CarettaKids: A System for Supporting Childrens' Face-to-Face Collaborative Learning by Integrating Personal and Shared Spaces

Akiko Deguchi
Graduate School of Cultural Studies and Human Science
Kobe University
3-11 Tsurukabuto, Nada-ku, Kobe, Hyogo 657-8501 Japan
deguchia@kobe-u.ac.jp

Etsuji Yamaguchi
Faculty of Education and Culture
University of Miyazaki
1-1 Gakuen-Kibanadai-Nishi,Miyazaki
889-2192 Japan
etuji@cc.miyazaki-u.ac.jp

Shigenori Inagaki
Faculty of Human Development
Kobe University
3-11 Tsurukabuto, Nada-ku, Kobe, Hyogo 657-8501 Japan
inagakis@kobe-u.ac.jp

Masanori Sugimoto
Department of Frontier Informatics
Graduate School of Frontier Sciences, University of Tokyo
5-1-5 Kashiwanoha, Kashiwa, Chiba
277-8561 Japan
sugi@itl.t.u-tokyo.ac.jp

Fusako Kusunoki
Department of Information Design
Faculty of Art and Design
Tama Art University
2-1723 Yarimizu, Hachioji, Tokyo, 192-0394, Japan
kusunoki@tamabi.ac.jp

Sanae Tachibana
Sumiyoshi Elementary School
Attached to Faculty of Human Development, Kobe University
5-11-1 Sumiyoshi-Yamate, Higashinada-ku, Kobe, Hyogo
658-0063 Japan
CZS14613@nifty.ne.jp

Tomokazu Yamamoto
Sumiyoshi Elementary School
Attached to Faculty of Human Development, Kobe University
5-11-1 Sumiyoshi-Yamate, Higashinada-ku, Kobe, Hyogo
658-0063 Japan
tyamamoto@fsm.h.kobe-u.ac.jp

Takao Seki
Faculty of Human Development
Kobe University
3-11 Tsurukabuto, Nada-ku, Kobe, Hyogo 657-8501 Japan
0200546d@y02.kobe-u.ac.jp

Yuichiro Takeuchi
Department of Frontier Informatics
Graduate School of Frontier Sciences, University of Tokyo
5-1-5 Kashiwanoha, Kashiwa, Chiba
277-8561 Japan
takeuchi@itl.k.u-tokyo.ac.jp

ABSTRACT
We developed a new system called *CarettaKids* that supports face-to-face collaborative learning by children. *CarettaKids* uses a sensing board based on the Radio Frequency Identification (RFID) technology to support collaboration in a shared space, and the Personal Digital Assistant (PDA) device to support activity in personal spaces. We also introduced this system into an actual classroom environment to evaluate its performance in support for children's collaborative learning, by analyzing the childrens' interaction. As a result, we have confirmed that *CarettaKids*'s feature of transition between two spaces, makes it possible for children to reflect on problems detected in the shared space so as to find solutions in their respective personal space, and to engage in an active exchange of opinions in the shared space, based on ideas generated from personal-space learning.

IDC '06, June 7-9, 2006 Tampere, Finland

Keywords
Personal and shared spaces, Face-to-Face collaboration, PDA, RFID, Interaction analysis

ACM Classification Keywords
H.5.1[Multimedia Information Systems]: Artificial, augmented, and virtual realities, H.5.2[User Interfaces]: Interaction styles, K.3.1[Computer Uses in Education]: Collaborative learning.

INTRODUCTION
In school and elsewhere, children learn not only individually but also collaboratively in interaction with other children. In some research domains including Computer Support for Collaborative Learning (CSCL), various technologies

have been developed to support children's interaction in collaborative learning.

Many of such technologies support interaction between children who are in separate locales or in a remote situation. In the ordinary school environment, however, children usually learn in interaction with each other while in one locale or in a face-to-face situation. In view of this, developing technologies to support children's interaction of this kind seems an important research subject[1][3].

