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Educational Software Employing Group Competition Using an Interactive Electronic Whiteboard

YOKO OTSUKI
Tokyo University of Agriculture and Technology, Japan
yhoko@hands.ei.tuat.ac.jp

HIROKAZU BANDOH
Fukuoka Institute of Technology, Japan
bandou@fit.ac.jp

NAOKI KATO
Tokyo Gakugei University, Japan
naoki@bmoon.jp

BIPIN INDURKHYA, AND MASAKI NAKAGAWA
Tokyo University of Agriculture and Technology, Japan
bipin@cc.tuat.ac.jp
nakagawa@cc.tuat.ac.jp

This article presents a design of educational software employing group competition using a large interactive electronic whiteboard, and a report on its experimental use. Group competition and collaboration are useful methods to cultivate originality and communication skills. To share the same space, the same large screen, and face-to-face communication with others is very important in a group competition. By employing a large interactive electronic whiteboard, we can also introduce the benefits of IT into this environment. We have designed a group competition application, i.e., Kanji pairing software using an interactive electronic whiteboard. Through experimental use of the application at two elementary schools, we confirmed the necessity of selecting competitive elements according to the children's personalities, the teacher's leadership style, as well as the potential to motivate children to learn. Moreover, the children kept their concentration and the teacher grasped children's study processes. Therefore, we have found that an interactive electronic whiteboard and group competitive software can be effectively employed in classroom learning.

In recent years the importance of the role of computers in elementary school education is increasingly being recognized. For instance, the revised curriculum introduced in Japanese elementary schools in 1998 stated: "In each subject, the teacher should aim to make the children familiar with using computers and information networks in their study by introducing audiovisual and other necessary educational material." In order to meet this objective, computer labs are rapidly being set up in elementary schools, and teachers are also making an effort to acquire and hone their computer skills.

Many schools are making an effort to incorporate computers in the teaching of various subjects, and several software systems in the field of Computer Aided Instruction (CAI) have been developed to assist in this task. Many of these systems are drill-based or tutorial-based and show a varying ability to adapt to the student's progress (Alexandris, 1998). More recently, Computer Supported Cooperative Learning (CSCL) systems have also been proposed, which allow students to collaborate with each other in a group (Strijbos, 2001). However, little attention has been given to the role of competition in learning.

While an undue emphasis on competition may be stressful, a certain level of competition is necessary to motivate and inspire students. If the competition is between teams, it also fosters cooperation among team members and promotes improvisation. With proper supervision and guidance, the teacher can also help with the development of individual students. Therefore, the students can get a sense of achievement and feel encouraged to study further.

Introducing the computer into group competition-based teaching reduces the time needed by the teacher for preparation, which in turn allows the teacher to pay more attention to the students and to monitor their growth and development. The teacher can check the students' answers and their results can be discussed in the group to encourage the students' ideas naturally. Furthermore, schematics, animations, and other audiovisual material can be used to facilitate students' understanding, as software tools for preparing such materials are now available.

The interactive electronic whiteboard has already been introduced for classroom teaching, and has been shown to possess many advantages. The electronic whiteboard is a large whiteboard with a pen-input tablet and an eraser, which work like normal chalk and eraser. We have already developed several useful interfaces for the electronic whiteboard [IFIP] (Nakagawa, Oguni, & Yoshino, 1997, Nakagawa, Hotta, Bandou, Oguni, Kato, & Sawada, 1999). More recently, we have been working on incorporating the electronic whiteboard into classroom teaching to integrate the advantages of traditional classroom teaching and those of using the computers in the classroom [ACM SIGCHI] (Sakurada, Bandoh, & Nakagawa,1999, Bandoh, Nemoto, Sawada, Indurkhya, & Nakagwa, 2000, Otsuki, Bandoh, Kato, & Nakagawa, 2001).

