discussion process. The corresponding results are shown in Table 3.

Table 3: Frequency of evaluation of knowledge of cloud computing (per class)

| Class | Grade | Number of valid answers | Point of view (1) | | | Point of view (2) | | | Point of view (3) | | | Point of view (4) | | | Point of view (5) | | | Point of view (6) | | | Point of view (7) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | S | A | B | S | A | B | S | A | B | S | A | B | S | A | B | S | A | B | S | A | B |
| A | 3 | 17 | 0 | 8 | 9 | 0 | 9 | 8 | 0 | 4 | 13 | 1 | 6 | 10 | 0 | 1 | 16 | 0 | 9 | 8 | 0 | 2 | 15 |
| B | 4 | 31 | 2 | 9 | 20 | 0 | 12 | 19 | 0 | 2 | 29 | 0 | 0 | 31 | 6 | 16 | 9 | 0 | 2 | 29 | 0 | 0 | 31 |
| C | 4 | 25 | 0 | 1 | 24 | 0 | 1 | 24 | 0 | 0 | 25 | 0 | 1 | 24 | 0 | 0 | 25 | 0 | 0 | 25 | 0 | 0 | 25 |
| D | 5 | 21 | 1 | 10 | 10 | 0 | 8 | 13 | 0 | 0 | 21 | 0 | 8 | 13 | 0 | 2 | 19 | 0 | 2 | 19 | 0 | 2 | 19 |
| E | 6 | 33 | 0 | 1 | 32 | 7 | 23 | 3 | 8 | 3 | 22 | 0 | 4 | 29 | 0 | 13 | 20 | 0 | 2 | 31 | 0 | 1 | 32 |
| F | 6 | 18 | 0 | 3 | 15 | 0 | 2 | 16 | 0 | 0 | 18 | 0 | 2 | 16 | 0 | 1 | 17 | 0 | 1 | 17 | 0 | 0 | 18 |
| Total | | 145 | 3 | 32 | 110 | 7 | 55 | 83 | 8 | 9 | 128 | 1 | 21 | 123 | 6 | 33 | 106 | 0 | 16 | 129 | 0 | 5 | 140 |
| Number of students who understand (S+A) | | | 35 | | | 62 | | | 17 | | | 22 | | | 39 | | | 16 | | | 5 | | |
| Percentage | | | 24.1% | | | 42.8% | | | 11.7% | | | 15.2% | | | 26.9% | | | 11.0% | | | 3.4% | | |

## 3.6 Analysis of Results

### *3.6.1 Overall Analysis*

To analyze the students' cloud computing knowledge, the scores were compiled by assigning two points to S, one point to A, and zero points to B (0–2 points for each point of view, with 0–14 points in total).

The mean of the sum of the scores for each class was then calculated. In descending order of magnitude, the mean scores, (standard deviation (*SD*)), and grade are given in parentheses) were as follows: Class E, 3.00 (1.76, sixth grade); Class A, 2.35 (2.03, third grade); Class B, 1.84 (1.14, fourth grade); Class D, 1.52 (1.05, fifth grade); Class F, 0.72 (1.19, sixth grade); and Class C, 0.08 (0.39, fourth grade).

In addition, a one-factor between-subjects analysis of variance (ANOVA) with class as a factor was conducted to determine if there were differences in understanding among the participating classes. Table 4 shows the mean (*SD*) of the total scores for each class and the ANOVA results.

Table 4: Mean (*SD*) of total scores for each class and test results of ANOVA

| Class | A | | B | | C | | D | | E | | F | | *F* value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3rd Grade | $n = 17$ | 4th Grade | $n = 31$ | 4th Grade | $n = 25$ | 5th Grade | $n = 21$ | 6th Grade | $n = 33$ | 6th Grade | $n = 18$ | |
| Total (*SD*) | 2.35 (2.03) | | 1.84 (1.14) | | 0.08 (0.39) | | 1.52 (1.05) | | 3.00 (1.76) | | 0.72 (1.19) | | 15.44 ** |

