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Practical Study of ICT Installation in a Public Elementary School in Japan

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Abstract: This paper explains the field trial of tablet installation in a public elementary school in Japan. Three applications were incorporated in the trial, including the educational SNS Edmodo, an English word learning application, and a math drill application. Evaluations were carried out based on questionnaires and from the viewpoint of the learning effect. According to the questionnaire investigation, the atmosphere, activity level, concentration, and understandability in the class improved with the installation of the tablets. Experimental results also showed significant test score improvement by heavy users of the math drill application compared to light and midrange users.

Keywords: Adaptive testing, adaptive learning, Bayesian net, tablet, iPad, Edmodo

1. Introduction

Smartphones and tablet devices are now widely used. According to Cabinet Office research in 2013, the family unit penetration rate in Japan reached 54.7% for smartphones and 20.9% for tablet devices. Looking at the educational situation in Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXST) has set a goal of reaching a 100% penetration rate among students in elementary, junior high, and high schools by 2020.

Zylka and Mueller (2014) demonstrated several checkpoints, such as pre-training of teaching staffs, for installation in the school. This research is based on practical research of tablet installation in a community school in Germany. However, actual evaluation is ongoing, and the results have not been reported yet. The United States is one of the most developed countries in the educational use of tablets. An and Aron (2013) even introduced a case study examining logistical models for iPad implementation in a New Jersey public school.

On the other hand, Japan is undeveloped, especially in public elementary education. In this research, we carried out a trial tablet installation in a public elementary school in Japan. As we stated before, there are many challenges to iPad use in an educational context; however, it is impossible to completely follow the examples due to the differences in governmental guidelines for education, constraints on the resources or institution, and other factors. The purposes of the trial were to demonstrate the practical use of tablets in a public elementary school in Japan and analyze the learning effects of tablet installation before full-scale installation in 2020. In our trial, we introduced three applications: the educational social network service (SNS) Edmodo (2015), the English word learning application eCarta (2015), and a math drill application. Edmodo was introduced as ICT literacy education for the trial. The other two applications were introduced for academic development.

In this paper, we explain the trial and show the evaluation results from the questionnaire investigations and an analysis of the learning effect. Section 2 is a summary of the trial. Sections 3 to 5 deal with Edmodo, the English word learning application, and the math drill application that incorporates an adaptive learning framework. Section 6 presents the evaluation results. Finally, section 7 concludes the paper.

2. Summary of the Trial

The trial took place at Kamo Elementary School in Fukuoka, Japan. The period of the trial was from September 2014 to March 2015. We assigned iPads to all 89 students in the fifth grade. The Edmodo

application was installed on each device. We implemented the e-Carta and math drill applications on the Edmodo platform. We carried out pre-trial, mid-trial, and post-trial questionnaire investigations with the same questions to track changes in student attitudes toward learning.

3. Educational SNS

We introduced Edmodo as an educational SNS to communicate with class members. Compared to the other SNS services, Edmodo has the following characteristics:

- ✓ Edmodo has three kinds of accounts: parent, teacher, and student. (However, parents were not involved to the trial.)
- ✓ One-to-one communication between students is not allowed on the system network.

Teachers at Kamo Elementary School used Edmodo to teach ICT literacy, such as posting and replying to messages and the importance of password and ID management. Before the trial, there had been a demand from the school to foster this kind of ICT literacy.

4. English Word Learning Application (eCarta)

eCarta is an English word learning application that was originally developed by the National Institute of Information and Communications Technology (NICT). First, the application displays cards to the learners. Each card has one picture. Second, learners listen to the pronunciation of description associated with the picture. Then, learners pick the card with the picture related to the description.

The original application is sold in the App store and is designed for independent study. We modified the application to fit the application to the class activity. The modified version synchronized the teacher's card selections to the students' displays. Additionally, the modified version worked as an application on the Edmodo platform.

5. Math Drill Application

The system has two modes: testing mode and learning mode. The testing mode measures learners' understanding of each course unit using the Expected Value of Item Network Information (EVINI) adaptive testing scheme (Ueno et al. 1994). EVINI was inspired by the Expected Value of Sample Information (EVSI) (Raiffa 1961) concept from decision theory. In the proposed system, the learning mode assigned drills from the course units individualized for each learner. Compared to the adaptive test using conventional item response theory (Birndaum 1968), this network-based adaptive testing method enabled more detailed modeling of the relationship among course units. We explain the adaptive testing framework and system configuration of the math drill application in sections 5.1 and 5.2, respectively.