In this study we focus on developing competition-based study environment using the electronic whiteboard in a classroom. We believe that the use of an electronic whiteboard fosters teamwork and face-to-face communication.

Towards this goal, we present the design of competition-based educational software for learning kanji pairs. We also demonstrate the potential of the software by showing how it allows the competitive elements to be adjusted depending on the personality of the students in a class, and how it assists the teacher in directing the flow of teaching. Further, we studied the effectiveness of the software in monitoring the learning progress of the students in their abilities to improvise and cooperate.

DESIGN OF EDUCATIONAL SOFTWARE BASED ON GROUP COMPETITION

There are two approaches to incorporating group competition in educational software. One approach is result-oriented and the other is procedure-oriented. We feel that for educational software aimed at elementary schools, a procedure-oriented approach, where the procedure accompanies the result, is necessary. Thus the teacher should focus on how the students approach, think, and cooperate in their studies. In order to do that, the teacher has to know the correct procedure for studying each subject so that the teacher can provide clear directions to the students.

In designing our system, the following issues are considered to be central:

- To have an environment that facilitates group members working together and improvising.
- To have an environment that gives the teacher feedback about the methods used by the students in solving problems.

Since our system is designed for classroom use, the following issues are also given consideration.

- The teacher should be able to run the class easily without needing extra preparation.
- The students should be able to apply their learning experiences to later studies.

Competitive Element

Each class has different characteristics as each class is composed of students with different personalities. An effective teacher must adapt an atmosphere and teaching techniques to the characteristics of the individual class.

In particular, it is important to adjust the level of competition in a group competition-based educational technique. For example, in a class with a wide range of student abilities, only highly able students may be strongly motivated. This may limit other students' participation when the software is such that the clearly identifed winner is. On the other hand, in a class where all the students are roughly at the same level, this same feature in the software may motivate the students to plan a winning strategy. This remark applies not only to the students' ability to study but also to their ability to

cooperate, ability to think positively, and so on.

In designing our system, we deemed the following set of competitive elements that could be set depending on the characteristics of an individual class:

- Displaying the winner
- Displaying points earned in the game
- Awarding points to the team that answered first
- Limiting the length of the game to a specified time or the number of correct answers

Choice of Study Material

We considered two ways to choose the subject material for this group competition-based educational software. One approach is to delegate this task to the software. Such an approach, where the software plays the role of the teacher, may be useful for individual study software. The other approach, which is useful in a classroom setting, is to have the teacher choose the material appropriate for each study session. We follow this latter approach in our design because our system is aimed at being used in a classroom. In other words, our design is based on the assumption that the software is just a tool to help the teacher in running the classroom, and all the responsibilities of choosing appropriate teaching materials are delegated to the teacher.

Displaying Incorrect Answers

An effective classroom teacher is always conscious of the level of students' understanding. For this, it is important for the teacher to not only make the students solve problems but also to explain their ways of thinking in solving the problem. The wrong answers are often very helpful, for they point to mistakes in methodology. Based on this information, the teacher can adjust the focus of their teaching to correct the students' misconceptions. The students can master this concept and then proceed to the next step. If the teacher skips wrong answers, the supporting software becomes a mere tool to measure achievement levels. Therefore, to increase the level of educational effectiveness, we have designed our software so that it displays not only the correct answer but also incorrect answers so that the teacher can make use of this information.

Handwriting-based Input

Keyboards are often used as an input device for personal computers. A keyboard allows a trained person to enter data rapidly. However, for Japanese kanji characters, an over-dependence on the keyboard reduces one's ability to write the kanji characters even though the same pupil can read them. In particular, in the elementary school curriculum, where writing kanji is emphasized to a great degree, using a keyboard is very counterproductive. The ele-

mentary school children are also not familiar with inputting kanji characters using Roman characters, which is necessary when using a keyboard. Moreover, typing with a keyboard is difficult for children – it forces their attention away from the subject being studied and may even stifle creativity. For all these reasons, our system uses a pen-based input method that allows students to input kanji characters naturally as if they were writing it on a piece of paper.

