

Exploiting Bodily Movement to Regulate Collaborative Learning by Designing a Tablet-Based CSCL System

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Abstract. This paper describes the design of XingBoard (Crossing Board) system from the viewpoint of bodily control of interaction. XingBoard is a tablet-based tool that supports a bi-directional transition between personal and collective activities in collaborative learning process. For this purpose, this system provides a shared space for discussion comprised of multiple, connected tablet terminals and allows users to move post-it like cards from one terminal to another. In addition, the system can copy cards from a shared space to each learner's tablet for individual work, which consists of reflection on or revision of the results of the group discussion. To evaluate the system from an interaction perspective, we record scenes where a group of 4 subjects use XingBoard. As a result of interaction analysis, it turns out that XB, by its tangible nature, supports collaborative work by enabling learners to use their bodily movements as interaction re-source.

Keywords: CSCL system · Tablet terminals · Personal-collective activity transition · Tangible interface · Bodily movement · Interaction analysis

1 Introduction

This paper describes the design of XingBoard (Crossing Board) system from the viewpoint of bodily control of interaction. XingBoard is a tablet-based tool that supports a bi-directional transition between personal and collective activities in collaborative learning process. Design of XB system takes advantage of the tangible nature of a tablet terminal in order to support learners to regulate collaborative activity through their bodily movement. This paper is divided into three parts. Firstly, educational context of the XB system is discussed. In that part, the significance of transition between personal and collective activity in a collaborative learning session will be shown. Secondly, the concept and functions of XB system, which is a tablet-terminal based CSCL system

designed for supporting transition between personal and collective activity, is described. Finally, the authors discuss how this system takes advantage of the tangible nature of a tablet terminal in order to regulate collaborative activity with enabling learners to exploit their bodily movements to control and organize collaboration.

2 Educational Background

It is very common to design a collaborative learning session in the way that it starts from a personal activity and then to proceed to group activity. In the group activity, learners are expected to share each idea generated through the personal activity and then to discuss in order to reach collective result or understanding. In many collaborative learning sessions, a plenary discussion that functions as an overall summary is placed in the very last phase of the learning and there is no chance to return to a personal activity again. The flow is one way. The authors believe that making learners engage in a personal contemplation based on the result of group discussion is very important for learning.

One of the reasons is the effect of review/reflection in learning [1, 2]. By reviewing the results of a collective activity again, learners can notice points that they missed in the discussion and identify any points that need to be covered further. In addition, the personal contemplation makes learners to anchor the conclusion of discussion onto their personal experiences or preexisting knowledge. Trying to rephrase the collective words into personal words is expected to lead the learners to deeper understanding. Another reason is based on the limitation of group work. As Johnson et al. pointed out, in group learning, there are differences in the degree of learners' attendance to work and the contribution from each learner, and it is possible that each learner's role is fixed [3]. Some learners may not be able to express their opinions in a discussion, and others may not be able to understand the discussion because of its rapid pace. Reviewing the material individually after the group work can provide an opportunity for each learner to think carefully about the results of the collective activity. Based on above discussion, the authors propose the "back and forth model" for collaborative learning. With this model, learners transit between individual and collective activity. Typically, learners begin learning with individually, and then proceed to collaborative activity, after the collaboration they return to the phase of individual reflection, finally they gather again in order to share their personal contemplations and discuss based on it.

The benefit of this model is that students are led to generate ideas interactively to arrive at a deep understanding. The learning process begins with a personal activity, in which each learner is expected to develop his/her own ideas while keeping in mind others' viewpoints. Because they would anticipate that their outputs of this individual activity will eventually be shared in a collective activity with other learners. With anticipation for future collective work, learners necessarily develops a sense of accountability for the output of their own works. In the collective activity, multiple

viewpoints and values are to be compared. Any differences or discrepancies can prompt learners to develop new ideas. When they bring the results of their collective activity back for their own individual review, they are required to re-examine the results of the preceding discussion by applying them to an individual context and trying to explain them in their own words. This change of contexts may enable them to identify points that were not fully discussed in the collective discussion or that need to be further elaborated. If the learners gather again to share the results of their individual contemplations, they will consider the ideas from multiple viewpoints, thereby arriving at a deeper understanding of the theme.