5.1 Adaptive Testing

A Bayesian network (Pearl 1989) framework was used to build an inference model of the learners' understanding. The model structure and conditional probability table (CPT) were trained on preliminarily collected learner logs. Each node of the Bayesian network related to a course unit, and each node had two values—*understanding* and *not understanding*—denoted by "1" and "0" respectively.

Using the results of the answered units, the Bayesian network calculated the probability of understanding the units that had not been answered by the learner. This inference was used in the two parts of the adaptive learning system. One was to select the testing unit in the testing mode. Using the conditional probability given by the inference, the system selected the most informative units ($\hat{j}$) calculated by Eq. 1 as the next testing unit:

$$\hat{j} = \arg\max_{j \in N} EVINI_j \tag{1}$$

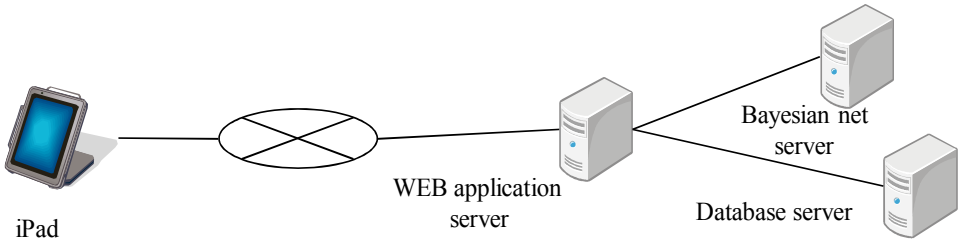

Figure 1. System configuration of math drill application.

where N stood for set of the units that had not been answered by the learner, and $EVINI_j$ was given by the following formula:

$$EVINI_j == \sum_{x_j=0,1} P(x_j) \sum_{X_l \in X_L} P(X_l \mid x_j) \log P(X_l \mid x_j) - \sum_{X_l \in X_L} P(X_l) \log P(X_l) \qquad (2)$$

where X_l was a pattern vector (understanding pattern) in a set of nodes that consisted of the j-th node and its child and parent nodes. Thus, $P(X_l)$ was the joint probability. X_L was the set of pattern vectors for the j-th node and its child and parent nodes.

The second use of the inference was to determine learner understanding of the units that had not been answered during the testing mode. Since the mode was switched by the teacher for the whole class, some students could not complete the testing mode. In that case, for each student, the system inferred the probability of understanding uncompleted units in the testing mode. In the learning mode, the uncompleted unit whose probability of understanding was over 50% would be removed from the unit.

5.2 System Configuration

The math drills for adaptive learning were made by Gakken Educational ICT. There were 43 units (105 subunits for fourth to sixth grade. We used all the units for the adaptive learning system implementation. Each subunit consisted of eight drill questions on average. For each subunit, we divided drill questions into three sets as follows:

- ✓ Model training set: We picked one question from each subunit to train the Bayesian net model. These drill questions were answered by students from Kamo Elementary School prior to the adaptive learning system implementation.
- ✓ Testing mode set: We picked another question from each subunit for use in the testing mode.
- ✓ Learning mode set: The rest of the drill questions were used for the learning mode.

In the testing mode, the results of the answer check were not shown to the learner. However, the results were shown to the learner in the learning mode. Additionally, examples of solutions were given to the learner if the learner's answers were wrong.

As described above, each node of the Bayesian network was assigned one unit. Each unit consisted of one or more subunits (2.4 subunits on average). For the model training set and testing mode set, the system regarded the unit as understood only if all drill questions from the subunits in the unit were correctly answered.

Figure 1 shows the configuration of the proposed system. The Web application server displayed HTML5 drills for both modes. In the testing mode, the system automatically set testing units for each learner. The unit selection was based on EVINI, which was computed using the learner's previous answers. To calculate EVINI, a Bayesian net server inferred the probability of understanding the units that had not been answered by the learners. For the model training and inference, we used the API from Bayonet (Motomura 2001), which is a general-purpose Bayesian net tool kit. The database server stored learners' logs of each learner's drill answers.