Using an Electronic Whiteboard

The normal display of a personal computer is too small to be shared among all the students in a classroom or for working together. A network connection is one way to share information among the members of a group, but working in a network setting precludes face-to-face communication. Thus, a sense of physical presence and face-to-face contact normally encountered during teamwork are lacking when working with a network. Moreover, the teacher does not get visual feedback from the students, which prevents him or her from adjusting the teaching pace appropriately.

For this reason, our system is designed to work with an electronic whiteboard having a large display so that the students can share the same working space in a classroom (Figure 1). We believe that the large display electronic whiteboard has the following advantages:

- It generates a sense of team spirit that promotes cooperation and improvisation.
- Direct oral and visual communication in close proximity facilitates sharing of knowledge and information.

Figure 1. Using electronic whiteboards in a classroom

- The status of the opposing team can be observed, which may encourage team members to improve their strategy.
- Other children who are not participating in the competition can also watch the status of the game, therefore, it increases the tension which may aid in the learning process.
- The teacher can observe what the students are doing and can give them proper instructions and feedback.

IMPLEMENTATION OF A COMPETITION-BASED EDUCATION SUPPORT SYSTEM

Hardware Structure

We considered two approaches in designing a hardware structure that allows access by multiple users necessary for a competition-based software, namely, to allow simultaneous access or to allow sequential access. We chose to follow the simultaneous access approach for our design because it is faster and hence more effective given the limited time available for each class. However, this requires that the hardware must support multiple user access for working out the answers, writing the correct answer, etc. Another problem that must be addressed concerns the display area, which is smaller on an electronic whiteboard than a traditional blackboard.

In our approach, in order to create a large work area, multiple electronic whiteboards are connected to a single personal computer that acts as a driver and provides access to the software (Otsuki, Bandoh, Kato, & Nakagawa, 2001). Although a conventional way of connecting multiple electrical whiteboards to a single personal computer does not allow it, we implemented a special driver that

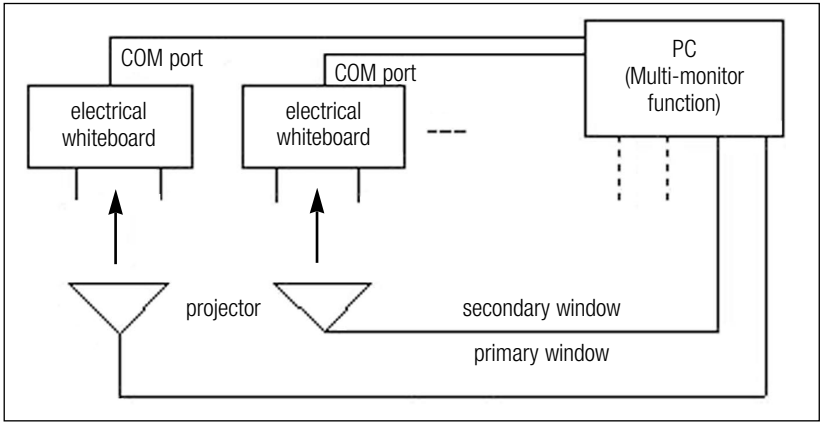

Figure 2. Hardware configuration (employing the front projection type)

allows simultaneous accesses to the multiple electronic whiteboards. Furthermore, the display area is expandable by using the Windows multi-monitor function.

Figure 2 shows the schematic of a projector type electronic whiteboard that is composed of two electronic whiteboards. It is also possible to use back-projection type electronic whiteboards.

Kanji-pairing Software

The kanji-pairing software is implemented to illustrate competition-based education software usable with multiple electronic whiteboards. The software is designed to emulate a classroom teaching activity in which the students make meaningful pairs of kanji characters starting with a kanji character suggested by the teacher. The screen for the kanji-pairing software is shown in Figure 3 and Table 1 shows the functions realized with this prototype of educational software based on group competition.