In the study presented here, we developed and examined a new system called *CarettaKids* that supports face-to-face collaborative learning by integrating personal and shared spaces while assuring children's individual learning in separate spaces. The new system was introduced into an elementary science class, so as to evaluate its performance in actual classroom environment.

INTEGRATION OF SHARED AND PERSONAL SPACES

CarettaKids uses a sensing board based on the Radio Frequency Identification (RFID) technology to support collaboration in a shared space, and the Personal Digital Assistant (PDA) device to support activity in personal spaces [5] [6].

Fig. 1 outlines the *CarettaKids*, comprising a sensing board, PDAs, an LCD projector and a PC server. The sensing board supports learning in a shared space[4]. Input devices include physical objects to be placed on the sensing board. The PC server conducts simulation according to information input via these devices. Simulation results calculated by the PC server are superimposed on the physical objects via the LCD projector.

The PDA supports learning in the personal space. Using a stylus, each user can move, on his or her PDA, icons corresponding to physical objects on the sensing board, thus realizing the same simulation as on the sensing board. Inputs on the PDA are transmitted to the PC server on a wireless LAN. Simulation results are in turn transmitted to the PDAs via the LAN and appear on the PDA screens. The shared space on the sensing board is linked with the personal spaces on the PDAs via the wireless LAN and RFID technology, allowing users to move seamlessly between the two spaces.

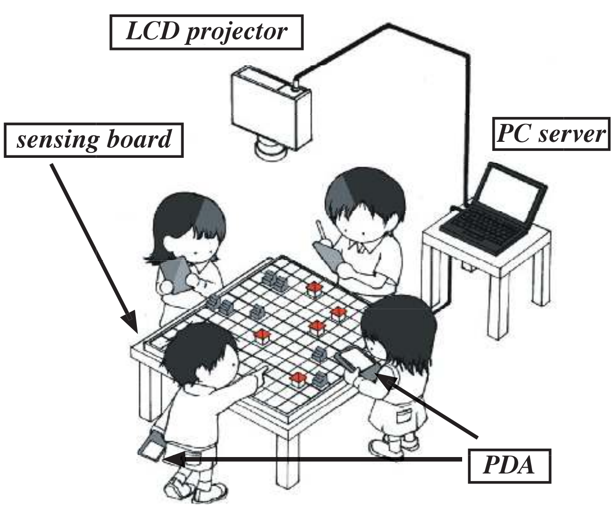

Figure 1. Overview of *CarettaKids*

Fig. 2 shows the shared space in *CarettaKids*, the simulation using our system involves designing a city while taking into consideration trade-off between environmental and economic merits. Physical objects to be placed on the sensing boards represent trees, factories and houses. When these three types of objects are arranged on the sensing board, parameters concerning carbon dioxide and financial assets change according to their arrangements, with simulation results appearing on the squares and on the left end of the sensing board.

Fig. 3 shows the personal space in *CarettaKids*, on the PDA screen, a 1/6 grid identical to the one on the sensing board is displayed along with the types and numbers of objects currently placed on the board and the living comfort and financial assets indices. The user can carry out the same simulation on his or her PDA as in the shared space.

The user can also copy object arrangements on the sensing board onto his or her respective PDA. By clicking the

Figure2. Shared space in *CarettaKids*

Figure3. Personal space in *CarettaKids*

"Load" button with the stylus while bringing the PDA close to a given area on the sensing board.The user can also copy his or her object arrangements and simulation results displayed on the PDA onto the sensing board by clicking the "Proposal" button on the PDA.

EXPERIMENT AT SCHOOL

Our experiment was carried out in a sixth-grade(11/12-year-old children) class (33 students in total) in an elementary school in Japan. The class was divided into six groups each comprising five or six children. Each group was provided with one set of the system. For all the children, it was the first time to use the system.