† : $p < .10$, * : $p < .05$, ** : $p < .01$

The results showed that the class factor was significant ($F(5,139) = 15.44$, $p = 0$, $\eta 2 = 0.36$). Thus, an analysis of multiple comparisons using the Bonferroni method was conducted (Figure 2), and, when described in order of increasing mean by class, Class E 3.00 did not differ significantly from Class A 2.35 ($t(139) = 1.83$, ns) and was significantly greater than Class B 1.84 ($t(139) = 3.36$, adjusted $p < .01$). Class A 2.35 did not differ significantly from Classes B 1.84 ($t(139) = 0.98$, ns), and D 1.52 ($t(139) = 1.84$, ns), and was significantly greater than Class F 0.72 ($t(139) = 3.33$, adjusted $p < .01$). Note that the mean of 1.84 for Class B did not differ significantly from the mean of 1.52 for Class D ($t(139) = 1.08$, *ns*) and 0.72 for Class F ($t(139) = 2.80$, *ns*), and was significantly greater than the mean of 0.08 for Class C ($t(139) = 4.87$, adjusted $p < .01$). In addition, Class F 0.72 did not differ significantly from Class C 0.08 ($t(139) = 1.55$, *ns*).

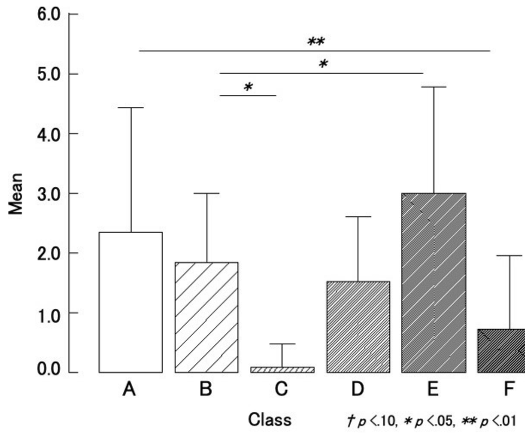


Figure 2: Mean scores by class

We found that total scores differed significantly among the classes. Considering that the highest total score was 14 points (2 × 7 points of view = 14 points), and the highest total score was seven points (1 × 7 points of view) when all points of view were somewhat understood, we cannot say that all classes exhibited a high level of cloud computing knowledge.

### *3.6.2 Analysis by View of Point*

A one-factor within-participant ANOVA with the point of view as a factor was also conducted to identify differences in understanding according to the different points of view. Table 5 shows the means (*SD*) of the scores by point of view and the ANOVA results.

Table 5: Mean (SD) and ANOVA results for scores by point of view

| | | Point of view | | | | | | | *F value* |
|---|---|---|---|---|---|---|---|---|---|
| | Total | (1) | (2) | (3) | (4) | (5) | (6) | (7) | |
| Score (*SD*) | 1.68 (1.69) | 0.45 (0.56) | 0.46 (0.58) | 0.17 (0.50) | 0.17 (0.40) | 0.31 (0.54) | 0.09 (0.29) | 0.03 (0.18) | 23.08 ** |

† : $p < .10$, * : $p < .05$, ** : $p < .01$

This analysis revealed that the point of view factor was significant ($F(6,864) = 23.08$, $p = 0$, $\eta p^2 = 0.14$). Thus, an analysis of multiple comparisons using the Bonferroni method was conducted (Figure 3). When the mean scores for each point of view were described in order of size ((2), (1), (5), (4), (3), (6), (7), 0.46 did not differ significantly from (1) 0.45 and (5) 0.31 (adjusted $p$s > .10), and was significantly greater than (4) 0.17 ($t(144) = 5.49$, adjusted $p = 0$). In addition, (1) 0.45 did not differ significantly from (5) 0.31 (adjusted $p > .10$) and was significantly greater than (4) 0.17 ($t(144) = 5.49$, adjusted $p = 0$). The value of (5) 0.31 did not differ significantly from both (4) 0.17 and (3) 0.17 (adjusted $p$s > .10), and was significantly greater than (6) 0.09 ($t(144) = 4.15$, adjusted $p < .01$). Also note that (4) 0.17 did not differ significantly from (3) 0.17 and (6) 0.09 (adjusted $p$s > .10), and was significantly greater than (7) 0.03 ($t(144) = 3.82$, adjusted $p < .01$). The value of (3) 0.17 did not differ significantly from (6) 0.09 (adjusted $p > .10$) and tended to be significantly greater than (7) 0.03 ($t(144) = 3.05$, adjusted $p < .10$). Finally, (6) 0.09 did not differ significantly from (7) 0.03 (adjusted $p > .10$).