3 ICT Tool for “Back and Forth” Collaboration

3.1 Requirements

In this section, we examine what is needed to support “back and forth” learning using ICT. To support personal activity the tool needs to offer learners an exclusive personal field and functions to record and edit (add, delete, and move) information on the field individually. This will help them develop their own ideas about the lesson theme and organize the results of their investigation. For supporting the collective activity of “back and forth” learning, the tool should offer functions to combine and share the results of the preceding personal activity. In addition, the tool should support transition from working collectively to working individually. For this transition, it must be able to distribute the output of the group work to all the group members so that they can examine the results individually in the following personal activity. Again, the functions of recording and editing information are needed for the learners to re-examine the distributed results and input new ideas.

3.2 Development of XingBoard System

The authors developed XingBoard (Crossing board) system as a tool that fulfills the requirement shown above. XingBoard is a system that uses cards, similar to sticky notes, to share ideas in order to support “back and forth” learning. Figure 1 shows the overall concept. In the following, we will explain the concept by following the learning flow.

Personal Activity I. Each learner is given a tablet terminal to record ideas and results obtained from his/her individual work. The ideas can be written on a “card”, which resembles a sticky note. The cards can then be organized or summarized.

Card Input and Moving a Card. When the learner touches the tablet screen with two fingers, an input screen appears. Letters can be input using the on-screen keyboard. The learner can choose/change the card color or drag the card (using a finger) to any group.

Grouping Cards. Learners can select cards by using their fingers to trace around them. They can group the selected cards by touching any place on the screen with two fingers. Groups can be nested. Figure 2 shows screen image with grouped cards.

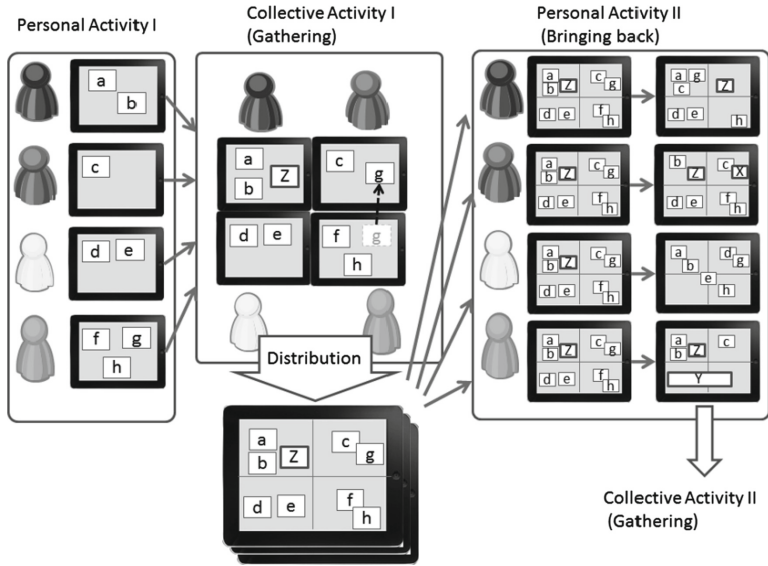


Fig. 1. Concept of XingBoard

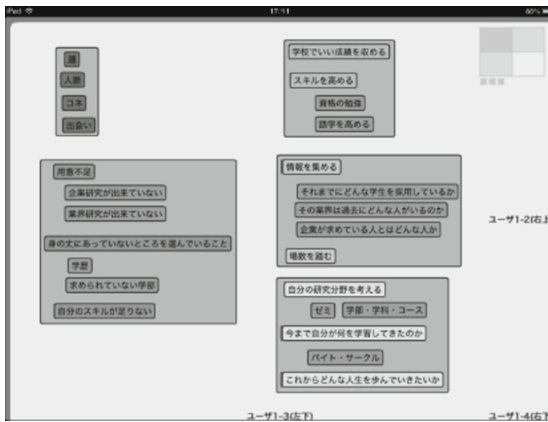


Fig. 2. Screen image of XingBoard

Collective Activity I. Collective Activity I. The learners report each other the results of their personal activity and then discuss in a group. Placing their tablet terminals side by side or end to end (see Fig. 1(center)), they can create an enlarged shared field where they can make a summary of the group results by moving and editing cards.

Moving Cards Between Terminals. Learners can move a card from one terminal to another using the motion shown in Fig. 3.

