T. Koschmann, D. Suthers, & T.W. Chan (Eds.), *Computer Supported Collaborative Learning 2005: The Next 10 Years!*
Mahwah, NJ: Lawrence Erlbaum Associates.

Promotion of Self-Assessment for Learners in Online Discussion Using the Visualization Software

Toshio MOCHIZUKI
Information Science and Technology Center, Kobe University
tmochi@kobe-u.ac.jp

Hiroshi KATO
National Institute of Multimedia Education
hkato@nime.ac.jp

Shin-ichi HISAMATSU
Graduate School of Media and Governance
Keio University
bm@sfc.wide.ad.jp

Kazaru YAEGASHI
Graduate School of Interdisciplinary
Information Studies, the University of Tokyo
kazaru@interlink.or.jp

Satoru FUJITANI
Faculty of Business Administration
Mejiro University
fujitani@mejiro.ac.jp

Tomoko NAGATA
Hyogo University of Teacher Education
tnagata@life.hyogo-u.ac.jp

Jun NAKAHARA
National Institute of Multimedia Education
jun@nakahara-lab.net

Toshihisa NISHIMORI
National Institute of Multimedia Education
nisimori@nime.ac.jp

Mariko SUZUKI
Faculty of Education, Shiga University
mariko@sue.shiga-u.ac.jp

Abstract. This study describes a method of self-assessment for learners in a collaborative discussion. The authors propose a method of self-assessment in an online discussion and examine its effectiveness through the development and evaluation of a software program to visualize the discussion on a Bulletin Board System. The software, referred to as "i-Bee" (Bulletin board Enrollee Envisioner), can visually display the co-occurrence relation between keywords and learners. Thus, the i-Bee can display the content-wise contribution made by each learner to the discussion. In addition, the i-Bee can display the recent level of participation of each learner and the frequency of each keyword used by the learners. The i-Bee enables students to assess and reflect over their discussion, to understand the condition, and to reorganize their commitment in a discussion reflecting their learning activity.

Keywords: Visualization, Self-assessment, Reflection, Online Discussion

INTRODUCTION

The study of Computer Supported Collaborative Learning (CSCL) is a challenge with regard to producing an environment conducive to mutual learning among learners using computers. Recent researches in e-learning have highlighted the significance of building an online learning community, which plays a role in the sustenance of a fruitful online learning experience (Palloff and Pratt, 1999). The significance of promoting communication among learners via the Computer-mediated communication (CMC) is rapidly increasing at present.

However, there are some difficulties faced by learners in mutually recognizing the status of a learning activity in the CSCL environment, which constitutes the most important research issue (Gutwin et al., 1995; Kato et al., 2004). Japanese communication researchers, Kimura and Tsuzuki (1998), pointed out that group communication in the CMC tends to be disorganized and to lack cohesion due to decreased interpersonal pressure, given the nature of the CMC. Briefly, learners are sometimes confused about what they should and should not discuss. This raises the question of how CSCL environments assist learners in recognizing their commitment and reorganizing their discussion in a content-wise manner?—if not, it may lead to a failure in the organization of a fruitful discussion for learning.

In order to address this issue, the authors propose a method to self-assess the online discussions in electronic forums or Bulletin Board System (BBS). Self-assessment is very effective for learners seeking to improve their knowledge and learning strategy (Shaklee et al., 1997), particularly in a collaborative learning setting. Learners are required to monitor the actual condition of their discussion, the learning process, and interpersonal relations in order to improve their learning community, and to plan the course of their education, which will enable them to make learning a significant experience.

Messages exchanged in the electronic forums are useful in the assessment of collaborative learning given the fact that they are visualized resources of interaction among learners in a collaborative learning setting. In other words, the messages exchanged in a discussion are reflective of the learner's ability in the context of the activity (*in situ*) (Pea, 1993; Palincsar, 1998)—according to the social constructivism perspective, the learner's ability in a collaborative learning setting emerges socially; therefore, the ability should be assessed on the basis of a visualized interaction among learners and the circumstances including artifacts and social factors. However, a manual assessment of these messages by the learners is not practical given the tremendous effort that is required of them.

In this study, the proposed method of content-wise visualization of the communication produces a mapping of coordinates, which indicates how strongly each learner relates to each keyword in his/her messages. Mapping reveals the whole structure of communication in the learning community—the manner in which each learner participates in the communication and the organization of group communication.

In order to examine the validity and usefulness of the proposed method, the authors developed a software referred to as "i-Bee," (Bulletin board Enrollee Envisioner), which can visualize the relationship between learners and keywords in online messages in real time. This software also provides snapshots of past discussions and animations, which show the trajectory of change from a given period. Thus, the i-Bee aims to encourage learners to perceive their discussion as a whole and to encourage them to assess their discussion.

The purpose of this study is to examine the effectiveness of self-assessment of online discussions through the development and evaluation of the i-Bee based on the proposed method. With regard to learners' self-assessment, this study primarily focuses on and discusses the experience of learners to recognize and improve a discussion using the i-Bee.