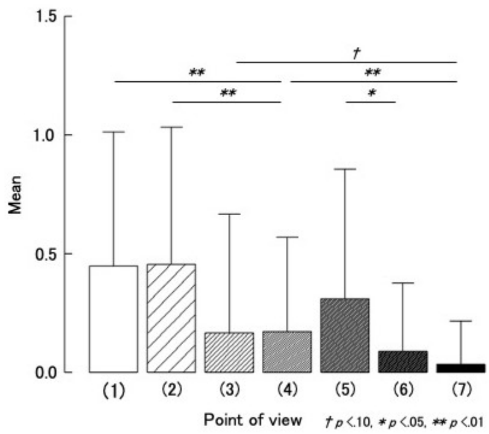


Figure 3: Mean scores by point of view

The scores by point of view were as follows: (2) 0.46 = (1) 0.45 = (5) 0.31 > (4) 0.17, (1) 0.45 = (5) 0.31 > (4) 0.17, (5) 0.31 = (4) 0.17 = (3) 0.17 > (6) 0.09, (4) 0.17 = (3) 0.17 = (6) 0.09 > (7) 0.03, (3) 0.17 = (6) 0.09 > (7) 0.03, (3) 0.17 = (6) 0.09 > (7) 0.03, (4) 0.17 = (6) 0.09 = (7) 0.03, and (5) 0.09 = (7) 0.03. .03, (6) 0.09 = (7) 0.03. Thus, we can conclude the following. The scores for (2) “Understands that data (applications) are not in the device but in the server on the network” and (1) “Understands that data is always communicated” were higher than those of the other points of view. In addition, the scores for (4) “Understands that the same data can be accessed on different devices by logging in with the same account,” (3) “Understands that communication between devices is through a server” and (6) “Understands that the same data can be accessed even if the network is different” were higher than the scores for the other points of view. Here, (7) “Understands that an account is necessary” had lower scores than the other points of view.

# 4 Survey 2: Utilization of One-to-one Devices in the Classroom and Homeroom Teachers' Teaching History

We hypothesized that the students' cloud computing knowledge may be related to their utilization of one-to-one devices and their homeroom teacher's teaching experience. Thus, we administer a questionnaire [9], i.e., Survey 2, and cross-tabulated the results with those obtained for Survey 1.

## 4.1 Survey Scope and Time Period

Survey 2 was administered to six teachers teaching the target classes in Survey 1.

Note that Survey 2 was conducted during the same period as Survey 1, i.e., December 2020 to January 2021.

## 4.2 Survey Content and Methods

Here, Google Forms was used to administer Survey 2, which was a questionnaire on the duration and frequency of the students' utilization of one-to-one devices in the classroom, the homeroom teachers' overall experience, teachers' experience utilizing ICT, experience teaching students to utilize ICT, and experience teaching students to utilize one-to-one devices.

Note that the teachers' ICT utilization experience and the experience of teaching students to utilize one-to-one device is affected by the time when the school was equipped with ICT. In addition, the experience of teaching students to utilize ICT is influenced by the grade in which they are in charge of. Therefore, teaching experience is not necessarily related to other experiences.

## 4.3 Results

Table 6 summarizes the results of Survey 2.