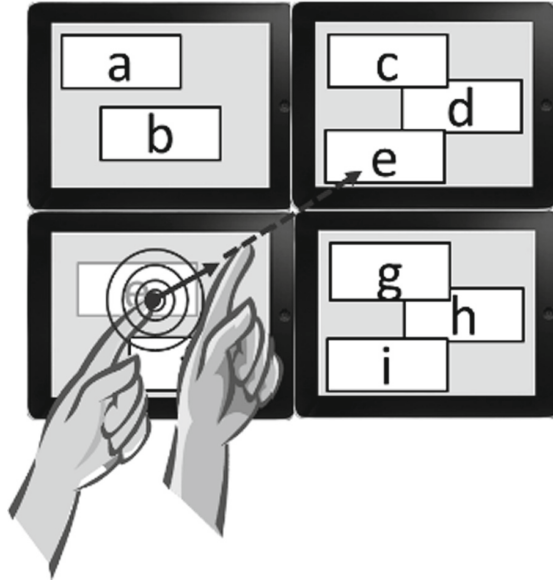


Fig. 3. Moving a card between terminals

When a learner touches a card with one finger, a red ripple will appear, and he/she can move the card to another terminal screen by flicking the finger in the desired direction, as illustrated in Fig. 3. It is possible to move a card from one screen to another in a diagonal direction and even to move grouped cards. Using this function, learners can organize the cards on their own terminals and then integrate them with other group members' cards.

Turning Cards Upside Down. Touching the screen with three fingers will make the cards turn upside down. This function makes it easy for learners to read each other's screens when they are seated in a circle or across from each other. Touching the screen again with three fingers will return the cards to their original orientation.

Personal Activity II. Each learner reviews the results of the collective activity individually and then reedit cards in order to revise the group’s result based on his/her own understanding.

Copy Distribution. The results of the collective activity are recorded on a sheet of domain which is composed of four tablet terminals. “Copy distribution” is a function that copies the output of the group work, which is recorded on a field comprised of gathered four tab-lets, onto each tablet terminal so the group members can bring it back to their personal space and examine individually. Figure 4 shows a screenshot image after a copy distribution. Since four tablet screens are copied onto one terminal, the spaces between the cards are automatically adjusted. Learners can move and edit the cards after the distribution.

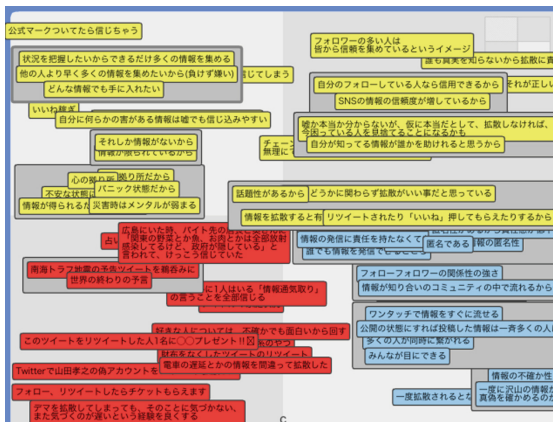


Fig. 4. Screen image after copy distribution

With this function, a learner can review the results of the group discussion individually and make further revisions if needed. Note that copy distribution is possible only when all four group members agree to it.

System Configuration. This system is configured as a client-server type. The development environment for a tablet terminal on the client side is Mac OS 10.6 and Adobe Flash CS6.0. It is an AIR application; therefore, it is possible for the system to be published as an iOS application and an Android application, respectively, and it runs in each environment. Also, when it is published as an SWF file, it can run in a web browser. The development environment in the server side is Windows 7 (Professional), Apache 2.2, PHP 5.3, and MySQL 5.5. In terms of the execution environment, if equivalent service is available, the system runs not only in Windows, but also in other OS such as Linux. Note that for the management of information such as a user and a

sheet, the type of OS (including iOS for iPad and Android) does not matter, as long as the web browser works and text input is possible.