6. Evaluation Results

In this research, we carried out pre-trial, mid-trial, and post-trial questionnaire investigations with the same question items. The purpose of the investigations was to track the changes of student attitudes

toward learning by providing iPads to the class. Additionally, we evaluated the math drill application from the viewpoint of the learning effect.

6.1 Results of Questionnaire Investigation

Figures 2 to 5 show the pre-trial, mid-trial, and post-trial questionnaire investigations results. The questionnaire consisted of a question with four choices (strongly agree, agree, disagree, and strongly disagree) with the following questionnaire items:

- ✓ Questionnaire item 1: Is learning fun?
- ✓ Questionnaire item 2: Are you willing to join the class?
- ✓ Questionnaire item 3: Do you concentrate on learning in your class?
- ✓ Questionnaire item 4: Do you fully understand what you learned in your class?

Looking at the figures, the percentage of "agree" and "strongly agree" in the post-trial results increased compared to the pre-trial results. Although, there was a small degradation in questionnaire item 4, there was not a big difference between the mid-trial results and the post-trial results. According to the results, a positive effect was observed from the installation of iPads.

For Edmodo use, we interviewed three teachers at Kamo Elementary School. According to the interviews, one teacher often used Edmodo to share reading information, including book reports by students. The teacher used Edmodo to issue badges to students who read many books. The other observed use of Edmodo was a questionnaire survey about reading to visualize and understand the reading situation of the class. The other two teachers seldom integrated Edmodo in any class activity. As mentioned by Zylka (2014), sufficient pre-training of teaching staff was thought to be very important, and this was missing in our trial.

For eCarta, we conducted a questionnaire survey on the usability of the application. A total of 94% of students answered "good" or "fair" to the questionnaire. For eCarta, an evaluation from the viewpoint of learning effects is ongoing.

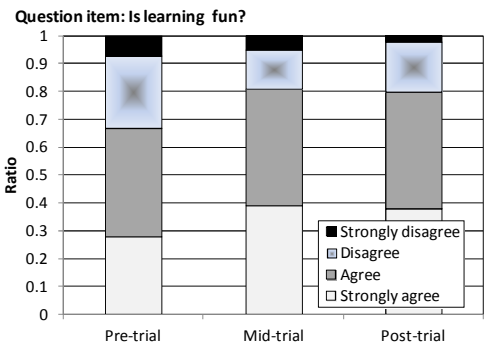

Figure 2. Results of questionnaire investigation (item 1).

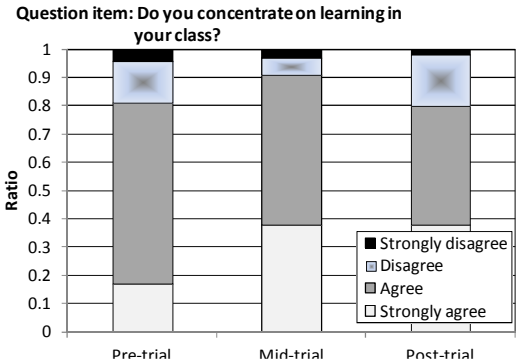

Figure 4. Results of questionnaire investigation (item 3).

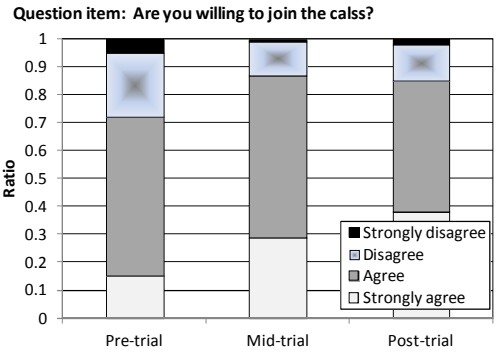

Figure 3. Results of questionnaire investigation (item 2).

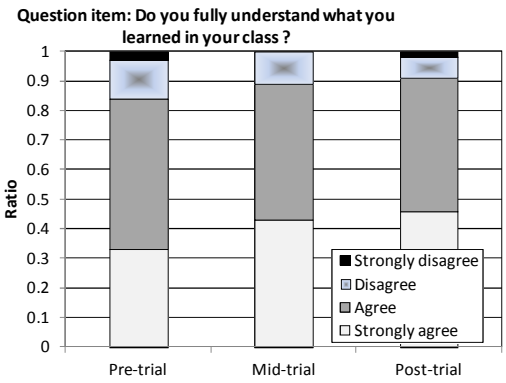

Figure 5. Results of questionnaire investigation (item 4).