Table 6: Duration and frequency of students' one-to-one device utilization, and teacher experience

| | Students | | | Teachers | | | |
|---|---|---|---|---|---|---|---|
| Class | Grade | Duration of one-to-one device utilization | Frequency of one-to-one device utilization | Teacher experience (yr.) | Teachers' ICT utilization experience (yr.) | Experience of teaching students to utilize ICT (yr.) | Experience of teaching students to utilize one-to-one device (yr.) |
| A | 3 | 1 mo. | 3 hrs./day | 13 | 6 | 4 | 4 |
| B | 4 | 3 mos. | 4 hrs./day | 8 | 4 | 8 | 1 |
| C | 4 | 1 yr, 10 mos. | 1 hrs./week | 12 | 2 | 2 | 2 |
| D | 5 | 9 mos. | 2 hrs./day | 13 | 13 | 10 | 2 |
| E | 6 | 5 mos. | 4 hrs./day | 8 | 8 | 4 | 4 |
| F | 6 | 4 mos. | 3 hrs./day | 11 | 3 | 1 | 1 |
| Mean | | 8.0 mos. | 13.5 hrs./week | 10.8 | 6.0 | 4.8 | 2.3 |
| *SD* | | 7.2 | 7.0 | 2.1 | 3.7 | 3.2 | 1.2 |

The results are summarized as follows, where the *SD* values are given in parentheses). The duration of one-to-one device utilization by students was 8.0 months (7.2), the frequency of one-to-one device utilization was 13.5 hours/week (per day responses were multiplied by five for a five-day week), the number of years of teaching experience was 10.8 (2.1), and the teachers' ICT utilization experience was 6.0 (3.7) years. In addition, the number of years of experience teaching students to utilize ICT was 4.8 years (3.2), and the number of years of experience teaching one-to-one device utilization was 2.3 years (1.2).

## 4.4 Analysis of Results

The results of Survey 2 were cross-tabulated with the cloud computing knowledge scores obtained in Survey 1.

### *4.4.1 Grade*

We also conducted an ANOVA among the one-factor participants with grade as a factor for the total scores. Table 7 shows the means (*SD*) of the total scores by grade and the ANOVA results.

The analysis showed that the grade factor was significant ($F(3,141) = 5.59, p < .01, \eta 2 = 0.11$).

Table 7: Means (*SD*) of total scores by grade and ANOVA results

| | Grade | | | | *F value* |
|---|---|---|---|---|---|
| | 3rd $n = 17$ | 4th $n = 56$ | 5th $n = 21$ | 6th $n = 51$ | Grade |
| Mean (*SD*) | 2.35 (2.03) | 1.05 (1.25) | 1.52 (1.05) | 2.20 (1.92) | 5.59 ** |

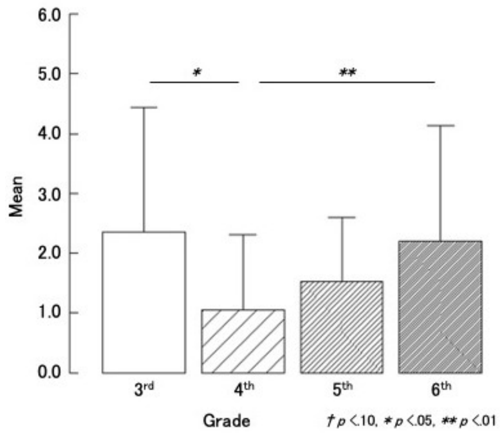


Figure 4: Mean total scores by grade

Thus, we performed an analysis of multiple comparisons using the Bonferroni method (Figure 4) and found that the mean of 2.35 for 3rd grade did not differ significantly from the mean of 2.20 for 6th grade ($t(141) = 0.35$, *ns*) and 1.52 for 5th grade ($t(141) = 1.57$, *ns*), and was significantly greater than the mean of 1.05 for 4th grade ($t(141) = 2.90$, adjusted $p < .01$). In addition, the 6th grade mean of 2.20 did not differ significantly from the 5th grade mean of 1.52 ($t(141) = 1.61$, *ns*) and was significantly greater than the 4th grade mean of 1.05 ($t(141) = 3$. Further, we found that the 5th grade mean of 1.52 did not differ significantly from the 4th grade mean of 0.95 ($t(141) = 1.14$, *ns*) or later.

