

Attempt to Design Electronic Bulletin Board Based on Information-Sharing Behavior Observations with Analog Bulletin Boards

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Abstract—In this study, based on the hypothesis that incorporating an analog information sharing environment, such as a station bulletin board, into a digital information sharing environment would enable casual and informal information sharing across small communities within a large organization, we conducted about 2 months of observation of whiteboard usage behaviors. Based on the results, we designed and implemented an electronic bulletin board through a large display that has functions to promote messages, improve their quality, and process them according to their importance, and allows users to post and view messages while conversing. We then conducted a user study for about 5 months to evaluate the effectiveness of the features of our electronic bulletin board based on the findings from our whiteboard observations and to test our hypothesis. As a result, we found that there were an average of 3 to 10 posts per day, including new posts and replies. In terms of reading, the survey found that about 90% of the 307 respondents (about 15% of all students) had read the bulletin board, confirming that our electronic bulletin board is being used daily as an information sharing tool. In addition, the "I saw it" reaction button was used for about 30% of all new posts and replies (552 posts), and the "Delete it" button was used for about 10%. Analysis of the message content in conjunction with the reaction buttons showed that they contribute to maintaining the quality of posts and judging the importance of posts, confirming the effectiveness of the implemented functions. Furthermore, the survey found multiple responses indicating that information sharing across departmental boundaries was possible, confirming that the hypothesis that by incorporating an analog information sharing environment, such as a station bulletin board, into a digital information sharing environment, it would be possible to achieve casual and informal information sharing across small communities within a large organization, is correct.

Keywords—component; informal information sharing; electronic bulletin board; analog bulletin board; user study.

I. INTRODUCTION

This study is aimed at providing an unconventional information-sharing platform to make the useful information in casual conversations with people within large organizations such as universities and companies. In our previous study [1], we set up an analog information sharing space using a whiteboard in our university, observed users' writing and browsing behaviors, and examined the elements necessary to promote lightweight and informal information sharing to clarify the effective aspects of information sharing in the analog world. On the basis of observations of the whiteboard, we designed and implemented an electronic bulletin board for

information sharing and confirmed through trial experiments that users continuously posted and replied to messages on the board.

In this paper, we conduct a more detailed analysis of the observed information sharing behavior in the analog world and a more detailed analysis of the user study of the electronic bulletin board we designed and implemented. In addition, we verify the effectiveness of the various functions of the implemented bulletin board, and examine whether the ultimate goal of this research—enabling casual and informal information sharing that transcends the boundaries of small communities within large organizations—is achievable or not.

In any organization, there are likely people who have already solved a particular problem or answered a particular question. Informal communications with such people can often contain useful information. However, information sharing that leads to problem-solving is often limited to close relationships. In large organizations such as universities and companies, people typically spend most of their time within small communities such as research laboratories or departments. Consequently, opportunities for information sharing beyond the boundaries of these small communities are limited. In some organizations, team communication services or social networking services (SNS) are used as a means of digital information sharing at the research laboratory or department level to support organizational information sharing [2] [3]. However, superiors and supervisors often use these platforms as a one-way communication channel. Community members perceive these platforms as formal spaces, hindering casual and informal information sharing.

To explore informal information sharing beyond the boundaries of existing organizations in the digital world, we consider the informal information exchange and sharing opportunities we experienced in the past through the use of online collaborative document-editing tools in a context-free and free-flowing manner. To further explore informal information sharing environments similar to the one we experienced, we also consider the analog information sharing environment of bulletin boards that were once installed in railway stations in Japan. These boards were originally intended for leaving messages about meeting places, such as for people who were late for appointments. However, they were often used for other purposes, such as sharing travel impressions, looking for friends, or scribbling graffiti. We believe that by incorporating an environment similar to these station message boards, where users can freely write in a free context, into digital information sharing environments, it is

possible to promote informal and casual information sharing across small communities within large organizations.

Based on the above discussion, this study hypothesizes that by incorporating analog information sharing environments like the bulletin boards at train stations into digital information sharing environments, it will be possible to facilitate informal and casual information sharing across small communities within large organizations. To test this hypothesis, we set up a whiteboard in our university as an information sharing space where people can freely write whatever they like. We observed and analyzed the users' writing and browsing behavior to examine which elements of the analog information sharing environment should be incorporated into the digital information sharing environment. Based on the results, we designed and implemented an electronic bulletin board as a digital information sharing environment. We then conducted a user study of the implemented electronic bulletin board to evaluate its effectiveness and usefulness.

This paper is organized as follows. Section II reviews related research. Section III describes the observational study of the installed whiteboards. Section IV presents the design and implementation of the electronic bulletin board based on the results of the previous section. Section V describes the user study of this electronic bulletin board. Section VI discusses the findings and limitations of the study, and Section VII concludes this paper.

II. RELATED WORK

While there has been extensive research on the design and development of information sharing environments, recent trends indicate a growing reliance on existing team communication services and social networking services (SNS) for digital information sharing [2] [3]. Existing research in this area primarily focuses on modeling user relationships and posting activities on online forums [4] or exploring asynchronous online information sharing as a potential solution to collaboration fatigue in remote meetings [5]. To the best of our knowledge, there has been very little research on the design and development of informal information sharing environments using large displays. This paper provides an overview of several studies on information sharing that is achieved through the installation of large displays in shared spaces, similar to our study.