The experiment was conducted as part of the regular curriculum of scientific education, covering one 45-minute lesson and two 90-minute lessons. In the regular curriculum of scientific education for the sixth grade in the Japanese elementary school, students are expected to learn that water and air (oxygen and carbon dioxide) circulate in the environment, and that animals including human beings and plants are situated in this circulatory cycle. The simulation therefore constituted experimental learning of the circulation of air in the environment.

INTERACTION ANALYSIS OF COLLABORATIVE LEARNING

In the present study, to approach the actual system utilization by children, Interaction Analysis was employed[2]. Interactions of one of the six groups were analyzed. The group consisted of six members: three boys and three girls.

To obtain analysis data, the group's verbal actions and system operations on the sensing board and the PDA were videorecorded. The recorded data were then transcribed into a written script, which was adopted as analysis data.

The analysis took into account the fact that the objective of the system was integration of shared and personal spaces, and that of the classroom experiment, verification of the system's technical effectiveness. In the present paper, therefore, we particularly focus on which the PDAs and the sensing boards were used in parallel, simultaneously and in an improvisatory manner, integrating the shared and personal spaces and most clearly accentuating the characteristics of the system. The two episodes are presented below to illustrate how the system actually supported the children's learning in the two different spaces, respectively.

Episode #1: Problem solving by moving from the shared space to the personal space

In episode #1, Child A4 solves a problem by moving from the shared space to the personal space.

Episode #1

01A1: Trees you don't need, I mean… surplus trees, you should delete them.

02A4: (operating the PDA) But you'd better not overdo it …… I mean, you can delete surplus trees, but if you delete too many, the financial situation goes down, like I did a little while ago.

03A1: Surplus …

04A4: (Looking all over at the sensing board)

05A4: (Copying an object arrangement on the sensing board onto the PDA)

06A4: (Operating the PDA)

(Omission)

07A4: (operating the PDA and pointing at the sensing board) Hey, perhaps I could improve by reducing trees here.

First, A4 develops the idea generated by Child A1 into another in her personal space, that is, surplus trees must be deleted, but doing so excessively can worsen the city's financial situation (02A4). Later, looking all over at the sensing board (04A4), she copies the object arrangement of an area onto her PDA (05A4). Then, while operating the PDA (06A4), she succeeds in increasing the financial asset index by removing certain trees (07A4). This is to say, Child A4 "takes home" the problematic object arrangement in the shared space to her PDA in an attempt to solve the problem by applying the idea she has generated in her personal space. For A4's individual problem-solving, the system's feature of seamless moves between the shared and personal spaces proved highly effective.

Episode #2: Discussion by moving from the personal space to the shared space

In episode #2, the transfer of the idea generated by Child A3 in his personal space to the shared space triggers a spirited discussion in the group.

Episode #2

01A3: (projecting the object arrangement and simulation results on the PDA onto the sensing board) The rule I've found is, uh … like A4 said something about making a mistake earlier … you know, she said placing trees around a cluster of houses didn't work, and so I tried it the other way around, I mean, I surround trees with houses, and then it went well, you know, it worked, like just now I got 36 and 30, and even 40 and 45, I went that far …

02A2 – A6: (listening to A3 while looking at the sensing board)

03A1: (pointing at objects outside the sensing board) Ah, you mean, like these?

04A3: Yeah, yeah.

05A1: Like these?
06A3: Yeah, where you have these (as if to encircle some objects on the sensing board with the hands), you place houses like this, and you do like this, then, it works, I mean …
07A1: OK, but you must put another house here and two trees here, and then this way you end up using a lot of trees.
08A2: No, no, not necessarily. For example (picking up an object from the sensing board), here you've got one of them, and so you can arrange them in a cross, put trees here and there …
09A1: (Nodding in approval) Aha …
10A3: Oh, wait, that didn't work when I tried …

At first, A3 projects the object arrangement and simulation results on his PDA onto the sensing board and explains the rule he has identified to the other children. The other children listen to him, examining the sensing board (02A2 – A6) all over. When A3 finishes his explanation, Child A1 checks it, pointing at objects placed outside the sensing board, which A3 confirms (04A3). (A3 used the objects placed outside the board to explain his rule to the others.)