### *4.4.2 Teaching Experience*

A two-factor mixed design analysis of variance was also conducted with the students in the classrooms taught by the teachers with an average of less than 10.6 years of teaching experience (short experience, $n = 64$) and an average of 11–13 years (long experience, $n = 81$) divided into two groups, i.e., long and short teacher experience placed between participants and points of view scores placed within participants. Table 8 shows the means (*SD*) of the scores by point of view and the ANOVA results for the short and long experience groups.

Table 8: Means (*SD*) of the scores by point of view and ANOVA results for the short and long teaching experience groups

| Teaching experience | | | Point of view (1) | (2) | (3) | (4) | (5) | (6) | (7) | *F value* Short and long experience | Point of view | Interaction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Short | $n = 64$ | Mean (*SD*) | 0.61 (0.63) | 0.72 (0.62) | 0.31 (0.68) | 0.09 (0.34) | 0.64 (0.65) | 0.05 (0.21) | 0.02 (0.12) | 27.52 ** | 29.49 ** | 18.26 ** |
| Long | $n = 81$ | Mean (*SD*) | 0.32 (0.47) | 0.25 (0.43) | 0.05 (0.22) | 0.23 (0.42) | 0.05 (0.22) | 0.12 (0.33) | 0.05 (0.22) | | | |

* : $p < .05$, ** : $p < .01$

This analysis revealed a significant main effect of teacher experience ($F(1,143) = 40.25, p < .01$, $\eta p^2 = 0.20$) and a significant interaction of teacher experience x points of view scores ($F(6,960) = 22.01, p < .01, \eta p^2 = 0.12$).

In addition, simple main effects tests were conducted for the interaction between teacher experience and the points of view scores that exhibited significance. Here, we used level-specific error terms to test the between-subject effects and pooled error terms for testing within-subject effects.

The results demonstrated that the simple main effect of teacher experience was significant for the following points of view: (1) ($F(1,143) = 9.91$, adjusted $p < .05$, $\eta p^2 = .07$), (2) ($F(1,143) = 28.46$, adjusted $p < .01$, $\eta p^2 = .17$), (3) ($F(1,143) = 10.55$, adjusted $p < .05$, $\eta p^2 = 0.07$), and (5) ($F(1,143) = 58.53$, adjusted $p < .01$, $\eta p^2 = 0.29$).

Thus, we found that the average scores for each teacher's classroom were as follows (Figure 5): experience short 0.61 > experience long 0.32 for point of view (1), experience short 0.72 > experience long 0.25 for point of view 2, experience short 0.31 > experience long 0.05 for point of view 3, and experience short 0.64 > experience long 0 .05 for point of view (5).

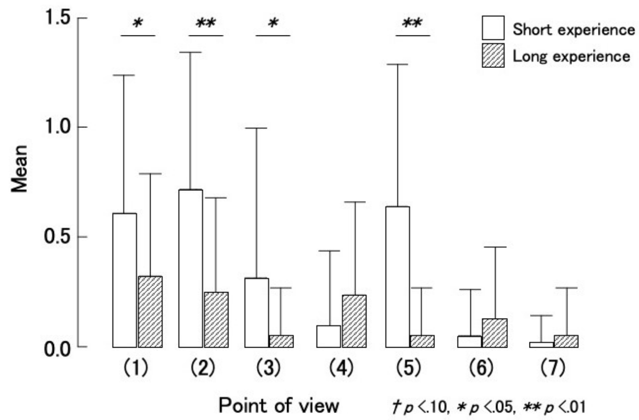


Figure 5: Mean total scores by point of view

### 4.4.3 *Teacher Experience in Teaching Students to Utilize One-to-one Devices*

Students in classrooms taught by teachers with an average of less than 2.3 years (short, $n = 95$) and an average of four years (long, $n = 50$) experience teaching students to utilize one-to-one devices were divided into two groups, and the length of experience teaching the utilization of one-to-one devices was analyzed both between and within participants. Here, a two-factor mixed design ANOVA was conducted, where the scores for each point of view were placed within the participants. Table 9 shows the means (*SD*) of the scores by point of view and the ANOVA results for both the short and long experience groups.