4 Interaction Support and Tangible Nature of XingBoard

In this section we discuss how XingBoard, tablet-based CSCL system, enables users' exploitation of their bodily movements in controlling collaboration as well as transition between personal and collective activity and then provides natural collaborative environment. Firstly, tablet terminal can be grasped by a hand and carried to any-where in the classroom. This enables learners switch between private and collective activity by physically placed tablet terminals in the learning space; scattered tablets makes scattered individual work spaces, assembled tablets in one place makes space of collective work. In short, spatial structures of work can be visually marked/formed by physical configuration of terminals. Secondly, tangible feature of tablet terminals enables learners to utilize their gaze and pointing action to control interactions as Goodwin has shown through analysis of everyday conversation [4]. Tablet terminals inevitably evoke users' gaze and pointing action while making them available for others. With tablet terminals, a group of learners can look into together a horizontally placed screen at a time. In this situation, the learners are naturally led to point an object on the screen while talking about the object. Importantly, the move of pointing can be monitored by the other learners. It is also natural in this situation that learners direct his/her line-of-sight to an object on the screen. That can also be noticed by others and therefore the eye-line functions as a social marker of attention. In this way, learners' gaze and pointing which are evoked naturally in the process of discussion or collaborative work are utilized as resources to control their collective attention, thus collaboration is supported naturally. That is impossible when using a laptop computer with an upright LCD that always constructs enclosed personally space [5]. Finally, tablet terminals, which can be set on a tabletop and surrounded physically by users, enables learners to utilize their body configuration to construct/dismiss a collective working space: orienting each other's body toward same direction together, that is forming F-formation [6], creates an overlap of attention foci and then construct shared working space. On the other hand, by drawing one's body from the shared workspace, the person's disengagement from the cooperative work is marked and therefore constituted. In this way, physical feature of tablet terminals helps learners to control their collaboration through their bodily movement.

4.1 Evaluation

We performed an evaluation experiment to see how XB supports learners to use their bodily resource to carry out discussion and transition between personal and collective phase of their activity.

Session Design. Four university students participated in the evaluation. They engaged in a discussion activity using XingBoard, and we videotaped the process. The discussion theme was “How to deal with hoaxes and lies circulated on SNS at times of disasters”. The tablet terminal model was the Apple iPad2. After introduction (which included time to learn how to operate XB), the experimental session was organized as followed: (1) Personal activity, in which they individually work on the following questions; (a) why people believe in rumors in the event of a disaster, (b) why people complicit to circulate the rumors, and then (c) what possible measures to avoid that is. (2) Group discussion, (3) Personal activity where they obtain the result of the discussion using distribution copy function of XB and revise it based on personal reflection. (4) Group discussion based on the results of each other’s personal contemplation.

4.2 Analysis

In this section, we discuss how XB facilitates learners’ interaction using body resources based on videotaped data. In the following transcript; parentheses indicate unclear utterance, angle brackets indicate description of action, single left square bracket connecting two utterances indicates overlapped talk, square brackets show markers for explanation, and curly brackets indicate annotations by the authors.

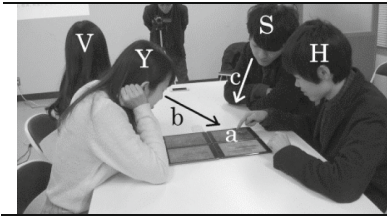
Making Foci of Conversation by Social Markers of Attention. Transcript 1 demonstrates how XB supports learners to utilize their gaze and pointing action to control conversation. Here, they have just started discussion by mutually seeing each other’s result of preceding personal activity. Student H starts speaking with pointing at a card on S’s screen (H01-[a]). His pointing indicates the direction of his attention socially. Subsequently, S and Y move their body forward and look into the spot where Student H is pointing (Y02-[b], S03-[c]). This creates overlap of transactional segment and then constructs the foundation of discussion. Here we can observe smooth starting up of discussion exploiting pointing action and gaze as resources for interaction.

Transcript 2 shows conversation following the transcript 1. They are talking about their experiences about a fraud tweets which coax people into re-tweet by offering attractive bait. Student Y talks about her experience (Y02, Y04). At the end of her talk H points to a card on the V’s screen ([a]). This pointing action can be considered as a social display of H’s intention to start up discussion on V’s card. However, at the very moment, the other participants are laughing aloud at Y’s talk that Y retweeted even in the toilet and they do not respond H’s intention, i.e., they do not look at the card H is pointing. H canceled the pointing once ([b]). As the laughter ends, he restarts, i.e., points to the same card again saying “This” (H06-[c]). At this time, as a response to H, Y asks “Which one?” (Y07) with looking at the direction of the card pointed by H ([d]). Almost simultaneously, S also leans forward and looks into the same card ([e]), and thus overlap of their transactional segments is formed on the card ([e]). Therefore, they can start up discussion on the contents of the card.

In these transcripts, we observed learners using pointing action and gaze as resources to control collaborative work. These actions are generated naturally by

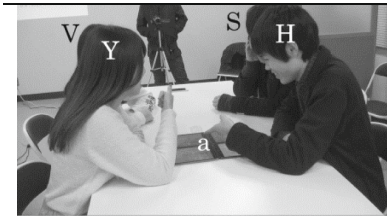
working with tangible tablet terminals which can be placed horizontally on the table. In this sense, it can be considered that the tangible characteristics of the tablet terminal made it possible to use the pointing action and gaze as interaction resources.