Prior to using this software, the teacher sets parameters that determine the level of competitiveness suitable for a certain group of students. The teacher also determines the kanji characters that are to be studied in class, and can

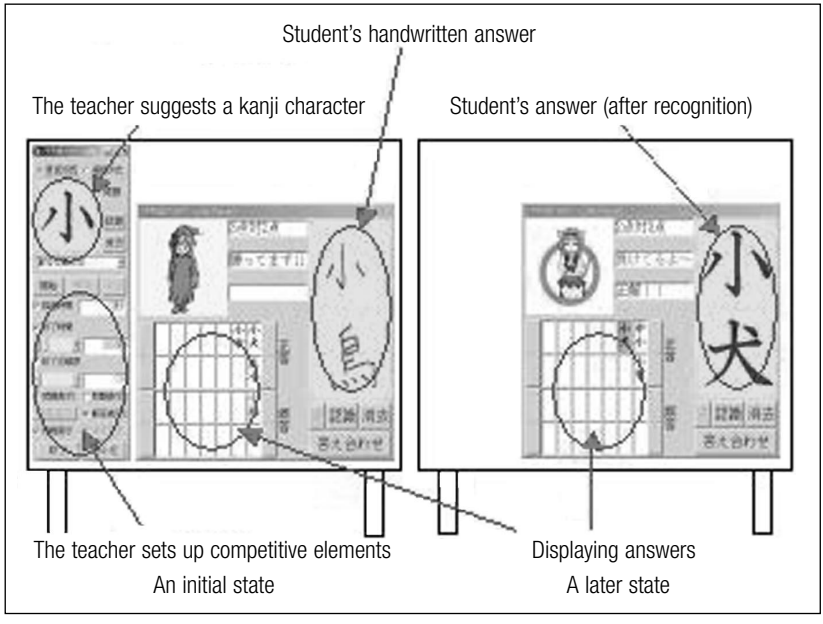

Figure 3. Screen displays of the electronic whiteboard for Kanji-pairing software

place restrictions on the order in which they will be used in the game.

The game starts when the teacher suggests one kanji character that must be used in the pairing game. Each group thinks up a meaningful kanji pair that starts or ends with the suggested kanji and writes it with an electric pen, which is recognized by a frame-based character recognition system. The software checks the answers in real time, and displays the correct and the wrong answers separately. If more than one group gives the same correct answer, the order in which the answer is given is indicated by the color of the font.

The work of the teacher is considerably reduced as the computer handles the checking of answers and the evaluation of students' performance. The teacher can suggest kanji characters on which he or she would like the students to focus. This allows the teacher to organize the teaching material and also allows students to participate freely. The computer can also check unexpected or rare kanji pairs by referring to its electronic dictionary.

Table 1
Functions Realized by the Prototype of Kanji-pairing Software Based on Group Competition

Design of educational software	**The function realized with the prototype (Kanji-pairing software)**
Competitive element	The teacher can set parameters that determine of competitiveness suitable. • Displaying the winner • Displaying the points earned in the game • Awarding points to the team that answered first • Limiting the length of the game according to the time or the number of correct answers
Choice of study material	The teacher can suggest one kanji character.
Displaying incorrect answers	The software can display the correct and the wrong answers separately. • If more than one group gives the same correct answer, the order in which the answer is given is displayed by the color of the font.
Handwriting-based Input	The software use of the electronic pens and frame-based character recognition system.
Using an electronic whiteboard	The software use of the multiple electronic whiteboards

TRIAL IN ELEMENTARY SCHOOLS

In order to evaluate the efficacy of the kanji-pairing game and the multiple electronic whiteboards, we used the prototype in actual classrooms. Two elementary schools participated in this study and we report here on this experience including the comments of the teachers.