Table 9: Means (SD) of the scores by point of view and ANOVA results for the short and long experience groups teaching one-to-one device utilization

| Experience in teaching students to utilize one-to-one devices | | | Point of view | | | | | | | *F value* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | Long and short experience | Point of view | Interaction |
| Short | *n* = 95 | Mean (*SD*) | 0.37 (0.50) | 0.21 (0.41) | 0.01 (0.10) | 0.13 (0.33) | 0.33 (0.59) | 0.03 (0.17) | 0.02 (0.14) | 41.74 ** | 29.05 ** | 13.47 ** |
| Long | *n* = 50 | Mean (*SD*) | 0.60 (0.63) | 0.92 (0.56) | 0.46 (0.75) | 0.26 (0.48) | 0.28 (0.45) | 0.20 (0.40) | 0.06 (0.24) | | | |

* : $p < .05$, ** : $p < .01$

The results of this analysis indicated that the main effect of experience length was significant ($F(1,143) = 41.74, p < .01, \eta p^2 = 0.23$). In addition, the results show that the interaction between experience length and point of view scores was significant ($F(6,858) = 13.47, p < .01, \eta p^2 = 0.09$).

Simple main effects tests were conducted for the interaction between the experience length and the point of view scores that exhibited significance. Here, we used level-specific error terms for testing between-subject effects and pooled error terms for testing within-subject effects.

The results showed that the simple main effects of length of experience were significant for point of view (2) ($F(1,143) = 74.93$, adjusted $p < .01, \eta p^2 = 0.34$), (3) ($F(1,143) = 32.18$, adjusted $p < .01, \eta p^2 = 0.18$), and (6) ($F(1,143) = 12.19$, adjusted $p < .01, \eta p^2 = 0.08$).

Here, we observed that the average scores of each teacher's class were 0.21 < 0.92, 0.01 < 0.46, and 0.03 < 0.20 for short experience in both points (2), (3) and (6), as shown in Figure 6.

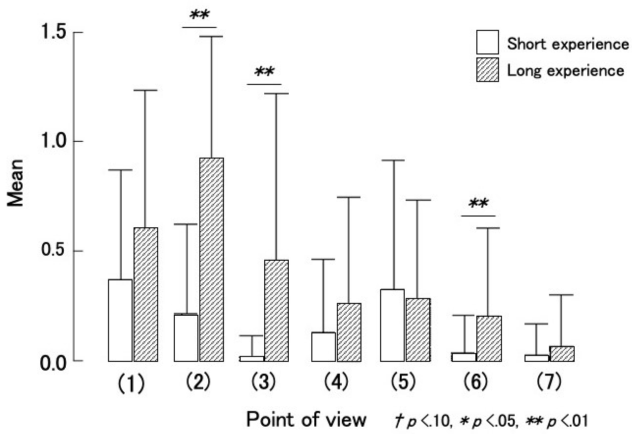


Figure 6: Means of total scores by point of view for short and long experience groups teaching one-to-one device utilization

# 5 Consideration

In this section, we discuss the practical relevance of the findings presented in this paper.

## 5.1 Consideration 1 (Survey 1)

The results of Survey 1 indicate that it is relatively easy to understand that data and applications are in involved in cloud computing and that devices communicate constantly with the cloud. In contrast, the results demonstrate that is relatively difficult to understand that data can be accessed by logging in with the same account even on a different device, that exchanges between devices are conducted through a server, that an account is required, and that the same data can be accessed even over different networks. We consider the following two points are the reasons for these.

1) With the current utilization of distributed one-to-one devices in both classroom learning and at home, students do not have the opportunity to access their data using different devices.

2) Despite the need for accounts, the fact that interactions between devices are conducted via servers and that devices that can be accessed on different networks are currently used in both classrooms and at home, students are generally unaware of the need for accounts, the intervention of servers, and that the school and home networks are different.