Transcript 1

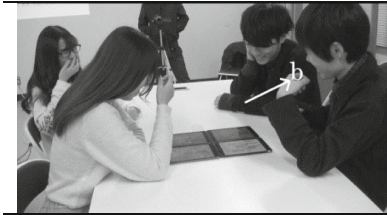


H01: I agree with this. <points at S's card: "You can get a theme park ticket only if you retweet this" > [a]
 Y02: What? [b]
 S03: <leans forward> [c]
 H04: If you retweet that ()

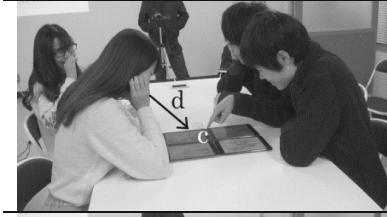
Transcript 2



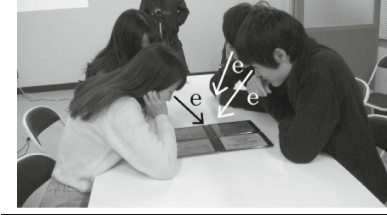
S01: Actually no one get a Disneyland ticket.
 Y02: Right. It's a lie. Absolutely. But I retweet it.
 S03: hhhh
 Y04: Yesterday, I took out [my phone] in restroom [and retweeted]
 H05 <Points V's screen> [a]



<Everyone laughs>
 <H puts back his hand [b]>



H06: This. [c]
 Y07: Which one? <looks at V's terminal>[d]



<Everyone look into V's terminal>[e]
 V08: Well, when I was in Hiroshima.

Making Transition from Individual to Collective Activity by Body Configuration. Transcript 3 shows the scene of transition from personal task to group discussion.

In this scene, they have been engaging in individual task. First, V utters “OK?” (V01) and then in response to this utterance, Y and H answer “Ok” (H02, Y04) with moving their bodies off their terminals and setting their upper body upright ([b], [d]). By this posture, the attention to the terminal is canceled, and as a result, their remarks “OK” can be heard as approval for suspension of current task.

Transcript 3

	<p>< Everyone is looking into each one’s terminal >[a] V01: OK? (For now, we should)</p>
	<p>H02: Yeah, OK. <makes his upper body upright>[b] S03: OK.<still looks into his terminal>[c] Y04: I’m OK.<makes her upper body upright>[d] V05: <makes her upper body upright>[e]</p>
	<p>[V06: Hey, OK, OK, OK, OK, OK? <Looks at S>[f] S07: OK, OK, OK, OK.</p>
	<p>Y08: This way? Which one? All right. <Each person pushes his/her terminal forward>[g]</p>
	<p><Everyone looks into terminals>[h] V09: OK, Then?</p>

Thus, the relevant transitional point to the next phase of work is constructed. On the other hand, although answering “OK” (S03), S continues operating his terminal ([c]). While V hurries him (V06-[f]), Y and H did not return to work while maintaining their upper body stood up. Here appears the scene where three people including Y, H and V

are waiting for S to finish his individual work. After that, Y, H and V starts to move their terminals toward the center of the table without waiting S to finish ([g1]). S also begins to move his terminal to the same direction a little late ([g2]). When four terminals are gathered in the center of the table and four participants orient their bodies toward the terminals, the transactional segment of each person overlaps on the terminals ([h]). As a result, a shared space for collaborative work is constructed here. This is apparently observable from everyone, so V could start up discussion by saying “OK, then”. In this transcripts, we observed learners accomplished the transition from individual activity to collective activity very naturally through utilizing their body configuration.