VISUALIZING ONLINE CONVERSATION

Several recent studies in CSCL have focused on visualization of learner activities in CSCL in order to create awareness among learners. For example, Nakahara et al. (in printing) developed a software, which visualized the status of interaction and activeness of electronic forums on a mobile phone screen, in order to promote participation awareness and encourage learners to participate in the discussion at any time. Other researchers have attempted to visualize social networks in the community (e.g. Martínez et al., 2003) by confirming the status of communities in CSCL. However, to date, very few precedent researches have focused on the visualization of contents of the discussion among learners. Puntambekar and Luckin (2003) have indicated that it must be worthwhile to allow learners to view the contents of the discussion and learn through reflecting over the process.

In this study, the authors propose a visualization method using a text-mining technique to assess conversation among learners on the BBS.

Application of Text-mining Technique

Researches in the field of text-mining have progressed in recent years. Numerous methods have been developed for extracting applicable keywords from the text data. Additionally, multivariate analyses such as the multivariable dimension scale (MDS) and Correspondence Analysis (CA) are generally used to visualize the relationship of individual keywords to the whole (Greenacre, 1984).

CA is a graphically descriptive method that facilitates an intuitive understanding of this relationship by presenting two or more discrete variables in a complex data matrix. For instance, when the matrix is based on the frequency of each keyword written for each person or group, frequently co-occurring variables are placed in close proximity to each other. It is considered to be suitable for learners to recognize the content-wise contribution made by each learner to the discussion as clusters (of keywords and persons) that are related elements in the text data (Li and Yamanishi, 1999). In addition, rather than Latent Semantic Analysis (Landauer, et al., 2004) which is suited for analyzing large amounts of data, CA is a more appropriate method to analyze small statistical data like messages on the BBS in a small group activity, since CA is independent from statistical assumptions.

Visualizing Discussion Using CA

In the method proposed in this study, if n learners discuss a relevant number of m keywords, which totals up to $n \times m$ for a cross-tab of $\mathbf{N}$, then CA yields a mapping of a row vector $\mathbf{F}$ and a column vector $\mathbf{G}$. In other words, the generalized singular value decomposition of the matrix $\mathbf{P}$, which is the relative frequency matrix of $\mathbf{N}$,

$$\mathbf{P} = \mathbf{A}\,\mathbf{D}_{\mu}\,\mathbf{B}^{T}$$

yields a left generalized singular vector **A** and a right generalized singular vector **B**. The use of these two vectors,

$$\mathbf{F} = \mathbf{D}_{R}^{-1}\,\mathbf{A}\,\mathbf{D}_{\mu}$$

and

$$\mathbf{G} = \mathbf{D}_{C}^{-1}\,\mathbf{B}\,\mathbf{D}_{\mu},$$

results in the standardized principal coordinates **F**, **G**, which construct a mapping (Greenacre, 1984).

In this mapping, $\mathbf{D}_{\mu}$ is the diagonal matrix leading to the generalized singular value diagonal vector, $\mathbf{D}_{R}$ is the diagonal matrix that makes matrix **P** the diagonal vector, and $\mathbf{D}_{C}$ is the diagonal matrix of the sum of the columns of matrix **P**. Additionally, **F** and **G** correspond with the coordinates of learners and keywords, respectively.

The Significance of Mapping Generated by the Analysis

Generally, when a CA is conducted using the relative frequency matrix **P**, **F** and **G** are distributed in proximity to each other if a coordinate of **F** and that of **G** have a strong co-occurrence relation. In contrast, if a coordinate of **F** and that of **G** do not have a co-occurrence relation, they are distributed far away from each other. In addition, a relatively high value in the matrix **N** represents a coordinate located closer to the original point and a relatively low value represents a coordinate located far from the original point.

Thus, it is believed that (1) the distribution of coordinates indicates the co-occurrence relation between each learner and each keyword in his/her messages and (2) the total data of (1) represents the topics in the discussions. Hence, CA can display the status of an overall discussion in the BBS as well as each learner's involvement in that discussion. Although other aspects of discussion, such as meaning and context, does not taken into consideration in the analysis, CA is simple and applicable to incomplete and fragmental sentences as seen in BBS messages.

The authors have already conducted a pilot study to examine the appropriateness of CA in order to visualize the discussion and to examine the effectiveness of mapping for the learner's self-assessment. The result is indicative of the possibility of learners focusing more on certain topics of participation, planning their participation in topics of lesser interest, and following up on members with the inability to fully participate in discussions (Mochizuki et al., 2003).

DEVELOPMENT OF THE I-BEE

Based on the method proposed above, the authors developed a CSCL software, referred to as i-Bee (Bulletin board Enrollee Envisioner), to visualize small-group (mainly asynchronous) discussions on BBS in real time. The i-Bee is a plug-in tool that works with discussion forums of exCampus and its databases, which is an e-learning module developed and distributed free of charge by the National Institute of Multimedia Education in Japan (Nakahara and Nishimori, 2003). It covers numerous functions necessary to build an e-learning site in a university—course management, learning management, interface for video streaming, discussion forums, etc.