At this point, A1 detects a problem with A3's rule: the object arrangement according to this rule results in a large number of tree-objects placed on the board (07A1), which causes the financial asset index to drop. Therefore, A1 argues, A3's rule is problematic.

In response to this, Child A2 proposes an alternative solution: another object arrangement following A3's rule but without using as many trees (08A2). A1, who pointed out the problem of A3's idea at first, agrees on the second solution (09A1).

However, A3, who proposed the new rule in the first place, is opposed to it. He says that he already checked A2's alternative solution in his personal space and that it did not succeed in building the target city (10A3).

In this manner, Child A3's idea resulted in an active exchange of different opinions among the children. For this kind of exchange to emerge, ideas generated in personal-space learning must be smoothly transferred to the shared space for all the children to examine them together, where learning must resume immediately, with physical objects placed there. It can be said that our system's features contributed to realizing just that.

CONCLUSIONS AND FUTURE WORK

In the present study, using the PDA and RFID technologies, we developed a system called *CarettaKids*, that integrates personal and shared spaces to support face-to-face collaborative learning by children. We also introduced *CarettaKids* into an actual classroom environment to evaluate its performance in support for children's collaborative learning, by analyzing the childrens' interaction.

As a result, we have confirmed that *CarettaKids*'s feature of copying object arrangements on the sensing board onto the PDA, thereby realizing smooth moves from the shared space to the personal spaces, allows children to reflect, in their respective personal space, on problems detected in the shared space so as to find solutions.

Likewise, the *CarettaKids*'s support for moving from the personal to shared spaces, that is, the projection of object arrangements and simulation results on the PDA onto the sensing board, makes it possible for children to engage in an active exchange of opinions in the shared space, based on ideas generated from personal-space learning.

In the classroom experiment of the present study, videorecorded data of the children's verbal actions and system operations, log data saved in the PC server, and the results of the children's subjective evaluation of *CarettaKids* utilization were collected. Further analyses of these data for a more comprehensive evaluation of *CarettaKids* would be one of our future research themes.

ACKNOWLEDGEMENT

This research project has been supported by Grant-in-Aid for Scientific Research (B) from Japan Society for the Promotion of Science.

REFERENCES

1. Druin, A., Stewart, J., Proft, D., Bederson, B., and Hollan, J. KidPad: A Design Collaboration between Children, Technologists, and Educators. In *Proceedings of CHI' 97* (Atlanta, GA, April, 1997), 463-470.
2. Jordan, B., and Henderson, B. Interaction Analysis: Foundations and practice. *The Journal of the Learning Sciences*, 4(1), 39-103, 1995.
3. Stewart, B., Bederson, B., and Druin, A. Single Display Groupware: A Model for Co-present Collaboration. In *Proceedings of CHI'99* (Pittsburgh, PA, April, 1999), ACM Press, 286-293.
4. Sugimoto, M., Kusunoki, F., and Hashizume, H. E^2board: An Electronically Enhanced Board for Games and Group Activity Support. In *Proceedings of the International Conference on Affective Human Factors Design* (Singapore, June, 2001), 238-245.
5. Sugimoto, M., Hosoi,K., Hashizume, H. Caretta: A System for Supporting Face-to-Face Collaboration by Integrating Personal and Shared Spaces. In *Proceedings of ACM CHI2004* (Vienna, Austria, April, 2004), ACM Press, 41-48.
6. Sugimoto, M., Kusunoki, F., Inagaki, S., Yamaguchi, E.: Enhancing Externalization and Reflection by Integrating Personal and Shared Workspaces. In *Proceedings of 9th European Conference on Computer Supported Cooperative Work* (ECSCW2005) (Paris, France, September, 2005), 117-119.