Starting Up/Closing Local Discussion Using Tablet Terminal as Substitute for Body. Transcript 4 show how local discussion between Y and H is constructed. They have been engaging in individual work. Y and H exchange words (Y01, H02, Y03) but keeping the body arrangement suitable for individual work. By this body configuration, the conversation between Y and H here appears as a temporary one. But next moment, Y pushes her terminal in the direction of H ([a]) saying “This” (Y04). At the same time Y looks at H. This behavior can be seen as an invitation for some sort of collaborative work. Thus, H’s utterance “I see,” (H05) can be interpreted as approval of that invitation. After that, Y gets bent forward a little, looks into the terminal of H ([c]), and reads one of the cards on H’s terminal (Y06). Since the terminal placed in the work area of an individual is exclusively owned by individuals, some “request for permission” is necessary to look into others’ screen. However, Y is accessing the card on the terminal of H without asking for permission in particular. Also, H will not blame it. From this, it can be said that a shared space where Y and H can access from both sides is generated here. Within this space, Y and H can keep on talking about the contents of the card written on the Y’s terminal (H07-H11). In this conversation, H is paying attention to the card that Y wrote: “kind of tweet urging you to re-tweet within 10 s”. Y explains in detail the contents of the card she wrote while giving an example (Y08, Y10). Immediately after H said “I see” (H11), Y pulls back her terminal in front of her ([e]). As a result, the shared space between Y and H is released, and the termination of the discussion can be observed. Immediately after that, Y and H turn their bodies and eyes toward S and V ([f]), and Y says “We are waiting for you” (Y12). In this scene, they appear as those who are finished their work together and waiting for S and V to finish their work.

The process of starting up and closing the local discussion analyzed here can be seen as a process of formation and breaking up of F-formation by two participants. Interesting point is that the terminal plays a role of body substitution. When Y pushes his terminal towards the center of the table, the upper body of Y stays still standing and thus her transactional segment does not overlap with that of H. In spite of that, Y and H begin conversation about cards on each other’s terminal. It was not the bodies of Y and H but the terminals that approached each other (of course, as the inevitable consequence of looking into the terminals, the two bodies are tilted slightly ahead and take a posture that is oriented towards each other). From the fact that Y terminates the discussion by returning the terminal to the original position, we can consider that the terminal has replaced her body, which has its unique transactional segment. A tablet terminal belongs to an individual, even if it is temporally, and the individual’s ideas are

recorded on it. In that sense it has relatively stronger nature of “extended self”. Tablet terminals, at least in this experimental session, probably have both “extended self” and mobility integrated inside, and this would be the reason why the tablet terminal functions as a substitute for the body as resource for interaction.

Transcript 4

	<p>Y01: ah, can I edit these? H02: (in yellow) Y03: This, perhaps this seems to be same.</p>
	<p>Y04: Oh, in this case, this is it. This! < Pushes forward her terminal>[a] H05: I see. <looks into Y's screen>[b]</p>
	<p>Y06: Mentally weak hhh, Oh, I see::, mental factor is. <looks into H's screen>[c]</p>
	<p>H07: I never pass information to someone in 10 seconds. <looks into Y's terminal>[d] Y08: hhh Haven't you seen that kind of information, you know, that says you can be rich only if you pass it to someone? H09: Yes, certainly. Y10: It is apparently a lie. They send us a scary picture urging us to circulate to others.</p>
	<p>H11: I see. <Y returns her terminal to the original position>[e] Y12: We are waiting for you two. <looks at V&S >[f] <H looks at V&S>[f]</p>

5 Conclusion

This paper described the design of XingBoard system, tablet-based tool that supports a bi-directional transition between personal and collective activities in collaborative learning process, from the viewpoint of bodily control of interaction. For that purpose, we recorded scenes where a group of 4 subjects used XingBoard. As a result of interaction analysis, it turned out that XB, by its tangible nature, supports collaborative work by enabling learners to use their bodily movements as interaction resource. Firstly, XB supports learners to make foci of conversation by utilizing bodily actions such as pointing and gaze as social markers of attention. Secondly, XB helps learners to transit from individual to collective activity through forming/breaking F-formation surrounding the tablet terminals. Thirdly, the tablet terminal of XB system is used by learners as substitute for body to control collaboration. Detailed analysis of collaborative work using XB is our further work.

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References

1. Moon, J.: Handbook of Reflective and Experiential Learning: Theory and Practice. Routledge, Abingdon (2004)
2. Pirolli, P., Recker, M.: Learning strategies and transfer in the domain of programming. *Cogn. Instr.* **12**, 235–275 (1994)
3. Johnson, D.W., Johnson, R.T., Holubec, E.J.: Circle of Learning: Cooperation in the Classroom. Interaction Book Company, Edina (1993)
4. Goodwin, C.: Conversational Organization Interaction Between Speakers and Hearers. Academic Press, Cambridge (1981)
5. Alvarez, C., Brown, C., Nussbaum, M.: Comparative study of netbooks and tablet PCs for fostering face-to face collaborative learning. *Comput. Human Behav.* **27**, 834–844 (2011)
6. Kendon, A.: Conducting Interaction: Patterns of Behavior in Focused Encounters. Cambridge University Press, Cambridge (1990)