The features of i-Bee have been discussed in the following section. The i-Bee has four features: (1) visualization of the relationship among keywords and learners in real time, (2) visualization of a time-series trajectory and snapshots at certain past periods, (3) visualization of recent levels of participation of learners and of recent frequency of keywords, and (4) location of messages containing corresponding keywords clicked as flowers by a learner on the i-Bee.

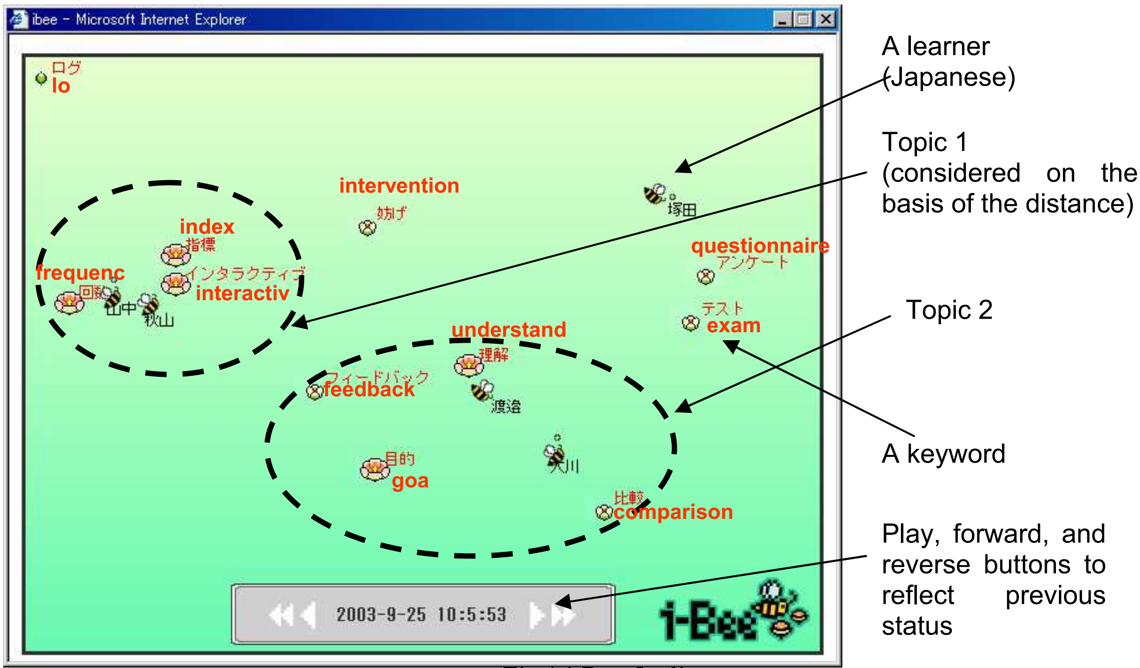


Fig.1 i-Bee Outline
(Arrows, circles, and English translations are not included in the original—only for explanatory purposes)

Real-time Visualization of Content-Wise Discussion

When a learner logs onto the BBS on exCampus, the i-Bee pops up as an additional window (Fig. 1). The i-Bee displays participating learners (bees) and keywords (flowers) selected by teachers. The distribution of the bees and flowers is based on the result of the CA conducted at that time. Each bee and flower is drawn with its name, which represents what is being described. The i-Bee refreshes the status not only when the learner logs in but also when the learner accesses every article; therefore, the i-Bee can display as new a status as possible.

While visualizing the coordinates, the i-Bee displays each bee turned toward the flowers as an indication of the number of times a learner uses the corresponding words. The angles of the bees are calculated based on the frequency and location of the flowers (see Table 1).

The i-Bee was developed for learners to recognize their status in the forums. Furthermore, it aimed at having learners reflect over their attitude in a discussion in a content-wise manner. In order for learners to appropriately assess their discussion, it is necessary to design a visualized image for them to easily recognize the overall image and their involvement in the discussion.

In order to address this issue, the authors adopted the "bees and flowers" metaphor to explain the co-occurrence relation between the learners and keywords in the discussion. Based on the algorithm of CA, strongly related elements should be located as coordinates in close proximity to each other. A comparison of the algorithm with the metaphor exhibits quite a resemblance—bees get drawn toward attractive flowers in order to

Table 1. Expressed Information and its Indexes, Targets, and Facial Expressions

Information	Index	Target	Facial Expression
What each learner talks	Coordinates calculated by CA	Distance between bees and flowers	The more a learner uses a certain keyword, the shorter the distance between the learner and the keyword.
Recent trend of keywords used by each learner	Weighted coordinate value of keywords calculated with the number of times each learner used the corresponding keywords recently	Head direction of bees	The more frequently a learner uses a certain keyword, the more the corresponding bee turns toward the corresponding keyword (however, the display is limited to angles of 45, 135, 180, 225, and 315 degrees)
Activeness of each learner	$i = \frac{number\_of\_the\_learner's\_articles\_at\_a\_certain\_period}{average\_number\_of\_the\_learner's\_articles\_per\_a\_period}$	Bee	$i \geq 1$: active bee $1 > i \geq$ threshold: normal flying bee threshold $> i$: sleeping bee
Activeness of each topic (keyword)	$i = \frac{frequency\_of\_the\_keyword\_used\_by\_all\_learners\_at\_a\_certain\_period}{average\_frequency\_of\_the\_keywords\_used\_by\_all\_learners\_per\_a\_period}$	Flower	$i \geq 1$: full bloom $1 > i \geq$ threshold: flowering period threshold $> i$: bud of flower

suck their nectar, while flowers require the bees to distribute their pollen. Thus, the learners can view the content and status of their discussion in the forum.