6.2 Evaluation of Learning Effect

For the evaluation of the math drill application, we analyzed math test scores from the first semester (before iPad installation) and the third semester (after iPad installation). As preprocessing, we omitted student data where the scores were missing due to absences on the testing day. A total of 13 students out of 89 students were filtered out by the preprocessing. Using the available data from 76 students, we normalized the score by the following formula:

$$S_{normalized} = \frac{S_{student} - S_{standard}}{S_{full}} \tag{3}$$

where, S_{full} and $S_{student}$ denoted the full score and the score of each student, respectively. $S_{standard}$ was the standard score given by the test provider. The positive value of the normalized score meant a better score than the standard score. The absolute value meant a difference from the standard score.

For the evaluation, we divided the students into three groups based on the use of the math drill application. The statistics of the groups are shown in Table 1. As shown in the table, the average score for group II (mid-user group) was the highest, and group III (heavy user group) was the second highest in both the first and third semesters. Comparing the normalized scores between the first and third semesters, group III was the only group whose scores improved in the third semester. The scores for the other two groups declined in the third semester.

We used Welch's *t*-test as a test of the significance of the score improvements shown in Table 1. Table 2 shows the results of the *t*-test at the 5% significance level. As shown in the table, group III had significant score improvement compared to groups I and II. In other words, the score improvements of heavy users were significantly larger than these of light and mid-range users. Considering these results, we can conclude that the math drill application has an effect on improvement of academic ability. And it is also important to motivate learners to be heavy users.

Table 1: Grouping of math drill users and their statistics.

Group name	# group size	Average answerd drill questions	Average of normalized score (first semester)	Average of normalized score (third semester)	Score improvement
Group Ⅰ	25	565	−0.0048	−0.0416	−0.0368
Group Ⅱ	25	880	**0.0397**	**0.0186**	−0.0211
Group Ⅲ	**26**	**1231**	−0.0036	0.0115	**0.0015**

Table 2: Results of Welch's *t*-test (5% two-side significance level)

Group name	Group Ⅰ	Group Ⅱ
Group Ⅰ	N/A	not significant difference
Group Ⅱ	not significant difference	N/A
Group Ⅲ	significant difference	significant difference

7. Conclusions

We conducted a trial tablet installation in a public elementary school in Japan to demonstrate the use and learning effects of the tablets. In this paper, we addressed the three components of Educational SNS, English word learning application, and math drill application. We carried out a questionnaire investigation and evaluation from the viewpoint of learning effect. According to the results, the atmosphere, activity level, concentration, and understandability by the class improved with the installation of the tablets. The experimental results showed significant test score improvement by heavy users of the math drill application compared to light and midrange users.

For futures work, we will consider gamification as one way to engage light and midrange users. For Edmodo use, we must also consider pre-training of teaching staff by sharing use cases in a class activity.

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References

Edmodo (2015) https://www.edmodo.com/

eCarta(2015) https://itunes.apple.com/app/id641031088

An, H., Alon, S. (2013). iPad Implementation Models in K-12 School Environments: An Exploratory Case Study, *Proceedings of Society for Information Technology & Teacher Education International Conference 2013,* 3005-3011

Zylka, J., Mueller, W. (2014). Checkpoints for Integration of a One-to-One Tablet Configuration in a School Learning Environment, *Proceedings of the 22nd International Conference on Computers in Education ICCE 2014*, 499-504

Ueno, M. et al. (1994). Proposal of a Test Theory with Probabilistic Network. *IEICE TRANSACTIONS on Fundamentals of Electronics, Communications and Computer Sciences*, J77-A(10), 1398–1408.

Raiffa, H. and Schlaifer, R. (1961) Applied Statistical Decision Theory, M.I.T. Press.

Birndaum, A. (1968) Statistical Theories of Mental Test Scores, Addison-Wesley, 395-479.

Pearl, J. (1989) Probabilistic Reasoning in Intelligent Systems, Morgan Kaufman Publishers.

Motomura, Y. (2001) Bayesian network construction system: BAYONET. *In Proceedings of Tutorial on Bayesian Networks*, 54–58. (In Japanese)