

## **Evaluation of the Support Function of a Knowledge-Creating Community: Visualizing Relationships between Members in an Online Situation**

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**Abstract:** The visualization of social interaction is a key factor in improving knowledge-creating communities. In this study, we examine whether a visualized feedback function based on articles on a bulletin board system (BBS) can improve the quality of community members' work. We developed a visual feedback function and compared reported activities in face-to-face and online-only environments using BBS log data. The data analysis for 2018 to 2020 showed that members used the visualization function continuously. Members also posted more creative article than in the period when there was no feedback function. A subjective evaluation suggests that the visualization function helped members and encouraged them to change their activities related to posting reply articles to colleagues on a BBS.

### **Introduction**

This study proposes a feedback function for a community of learners to facilitate sharing and enhance collective cognitive responsibility (CCR) in an online-only environment. In a knowledge-building community, learning as a community, not as individual learners, is essential (Scardamalia & Bereiter, 1991). In particular, it is important to enhance CCR and share it among members for knowledge building (Scardamalia, 2002).

To implement a new function for enhancing CCR in an online learning environment, the idea of socially shared regulation (Järvelä & Hadwin, 2013) has been suggested. In a collaborative learning situation, the goal is to build common ground based on the target problem and to share understandings with peers (Roschelle & Teasley, 1995). Within a community of learners, learners are encouraged to share their expertise (Brown & Campione, 1994). Recent studies related to socially shared regulation have pointed out that collaborative learning includes regulation processes to overcome difficulties in sustaining successful learning trajectories (Järvelä, 2021). In socially shared regulation, learners are expected to know not only about task progressions or the viewpoints of their peers but also about the social states of their peers.

### **Background**

Social network analysis (SNA) has become a promising means to develop a function for improving learners' CCR (Barabási, 2005; Strogatz, 2001). In particular, it is used to examine the status of members of the knowledge-building community (Ma et al., 2016; Tao & Zhang, 2021; Zhang et al., 2009). Further, there are also cases wherein learners have received SNA feedback. Ouyang et al. (2021) and Kondo et al. (2020a) particularly used SNA visualization results as feedback for community members.

Recent studies using machine learning (ML) or deep learning (DL) have become more accurate in coding learners' dialogues automatically (Fiacco et al., 2021). However, in the case of creative learning processes, ML or DL has limitations in providing feedback because in creative learning situations, learners are expected to develop new learning processes.

In this study, we focus on the feedback function of SNA for investigating the extent to which knowledge-building learning activities in a community are promoted in an online-only environment. We also visualize the relationships between each community member in an online-only environment using SNA. To determine whether knowledge-building learning relating activities have occurred, we assess the quality of interactions in the bulletin board system (BBS) using the analytical method of Berkowitz and Gibbs (1983).

### **Research target**

This study focuses on a community of student staff members responsible for the operation and improvement of a university's active learning classroom—Classroom-M—as a part-time job. Student staff members are expected to be “adaptive experts” (Hatano & Inagaki, 1986). They used a web-based electronic BBS developed by Kondo et al. (2020b). This BBS has been modified twice: in 2018 and in 2020 (see below for further details), and both of these modifications were to give the betweenness-centrality value (BC value) in SNA as feedback to the student

staff members. The BC value in SNA indicates the degree to which members of a community act as mediators between each member. Kidane and Gloor (2007) analyzed mailing lists and suggested that the BC value may be correlated with the degree of knowledge creation in a community. Student staff members could check the results of the feedback function anytime they needed to in 2019 and 2020.

In this study, we analyzed data from January 1, 2018 to December 31, 2020. We divided the three-year research target period into three periods (2018, 2019, and 2020) based on the timing of the changes to the feedback function. In addition, during the course of conducting this study, the workplace of the student staff members also shifted in 2020 because of the COVID-19 pandemic. Table 1 shows the BBS feedback function with the primary workplace of the student staff members per period.

**Table 1**  
*Provided Feedback Functions and Primary Workplace of Student Staff Members*

Year	Feedback function of betweenness centrality (BC)	Primary workplace
2018	(None)	Face to face and BBS
2019	Numerical BC value only	Face to face and BBS
2020	BC values to each individual with visualization	Online only (BBS and video conference)

## Method

We analyzed the effectiveness of the developed feedback function from three perspectives: survey of frequency of use of the function, questionnaire survey, and qualitative analysis of articles on the BBS. There were nine student staff members in 2018, ten in 2019, and nine in 2020. Three student staff members worked continuously from 2018 to 2020, and four worked continuously from 2019 to 2020. In total, 3,039 articles were posted on the BBS in 2018, 3,150 in 2019, and 3,045 in 2020.

First, for the survey of frequency of use of the function, we analyzed whether the visual feedback function was used and whether the use of the feedback function continued, based on the log data of the BBS in 2020. We focused solely on 2020 because the frequency of use of the numerical feedback function in 2019 had been analyzed by Kondo (2020b).

Secondly, we conducted a questionnaire survey with the student staff members to collect their impressions about the feedback function in 2020 using Google Forms for a subjective evaluation. The feedback function was considered effective if the student staff members increased their degree of engagement in their work in relation to using the feedback function. We focused solely on 2020 because a subjective evaluation in 2019 had been conducted and reported by Kondo (2020b).