Visualization of the Discussion Process

A previous research indicated that learners can effectively reflect over their learning experience when a learning support system provides trajectories or snapshots of their learning at several points (Collins and Brown, 1988). Therefore, in order to promote an increased level of reflection by learners over their discussion, the authors developed i-Bee in order to allow learners to view their previous status and the process of change during the discussion.

When a learner accesses the i-Bee, it displays a trajectory of the learner's coordinates from the unit time t-1 to t before providing a snapshot at that time t (t is the number of unit time, which is calculated from the beginning until a certain point of time). Using the configuration tool, moderators such as teachers or teaching assistants are required to appropriately configure the unit of time in accordance with the learning activity. For example, if the course is conducted once a week, the teacher may set the unit time as one week.

Furthermore, learners can also view their previous status at every unit of time. In other words, learners can view their status of discussion as snapshots for one week before, one unit of time before, one unit of time after, or one week after by clicking on the operation buttons provided within the window of the i-Bee.

While displaying the animation and snapshots, the i-Bee fixes the coordinates of flowers (keywords) and mobilizes those of bees (learners) to naturally indicate the trajectory of how each learner (bee) has related with the keywords (flowers) and other learners (bees).

Visualization of Activeness

Learners and moderators face difficulties in understanding the status of discussion on the basis of the simple coordinates of bees and flowers produced by the CA since it does not display the recent amount of learner's participation and that of the appearance of the keywords in the discussion.

In order to visualize their activeness at certain points, the i-Bee displays bees and flowers at three levels (refer to Table 1): "sleeping bee," "normal flying bee," and "active flying bee" represent the possible facial expressions of the learner's recent level of participation. "Bud of flower," "flowering period," and "full bloom" represent the recent appearance of keywords indicating their frequency. The i-Bee calculates each learner's activeness as the proportion of his/her messages within the recent unit time to its average per unit of time. In the case of certain keywords, the i-Bee calculates their activeness as the proportion of frequency of the keywords used by all learners within the recent unit time to its average per unit of time.

Cooperation with exCampus Discussion Forums

The authors developed the i-Bee to cooperate with the discussion forums of exCampus. Learners can launch a search for messages containing certain keywords illustrated as flowers on the i-Bee. Hence, learners can easily locate interesting messages while viewing the i-Bee by clicking on the corresponding flower. Thus, i-Bee assists learners in locating interesting or surprising articles from large amount of messages.

Implementation

Figure 2 shows the workflow of the i-Bee. It requires a morpheme analysis system, e.g., "ChaSen" for Japanese text (Matsumoto et al., 2000), to calculate the frequency of each word from the text of the discussion.

In order to use the i-Bee in a course, moderators are required to set keywords using the configuration tool because the automatic keyword selection, which is based on a statistical analysis, cannot choose the appropriate words representing a discussion. The configuration tool allows only the moderators to modify settings (unit of time to organize frequency matrix, users whose articles are analyzed, users who use i-Bee, keyword selection, etc). These keywords are stored in the condition database.

In the keyword database, the frequency of keywords is stored along with the indexical information in the discussion, reflecting over the condition database. A database records the appearance of each keyword, using the following information:

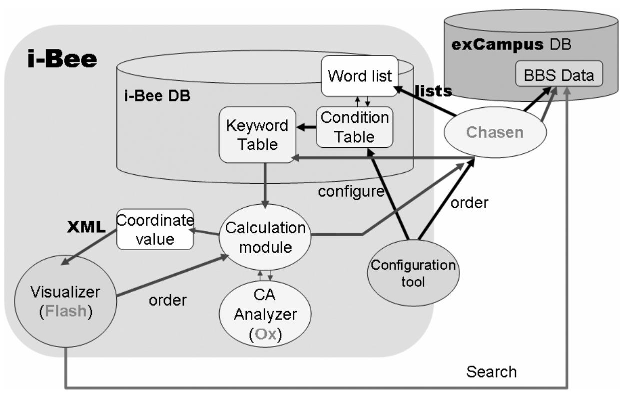


Fig.2. Workflow of the i-Bee

- Speaker/Author of the message in a certain period
- Total frequency of each keyword used in the messages by each speaker/author until a certain period

CA uses these data to construct a graphical display of the discussion profiles using Ox. Ox is a formula processing environment, which is an object-oriented matrix programming language with a comprehensive mathematical and statistical function library (Doomik, 2001).