## 5.2 Consideration 2 (Survey 2)

From Survey 2, we found that the scores were not higher for students in upper grades, and that there were differences among the classes investigated in this study. In addition, we found that the scores of students in the classes of teachers with less teaching experience were higher. It is expected that teachers with shorter teaching experience are less resistant to the utilization of ICT, including the utilization of cloud computing technologies. In addition, students taught to utilize one-to-on devices by more experienced teachers scored higher. Here, we believe that as teachers accumulate experience in teaching students to use one-to-one devices, they accumulate cloud computing knowledge, which they then are able to teach their students. This suggests that cloud computing knowledge must be taught by teachers.

## 6 Summary

In this study, we analyzed the cloud computing knowledge of middle and upper elementary school students.

1) To determine students' knowledge acquisition status, we administered a survey on the knowledge of cloud computing and evaluated the statements.

2) To examine the guidance required by students to develop effective cloud computing knowledge, we analyze the relationships between the students' knowledge acquisition status and the utilization of one-to-one devices in their classroom relative to homeroom teachers' teaching history.

Regarding the first point, we found that the acquisition of cloud computing knowledge was generally low. In addition, the results demonstrated that there were differences among the classes, with the upper grades not necessarily having a higher level of knowledge. In terms of the content of the knowledge, it was evident that students easily understood that data and applications are in the cloud and that devices always communicate with the cloud. In contrast, it was relatively difficult to understand that an account is mandatory, the same data can be accessed even if different networks and devices are used, and that communication between devices is conducted through a server.

For the second point, the following instruction is considered necessary for students to acquire sufficient cloud computing knowledge.

From Consideration 1, we offer the following conclusions. In the GIGA school environment, the use of one-to-one devices to access the Internet should be promoted, students should utilize a variety of cloud-based applications, and the fact that data are stored in the cloud should be reinforced.

In addition, students must be made aware of the need for an account, that they can access the same data on different networks or devices, and that the exchange between devices is conducted via a server. Here, students can be made aware of these factors by introducing and demonstrating their practical advantages.

Students should be given the opportunity to sign in to their account and access their data on a device other than a one-to-one device, e.g., a personal computer in a computer lab.

The following conclusions can be derived from Consideration 2. The teacher should cover and understand points of view (1) to (7) regarding cloud computing, and then make the students aware of the take-home and other utilization of cloud computing and its advantages. In addition, teachers should implement ways to make the students understand cloud computing knowledge while connecting it with their personal experiences using one-to-one devices and activities to supplement what they cannot experience in take-home programs.

## 7 Future Tasks

The results of Survey 1 indicate that the classes have not acquired sufficient cloud computing knowledge. The highest average score for point of view (2), "Understand that data (applications) are not in the device but in the server on the network," was only 0.46. Considering that the scores for each point of view were 2 for "well understand" and 1 for "somewhat well understand," a score of 0.46 is considered insufficient.

In this study, we also wanted to determine the relationship between students' initiative in terms of one-to-one device utilization and take-home use of the one-to-one device, as well as their acquisition of cloud computing knowledge. However, the classes that exhibited initiative in terms utilization and the classes that were taking home books were the same classes. In addition, the duration and frequency of the students' utilization of the one-to-one devices and the teacher's history of teaching ICT utilization to students were all in the same group when divided in terms of long/short or high/low. Thus, it was impossible to analyze the relationship between acquisition of cloud computing knowledge and the utilization of one-to-one devices in the classroom and homeroom teachers' teaching history. To clarify this, we would like to conduct a survey covering a wider range of classes. Additionally, we would like to consider when to teach and create a reference guide.

In terms of the cloud computing knowledge, we would also like to organize the items to be understood as knowledge for each point of view based on the evaluation criteria developed in this study. References [7] and [8] proposed that cloud computing should be taught by first giving knowledge and then allowing students to gain practical experience, and we would like to continue to study the processes of cloud computing education.

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