Finally, we conducted qualitative analysis of articles on the BBS to show the differences between the three research periods using the articles posted on the BBS using the qualitative analysis method proposed by Berkowitz and Gibbs (1983). The article category “daily report” included information resources referenced by the student staff members to solve problems or improve the Classroom-M environment, their ideas, and trials on the ideas suggested by colleagues. Through this discussion, the student staff members were expected to develop their work-related knowledge and improve their ideas.

## Results

### Survey of frequency of use of the function

From the BBS operation log for 2020, we extracted the date and time when student staff members used the feedback visualization function. The function was invoked 2,182 times by nine student staff members. We counted the number of days in each month that student staff members invoked the feedback function to ascertain how they invoked the function continuously at least once per month. The six student staff members who used the function continuously for more than nine months (75% of a year) were categorized as continuity Level III, two student staff members who used the function continuously for six to nine months were categorized as Level II, and one student staff member who used it for less than six months was categorized as Level I.

### Questionnaire survey

Eight of the nine student staff members participated in the questionnaire survey from the end of February 2021 to March 2021 using Google Forms. We analyzed the responses to the questionnaire item “Please explain how you changed your thinking about your activities using the visualizing feedback function. If you have not changed your way of thinking, please describe what you think about the visualizing feedback function. Answer in a free format.” Responses were categorized into three categories: (a) those who stated their interpretation of the meaning of the

relationship between the execution results from the feedback function and their work on the BBS, (b) those who mentioned changes in their own behavior when posting their articles but did not mention their interpretation between the execution results of the feedback function and their work on the BBS, and (c) those who referred to only about the BC value going up/down. The results are shown in Table 2.

**Table 2**

*Student Staff Members' Understanding of the Feedback Functions and Their Responses to a Community*

Staff member	Response	Category
A	I became more aware of who I was working with, not only in terms of the content of my work but also in terms of how I proceeded.	(a)
B	I started to pay more attention to my BC value and the status of my replies.	(a)
C	Among the three visualization functions, the reply relationship diagram made me aware of the fact that my replies concentrated on specific student staff members. My BC value did not go up when I only communicated with one student staff member, so I think my use of the visualization feedback function helped me to become more involved with other student staff members.	(a)
D	I tried to post comments to my colleagues as much as possible.	(b)
E	In particular, by using the network visualization function, I was able to see who interacted on the BBS, and I started to pay more attention to their posts.	(a)
F	I tried to prevent my BC value from going down. When I had not been able to check the BBS for a couple of days, by using this function to see my BC values, I realized that it was a bad way to work because my BC values were extremely low.	(c)
G	I changed my mindset to share more opinions to my colleagues.	(b)
H	I used the visualization function to look at everyone's BC values, and when mine was low, I looked at the network function and actively commented on the posts of those with whom I was not communicating.	(a)

## Qualitative analysis of articles on the BBS

We extracted 371 replies that were posted to the daily report category on the BBS during these three years. The first author classified the content of the replies according to the following criteria. If the content of the reply article referred to "regular/routine work," the article was classified as "Regular." If the content of a reply article referred to "adaptive/creative work such as investigating different work or making new proposals," the article was classified as "Adaptive." In this study, we defined "Adaptive" as operational transactions. Last, reply article content neither "Regular" nor "Adaptive," such as "I got it" or "thx (thanks)," were classified as "Other." The classification results by year are shown in Table 3. The first and second author independently coded of the categories (Regular, Adaptive and Other) for all 371 reply articles from 2018 to 2020 on the BBS. The agreement rate of the two raters was 84.1%. Interrater reliability was assessed using Cohen's kappa. The results showed moderate to strong levels of agreement: 0.64. When coded categories by two raters differed, the raters resolved disagreements through discussions.

A Chi-squared test was conducted to elucidate the ratio of articles between "Regular" and "Adaptive" from 2018 to 2020 shown in Table 3, and the result was statistically significant:  $\chi^2(2) = 97.462, p < .01$ . Residual analysis of the result showed that there were significantly more Regular articles in 2018 and 2019 than in 2020, and significantly more Adaptive articles in 2020 than in 2018 and 2019 ( $p < .05$ ).

**Table 3**

*Classification of Replies in Daily Reports on the BBS*

	Regular	Adaptive	Other
2018	59	15	49
2019	46	6	78
2020	3	52	63

## Discussion, conclusion, and implications

The results of the survey of the function's frequency of use in 2020 suggest that most staff members were getting accustomed to using the feedback function in their course of work. From the questionnaire survey, seven of the eight staff members who participated were categorized as (a) or (b), suggesting the impact of the feedback function.

Moreover, one student staff member who was categorized as category (c) may have misunderstood that the BC value was determined by him alone. We qualitatively compared reply articles on the BBS by classifying them as either “Regular,” “Adaptive,” or “Other” from 2018 to 2020. On comparing 2019 and 2020, the result captured the change of the work in the community due to the COVID-19 pandemic and the introduction of the visual feedback function on the BBS.

These results suggested that the visual feedback function was used continuously by most of the staff members, and it helped to change their work in a way that considered the relationships between the execution results from the feedback function and their work on the BBS in an online-only environment. To examine the effects of the visual feedback function on its own, it would be necessary to test it in different communities or evaluate it after the COVID-19 pandemic.

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