The i-Bee procedure is as follows: Firstly, the learners or the moderators open the visualizer (Fig. 1), which was developed using Macromedia Flash MX, and the calculator orders the morpheme analysis system to calculate the appearance frequency of each keyword used by each learner until a given period of time. Upon receiving the result, the keyword database stores the frequency matrix. In order to display the status at a certain period or the previous status, CA calculates a matrix that conjugates one at the time *t* and another at the previous period *t*-1, as mentioned earlier. In other words, when *n* (*l*, *t*, *w*) is the accumulated frequency that the learner *l* uses the keyword *w* until the unit time *t*, ***Nt*** is organized as below:

$$\underset{2L\times W}{N_t} = \begin{bmatrix} n(1,t-1,1) & \cdots & n(1,t-1,k) & \cdots & n(1,t-1,W) \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ n(l,t-1,1) & \cdots & n(i,t-1,w) & \cdots & n(i,t-1,W) \\ \vdots & \iddots & \vdots & \ddots & \vdots \\ n(L,t-1,1) & \cdots & n(L,t-1,w) & \cdots & n(L,t-1,W) \\ n(1,t,1) & \cdots & n(1,t,w) & \cdots & n(1,t,W) \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ n(l,t,1) & \cdots & n(i,t,w) & \cdots & n(i,j,W) \\ \vdots & \iddots & \vdots & \ddots & \vdots \\ n(L,t,1) & \cdots & n(L,t,w) & \cdots & n(L,t,W) \end{bmatrix}, where \quad l = 1,\cdots,L, t = 1,\cdots T, w = 1,\cdots,W$$

The calculator orders the Ox to analyze the data using CA. However, if a learner does not use any keywords or if a keyword does not appear at all, the operation is conducted with a matrix that omits the corresponding row or line from ***Nt*** since the operation cannot be completed due to the zero-line or the zero-row. The analysis results in some value of the axis, and coordinates **F** and **G** are elected as the first and second axis of the result. The calculator transforms the value of the coordinates to an XML format, and the visualizer receives the data from the calculator.

The graphical display produced by CA shows the co-occurrence relation among participants and keywords. Learners can reflect over not only their condition in the group but also the flow of the discussion.

EVALUATION

Method of Evaluation

As described above, the authors developed the i-Bee to promote understanding in learners of their current condition and to reflect over the overall discussion. Majority of us agree that it is extremely difficult to grasp human higher-order thinking such as reflection or meta-cognition. Protocol analysis is one of the means by which to reveal the human internal condition; for example, what the subject recognizes and how the subject feels under a certain circumstance (Ericsson and Simon, 1993). Some researches in collaborative learning used protocol analysis through constructive interaction among their subjects to reveal how they recognized and reflected (Roschelle, 1992; Miyake, 1986; Shirouzu et al., 2003). According to these researches, the authors gave weight to ideas spoken by the subjects to understand how their cognition worked while the subjects used the i-Bee.

Course Outline

The class studied for an evaluation of the i-Bee was referred to as “Preservice Training 7,” a winter term prerequisite course of 10 lectures in an undergraduate course for interns in elementary or junior high school in Japan. Nine seniors participated in the course. They underwent internship during the summer semester. The ultimate goal of the course was to reflect over their internship by preparing their teaching portfolios and discussing their experience on the BBS. The teacher, who placed emphasis on online discussions, requested the students to reflect their own opinion in their portfolios what they thought of during the discussion.

Discussion on the BBS was conducted for about 15 to 30 minutes at the beginning and the end of seven out of the 10 classes. In the first four out of the seven discussions, the students discussed their experience during the internship; in the next three discussions, they exchanged comments on each other's portfolios. Each topic was discussed in different forums and was independently analyzed by the i-Bee.

Data Collection

The authors observed a couple of students, Alice and Betty (fictitious names), using video cameras. They were both preparing their portfolios based on their internship in a junior high school, while they were engaged in both elementary and junior high schools. In the class, they usually sat adjacent to each other, as shown in Fig. 3. Their computer screens were also recorded using video cameras.

Fig. 3. A scene from the case
(Left: Alice; Right: Betty)

Even though the BBS supported asynchronous communication (i.e.,threaded discussion board), the students used the BBS synchronously during class hours. The reason is to collect their verbal data in a natural situation, in which they sat close together and verbally shared comments about what they saw on each of their i-Bee. However, the communication mode was partly asynchronous because the discussion was conducted across the lectures.

The first author participated in the course as a teaching assistant and recorded the data in five out of the ten classes. In the first class, the author sought the students' permission for data collection only for the purpose of the evaluation of i-Bee; they agreed.

The keywords for analysis with the i-Bee were selected on the basis of a consensus drawn between the teacher and the first author. They selected the keywords from messages with respect to the educational purpose, the learning context, and meaning of the keywords depending on the context of use. They altered the keywords based on the progress of the discussion. The selection process was conducted not only during class hours, but also mainly in intervals between the lectures. The thresholds for measuring the activeness of learners and keywords were 0.4 and 0.6, respectively.

RESULTS and DISCUSSION—HOW DID LEARNERS ASSESS WITH THE I-BEE?

The authors analyzed the videos and prepared transcripts based on them, including each utterance made by the students. A comparison of the screens with the utterance allowed the authors to study Alice and Betty's experience to recognize the representation of the i-Bee and the manner in which their recognition led to the progress of their discussion.