Sakurai Elementary School

The fifth grade class of the Sakurai Elementary School at Koshigaya City participated in this study. The kanji-pairing software was used with one section of the class containing 36 students and one teacher. The students were divided into six groups of six each, and the kanji-pairing game was played between pairs of teams three times.

The students were allowed to use the textbook and the dictionary. The teacher also advised students on strategies to work together in a group effectively, and their desks were rearranged to facilitate discussion among group members. After the game, the teacher explained not only the meaning of the kanji pairs produced during the game, but also gave their synonyms and antonyms. Sometimes the teacher also asked the students for the meaning of a kanji character.

The teacher felt that the students of this class were rather good in cooperating together and, moreover, this spirit of cooperation needs to be encouraged further as it increases the students' social and communication as well as their understanding of each other. For this reason, the teacher decided that putting an undue emphasis on competitive aspect of the game would run the risk of destroying the group harmony, and so the score was not displayed and answers given late were also counted in the score. The teacher determined the winner by evaluating the degree of cooperation and creativity within each group. Each game was limited to five minutes.

After the game, the students were asked to answer a questionnaire. Figure 4 shows the contents of the questionnaire and summary of the students' answers.

The teacher made the following five positive remarks after the game:

- The class was taught more or less as originally planned and the learning of kanji-pair words was effectively accomplished.
- It seems to increase the students' motivation.
- It seems to increase the cooperation among the students.
- The competitive element in the game fits the characteristic of the class.
- Everyone in the class could participate due to the large size of the electronic whiteboard.

There were no negative remarks.

The students made the following remarks:

- The game-like setup makes it fun to learn kanji-pairs and we want to play more and more.
- We want to learn more kanji-pairs.
- The teamwork in the group during the competition was lots of fun.

Koganei City Dai-ichi Elementary School

The fifth grade class of Dai-ichi Elementary School at Koganei City also participated in this study. The software was used for a class consisting of one teacher and 28 students. The students were divided into six groups, and the kanji-pairing game was played by pairs of groups three times.

Before starting the game, the teacher explained the composition of each kanji character and made sure that the students understood its meaning. The teacher did not allow the students to use a dictionary or notes etc., so the students had to rely on their memory of what they had learnt during the game. The desks were rearranged so that all the students could watch how the game was proceeding. After all the games were over, the teacher classified and explained the meanings of the pairs of kanji characters that were generated during the game, and also other kanji pairs that did not appear in the games. Finally, the teacher asked the students to write down all the kanji pairs in their notebooks to consolidate their learning.

The teacher of this class felt that all the students have similar academic aptitude, and they are quite mature so if the game were set up in a competitive style, it might be more stimulating for them. So for this group the time of each game was limited to five minutes, after which the score and the winner were displayed. Late answers were not accepted as valid. The teacher and the students discussed the results of the game and finalized the evaluation. Afterwards the students were asked to fill out the same questionnaire shown with a summary of students' answers in Figure 4.

The teacher made the following two positive remarks and a negative remark:

- The class was run as usual using the material originally intended by the teacher.
- Due to the time limit, the students sometimes wrote kanji characters in a wrong order or incorrectly.
- The competitive element seems suitable for this class. However, the final score should be adjustable to reflect any special circumstances.

The students made the following remarks:

- Pairing of kanji characters seemed easier than we first thought.
- We were able to understand well the composition and the meaning of kanji characters.

- It was very relaxing to learn while having fun and laughing.
- Unfortunately, many answers occurred to us after the game was over.
- It was fun watching the other games also.

The second remark above also pertains to another software package that the teacher used to explain the composition and the meaning of kanji characters. Our experience suggests that this software incorporating the electronic whiteboard is an effective learning tool to support classroom teaching compared to traditional blackboards and text-based teaching materials.