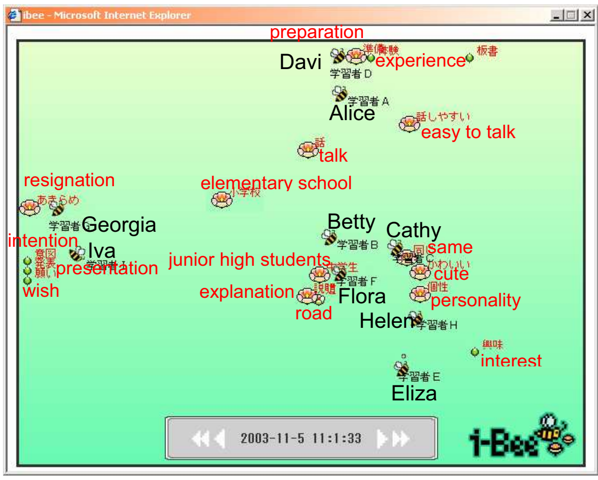
The results showed that (1) i-Bee can be a cognitive resource for learners to assess the conditions and (2) it can encourage learners to reflect and reorganize their learning activity by comparing their present status with their past status on the i-Bee.

In this study, the authors present two cases that prove the findings summarized above. For reasons of privacy, fictitious names have been assigned to the subjects used in the transcripts and figures. In the transcripts, the codes ":," "h," and empty double parentheses represent prolonged sounds, exhausted sounds, and unrecognizable utterances, respectively. Words enclosed in brackets indicate nonlinguistic action.

Providing Opportunities for Assessment of the Status of their Commitment in the Discussion

In this section, the authors describe the experience of the subjects to understand their commitment in comparison to that of other students. In this case, Alice found commonality with another student, as described below; it assisted her in communicating with a student she had not previously interacted with.

```
[Fragment 1]
[2006] Alice: Ah, here it is!
[2006] Betty: ((        )) same place as everyone else.
[2007] Alice: Yeah, I am near by David
[2009] Betty: You're right. ((           ))
[2011] Alice: Cathy is blurring again…hh…why is that? Why is it blurring?
[2017] Cathy: It's really sucking a lot of honey.
[2018] Alice: huhu hh: h
[2020] Alice: Might be poisoned!
[2021] Cathy: What should I do… it has a full stomach.
[2024] Alice: Hhhhh, this isn't good. (0.5) Eliza is still asleep.
[2029] Cathy: Ha hhhhh
[2030] Alice: And Flora is too. Wake up, wake up!
[2032] ? :    ((        ))
[2033] Alice: Ahahahahaha
[2034] Alice: Really?
```



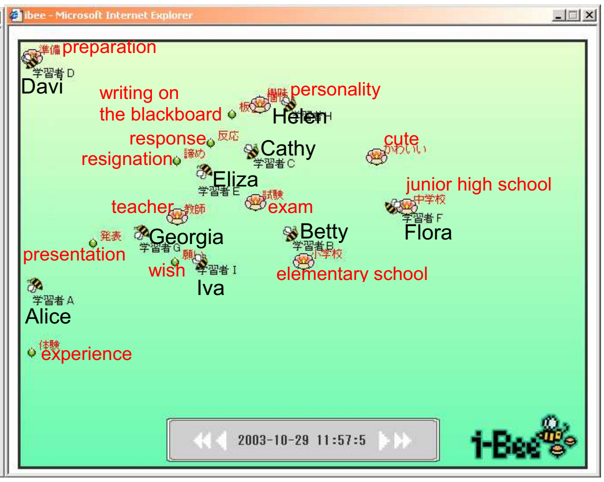


Fig. 4. Status of i-Bee at the time of Fragment 1 Fig. 5. Status of i-Bee at the time of Fragment 2
(Japanese words are original expressions. English translation is attached to each element)

```
[2038] Alice: "Preparing" and "experience" are there
[2043] Alice: It's friends with David
           [Alice changes screen to check David's remarks and reads his messages]
```

Figure 4 shows a representation of the i-Bee during the above-mentioned online discussion. In this fragment, Alice observed that her bee's location was closer to David's on the i-Bee, which is expressed by her statement, "Yeah, I am near by David" [2007]. She then began reading David's messages, which is expressed by her statement, "Its friends with David" [2043], although she did not pay much attention to his messages.

At this point, we must draw attention to one of Alice's statements, "'preparing' and 'experience' are there," [2038] before reading David's messages. Alice shifted her attention to "preparation" and "experience" although one observes the use of other phrases such as "easy to talk," "talk," etc. It appears reasonable to assume that she recognized commonality with David based on those two keywords at that time. In other words, the reason she began reading his messages was because she recognized commonality with him.

Stating that such an activity is a type of assessment of the discussion is not an exaggeration. Other similar fragments were observed in our research. Viewed in this light, the i-Bee can be regarded as a cognitive resource for learners to recognize their level of commitments, which encourages them to conduct assessments, particularly where they are less attentive.

Providing Opportunities for Reflection on the Discussion by Comparison with Past Status

The following fragment describes Alice and Betty's experience to reflect over their statements in a content-wise manner by understanding the change in their position on the i-Bee. Figure 5 shows the status of the i-Bee at that time.

```
[Fragment 2]
[4355] Betty: It's interesting.
[4356] Betty: I'm starting here. [clicking an icon on i-Bee with mouse]
[4363] Alice: Where am I? Oh, my bee is here.
[4366] Alice: It's here, but…I can't say I'm happy with where it is. (1.5) I'm in
              a slightly awkward location…
[4373] Alice: Aww…My bee has become further away from the others. I'm so lonely.
[4377] Alice: Hey, don't you think my bee is lonely and distant from the others?
[4378] Betty: Where?
[4380] Betty: I can't find you?
[4384] Betty: Oh, here you are, I see.
[4385] Alice: Yeah.
[4386] Betty: I'm here. As I predicted, I'm still at the "elementary school." I
              have to move on to "junior high school."
[4390] Alice: My location changed from the last time. It's near "experience" now
[4394] Betty: Oh, you're right, you're near "experience". h, h, hh
[4396] Alice: …but, the flower is wilted.
[4397] Betty: Big trouble for you!

                               — syncopation —

[4444] Betty: [She began to write a message titled "about junior high school
               students"]
```

As shown in Fig. 5, Alice's bee was located at a distance from the others, at a periclinal part of the mapping.

Alice stated, “I can’t say I’m happy with where it is,” “I’m in a slightly awkward location” [4366], and “I’m so lonely” [4373], moving her mouse cursor between her bee and others very quickly, immediately after finding her location [4366].

At this point, we should notice that Alice stated “my bee has become further away from the others” [4373] and “my location changed from the last time” [4390] in the transcript. These words “become further away” and “change” contain significance regarding the speaker’s recognition of the change in status. Briefly, it would not be possible for her to make such a statement without comparing her present status of the i-Bee with her past status.

Therefore, it is clear that Alice used negative phrases such as “a slightly awkward location,” “lonely and distant from the others,” [4377] etc. due to her recognition of the change in her status. These phrases are considered as her assessment for her bee that was located in a relatively undesirable position than before; this showed that she did not commit well to the discussion

Betty also assessed her location on the i-Bee in this fragment of conversation. It is noteworthy that she attempted to improve her condition expressed on the i-Bee on her own. At that time, as shown in Fig. 5, her location was closer to the “elementary school” and somewhat further away from “junior high school.”

She confirmed her location and stated, “As I predicted, I’m still at the ‘elementary school.’ I have to move on to ‘junior high school.’” [4386] She then began writing a message titled “about junior high school students,” which included her impression of the junior high school internship [4444].

In this case, similar to Alice’s, it may be stated beyond doubt that Betty remembered the previous location of her bee as being closer to the “elementary school.” She then “predicted” that the location scarcely differed from the previous one and confirmed as the above-mentioned scene. She then engaged herself in writing messages regarding “junior high school.”

Why did Betty state “I have to move on to ‘junior high school’”? At this point, we may recall their learning context, i.e., they prepared their portfolios based on their internship in junior high schools. Her position on the i-Bee expressed a lack of association between her commitment in the discussion and her practice in this course. Consequently, she became aware of this disjunction and changed her statement thereafter. It can be stated that such an activity on Betty’s part indicates self-assessment and improvement of her statement in the discussion.

All these statements clarify that the i-Bee can be a cognitive resource for learners to recognize a time-series change of state, which encourages them to assess their level of commitment to the topics or the whole of the discussion. Such recognition and assessment encourage learners to consider their level of participation at the meta-level.

CONCLUSION and FUTURE ISSUES

This study deals with self-assessment during a discussion, wherein learners can view the discussion, reflect in a content-wise manner, and reorganize their attitude in the discussion. The authors propose a method by which to visualize learners’ commitments to the content of a discussion and develop the software, i-Bee, which is implemented in the algorithm to encourage learners to assess their discussion. The evaluation elucidates that visualization of the discussion based on its contents should be a cognitive resource for learners to assess their learning through discussion along with observation of the difference between the status at that time and in the past.

Thus, the authors conclude that providing opportunities for such assessments and reflection encourages learners to improve their learning by comparing their learning context even in a collaborative learning setting.

Our final points should be covered in keeping with the future issues. The first issue is more precise analysis of the effect of the i-Bee, especially in the asynchronous situation, in order to reveal more concrete results which indicate how the i-Bee supports students. The second issue is with regard to selection of keywords. In order to assist even moderators such as teachers or assistants, a new method should be developed. This method should be able to satisfactorily select keywords for learners and teachers based on the learning context and from the viewpoint of social constructivism, which constitutes the basis of the collaborative learning theory. The third issue is with regard to the information provided by CSCL environments like the i-Bee. It can be said that providing awareness with regard to not only the discussion but also other social activities holds the possibility of encouraging learners to assess and improve their activities in the CSCL. However, this is only conjecture at this stage; we would like to empirically discuss in our future works.