Q1. Did you regard this lesson as pleasant?		
A. Very pleasant	**86%**	*79%*
B. Pleasant	**14%**	*21%*
C. Not so pleasant	**0%**	*0%*
D. Not pleasant at all	**0%**	*0%*
Q2. Did this make you interested in pairs of kanji characters?		
A. Became very interested	**45%**	*36%*
B. Became somewhat interested	**47%**	*57%*
C. Not interested so much	**8%**	*7%*
D. Not interested at all	**0%**	*0%*
Q3. Will you review this lesson at home?		
A. Will surely review	**3%**	*0%*
B. Will probably review	**72%**	*50%*
C. Will probably not review	**22%**	*32%*
D. Will not review at all	**3%**	*18%*
Q4. Did you cooperate with other members of your group?		
A. Cooperated very much	**50%**	*21%*
B. Cooperated some	**39%**	*68%*
C. Did not cooperate so much	**11%**	*11%*
D. Did not cooperate at all	**0%**	0%
Q5. Do you want to participate in such lesson from now on?		
A. Want to participate very much.	**81%**	*79%*
B. Want to participate	**19%**	*21%*
C. Do not want to so much	**0%**	*0%*
D. Do not want to at all.	**0%**	*0%*

Bold face = the Sakurai elementary school
Italics = the Koganei Dai-ichi elementary school

Figure 4. Questionnaire and results

DISCUSSION

The comments from the teachers indicate that the kanji-pairing software can be used in a traditional classroom using the material that the teacher has already prepared for traditional teaching. In other words, little extra preparation is required from the teacher. The software also facilitates a competitive element by allowing simultaneous inputs from the competing teams, checking the answers for correctness and displaying them, keeping the scores, and so on. The teachers also felt that the pairing of teams in the game improved students' cooperation within each team. Moreover, the game setting made it fun and increased the students' motivation to learn kanji pairs.

These conclusions are further supported by the students' comments. About 90% of the students responded that they were able to work together effectively with other members of their team, and that the game increased their motivation to learn kanji pairs. Many students commented that the game helped them to overcome the impression that learning kanji characters is difficult. Most students answered that the game was fun and they would like to play again. Our experience also showed that the teamwork and being allowed to use a dictionary and other material help the students to overcome their natural reluctance and shyness and improves their face-to-face communication abilities amongst themselves and with the teacher.

In comparing the results of the two experiments, it can be seen that the students at the Sakurai Elementary School rated the software better than the students at the Koganei Dai-ichi Elementary School. We feel that it shows that the competitive element was set more appropriately for the classroom at the Sakurai Elementary School. In the Koganei school set up, the time limit and the way of resolving ties when both the teams answered at about the same time seemed to be constraining factors. Nonetheless, in both cases, using the large display size made it possible for the teacher to keep track of the entire game proceedings, and they offered appropriate encouragement to the losing team by emphasizing the experience of the game rather than the result. Thus, it seems that it is useful and may even be necessary to adjust the competitive element of the game to adapt to the individual group of students. In this respect, the software system on the electronic whiteboard seems quite effective as it allows adjustments to the game procedure as needed.

Moreover, our experience showed that even students who were not playing the game participated indirectly by contributing to the strategy, which was possible because of the large display area of the electronic whiteboard. To conclude, our experiences show that the electronic whiteboard is an effective tool for running educational software that increases the students' motivation in the classroom.

CONCLUSIONS

We focused on group competition in this study and have shown how to design educational software that exploits children's inherent competitive spirit. The kanji pairing game is one such software, the efficacy of which was demonstrated in this study. In particular, we demonstrated the usefulness of incorporating a function that allows competitive factors to be adjusted to suit the characteristics of the subject and the nature of students. Further, we showed that the electronic whiteboard is effective for classroom teaching and allows the use of educational software incorporating competitive and cooperative strategies. Such software has the potential to increase students' motivation and foster creativity.

In future research, we are designing and implementing other educational software based on a competitive strategy running on the electronic whiteboard, and we plan to evaluate them in actual classrooms.

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