ACKNOWLEDGMENTS

A part of this research has received the assistance of Grant-in-Aid for JSPS Fellows for Toshio Mochizuki, Grant-in-Aid for Exploratory Research (No. 15650171, Representative: Hiroshi Kato), Grant-in-Aid for Scientific Research (B) (No. 16300280, Representative: Hiroshi Kato), Grant-in-Aid for Specific Field (No. 15020103, Representative: Mariko Suzuki), and Grant-in-Aid for Young Studies (B) (No. 16700560, Representative: Tomoko Nagata) from the Japanese Ministry of Education, Culture, Sports, Science and Technology.

REFERENCES

Collins, A. and Brown, J. S. (1988). The Computer as a Tool for Learning Through Reflection. In Mandi, H. and Lesgold, A. (Eds.) *Learning Issues for Intelligent Tutoring Systems*, Springer-Verlag, New York, pp.1–18.

Doomik, J. A. (2001). *Ox: An Object-Oriented Matrix Language* (4th Ed.). Timberlake Consultants Press, London.

Ericsson, K. and Simon, H. (1993). *Protocol analysis—Verbal reports as data*. The MIT Press, Cambridge, MA.

Greenacre, M. J. (1984). *Theory and Applications of Correspondence Analysis.* Academic Press, London.

Gutwin, C., Stark, G., and Greenberg, S. (1995). Support for workspace awareness in educational groupware. Proceedings of CSCL'95 (Bloomington, IN, October 1995), LEA, 147–156.

Kato, H., Mochizuki, T., Funaoi, H., and Suzuki, H. (2004). A Principle for CSCL Design: Emergent Division of Labor. Proceedings of ED-MEDIA 2004 (Lugano, Switzerland, June 2004), AACE, 2652–2659.

Kimura, Y. and Tsuzuki, T. (1998). Group Decision Making and Communication Mode: An Experimental Social Psychological Examination of the Differences between the Computer-mediated Communication and the Face-to-face Communication (in Japanese). *The Japanese Journal of Experimental Social Psychology*, **38**, 2, 183–192.

Landauer, T., K., Laham, D. and Derr, M.(2004). From Paragraph to Graph: Latent Semantic Analysis for Information Visualization. Proceedings of the National Academy Sciences, **101**, Suppl. 1, 5214-5219.

Li, H. and Yamanishi, K. (2001). Mining from Open Answers in Questionnaire Data. Proceedings of the 7th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (San Francisco, CA, August 2001), ACM Press, 443–449.

Martínez, A., Dimitriadis, Y., Rubia, B., Gómez, E., and de la Fuente, P. (2003). Combining Qualitative Evaluation and Social Network Analysis for the Study of Classroom Social Interactions. *Computers & Education*, **41**, 4, 353–368.

Matsumoto, Y., Kitauchi, A., Yamashita, T., Hirano, Y., Matsuda, H., Takaoka, K., and Asahara, M. (2000). Japanese Morphological Analysis System ChaSen version 2.2.1. [http://chasen.aist-nara.ac.jp/chasen/doc/chasen-2.2.1.pdf, available on Nov. 1st, 2004].

Miyake, N. (1986) Constructive Interaction and the Iterative Process of Understanding. *Cognitive Science*, **10**, 151-177

Mochizuki, T., Fujitani, S., Isshiki, Y., Yamauchi, Y., Kato, H. (2003). Assessment of Collaborative Learning for Students: Making the State of Discussion Visible for their Reflection by Text Mining of Electronic Forums. Proceedings of E-Learn 2003 (Phoenix, AZ, November 2003), AACE, 285–288.

Nakahara, J. and Nishimori, T. (Eds.) (2003) *e-Learning: New Challenges of the Japanese universities* (in Japanese). Ohmu Publishing Co., Tokyo.

Nakahara, J., Hisamatsu, S., Yaegashi, Y., and Yamauchi, Y. (in printing) iTree: Does the mobile phone encourage learners to be more involved in collaborative learning? Proceedings of Computer Supported Collaborative Learning 2005 (Taipei, Taiwan, May and June 2005), ISLS.

Palincsar, A. S. (1998). Social Constructivist Perspectives on Teaching and Learning. *Annual Review of Psychology*, **49**, 345–375.

Palloff, R. and Pratt, K. (1999). *Building Learning Communities in Cyberspace: Effective Strategies for the Online Classroom*. Jossey-Bass, Inc. Pub.

Pea, R. D. (1993). Practices of Distributed Intelligence and Designs for Education. In Salomon, G. (Ed.). *Distributed cognitions,* Cambridge University Press, New York, NY, pp. 47–87.

Puntambekara, S. and Luckin, R. (2003). Documenting Collaborative Learning: What Should be Measured and How? *Computers & Education*, **41**, 4, 309–311.

Roschelle, J. (1992). Learning by Collaborating: Convergent Conceptual Change. *The Journal of the Learning Sciences*, **2**(3), 235–276.

Shaklee, B. D., Barbour, N. E., Ambrose, R., and Hansford, S. J. (1997). *Designing and Using Portfolio*. Allyn and Bacon, Boston, MA.

Shirouzu, H., Miyake, N., and Masukawa, H. (2002). Cognitively Active Externalization for Situated Reflection, *Cognitive Science*, **26**, 4, 469–501.