Nishimoto et al. [6] conducted an important study on promoting synchronous information sharing in large-scale organizations. In their system, a person with a transponder, a device that automatically sends a signal when it receives a different signal, approaches a large display in a shared space, and a question registered in advance by the person is displayed. This facilitates synchronous information sharing with users of the shared space who happen to see and discuss the question. The advantage of their system is that it does not require information providers to register their information with the system in advance, while general knowledge-management software requires users to register their information with the system. However, this approach focuses on synchronous information sharing and has the drawback that users cannot

re-read previously displayed questions. In this study, we propose an electronic bulletin board that supports both synchronous and asynchronous information sharing. Users can engage in synchronous information sharing by directly conversing with each other next to the bulletin board, and they can also share information asynchronously by replying to previously posted content. However, one issue to consider is how long to keep posts displayed. To address this issue, we plan to conduct observational studies of posting and reading behavior on whiteboards and design the electronic bulletin board based on the observation results.

Snowdon et al. [7] proposed a recommendation system that semi-automatically displays filtered information on the basis of user comments and feedback for each post. One of the features of their system is that it gives users a more organic impression by randomly arranging the posted information when it is displayed. Their system's advantages include the random arrangement of post information to give users a more organic impression, which we also intend to incorporate into this study. On the other hand, when they actually operated their system, they found that the contents of the posts were often suited to the characteristics of the organization, but there was a problem that the posts were biased towards some users. To address this drawback, we intend to incorporate the findings of Fortin et al. [8] that suggest that displaying available posting spaces while maintaining a well-utilized appearance can attract users.

Chiba et al. [9] proposed "Attractiblog," a system that displays company blogs on a large display in a communication space to induce face-to-face informal communication to support information sharing in large organizations. This system uses ID tags to identify users and can display blog posts that are relevant to the situation, such as those commented on by users who are currently in the communication space. This system has the advantage of using company blog posts, which can facilitate discussions about the organization and lead to more meaningful information sharing. However, this system has the drawback of requiring real-name use. This is because they also presented the results of a survey [10] that showed that anxiety about the possibility of providing incorrect information is an obstacle to knowledge sharing in workplace information sharing, such as on company blogs. There are also reports that self-esteem is higher when interacting anonymously through system-mediated communication [11], leading to more voluntary self-disclosure [12]. Therefore, we assume anonymous use of our bulletin board.

Greenberg et al. [13] proposed "The Notification Collage," is used to share information not with individuals but with the community as a whole by allowing people in a small community to post their daily discoveries to the system. This system offers several advantages over conventional chat tools. Firstly, posted information is not displayed in a linear list, but rather randomly arranged like an analog bulletin board. This creates a more organic and visually appealing experience. Secondly, new posts are stacked on top of older ones, ensuring that the latest information is always visible to users, similar to chat tools. In this study, we intend to incorporate information presentation methods that correspond to information freshness

into the design of the electronic bulletin board, including random arrangement and keeping the latest information visible. On the other hand, the Notification Collage was designed to be used on both large displays and personal devices. However, it was found that most users preferred to post and view information from their personal devices, resulting in underutilization of the large displays and limited opportunities for synchronous information sharing. This can be considered a drawback of the system. As we believe that synchronous information sharing is also important, this study focuses solely on the use of large displays.

III. OBSERVATIONAL STUDY

In this study, we set up two whiteboards in our university for about 2 months and observed posting and browsing behavior to realize lightweight and informal information sharing in the digital world that incorporates effective elements of information sharing in the analog world. The observation aimed to elucidate the elements necessary for beneficial information sharing on whiteboards, where people can freely write whatever they want, and to examine the elements necessary for facilitating information sharing on an electronic bulletin board.

A. Overview of Observations

We installed two whiteboards in the corridors on the 2nd and 3rd floors of our faculty building at our university (see Figure 1) for about 2 months. The reason is that these locations are conspicuous to students on their way to the student hall building, where the cafeteria and store are located, and to the common lecture building, where many lectures are held.

We set up a pen and a cleaner on each whiteboard (Figure 2). To create an environment that encourages student interaction through the whiteboards, we posted a sign next to each whiteboard explaining that “this whiteboard is a space for writing questions and answers about student life.”

To collect data to be used to analyze information-sharing behavior, we took pictures of the entries on each whiteboard every weekday evening. From these pictures, we manually transcribed the contents written on each whiteboard and organized the contents of the writings and their relationships with other writings (related topics, question-answer relationships, etc.).

Furthermore, we conducted a questionnaire survey on the use of these whiteboards and information sharing related to daily life for all students in our university after the observation period. Additionally, we displayed a notice stating that the content written on the whiteboard would only be used for research purposes. We also informed participants in advance that if they could not consent to having their intended whiteboard writings utilized, they should refrain from writing on the whiteboard.

The observation period was approximately 2 months and was conducted on weekdays, excluding weekends and public holidays. To investigate the necessary requirements and incentive mechanisms for designing electronic bulletin boards, the observation period was divided into 5 periods, and the conditions for the whiteboards were changed on the 2nd and

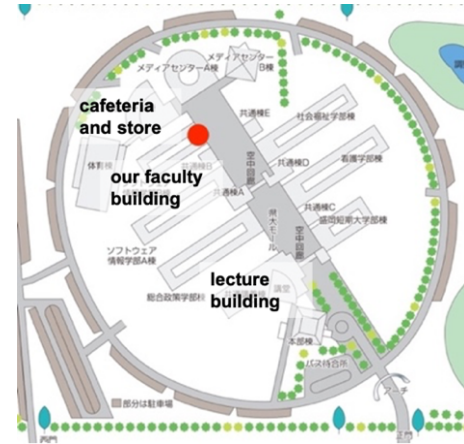


Figure 1. Campus plan of our university and locations of whiteboards [Red circles indicate locations (2nd and 3rd floor)].

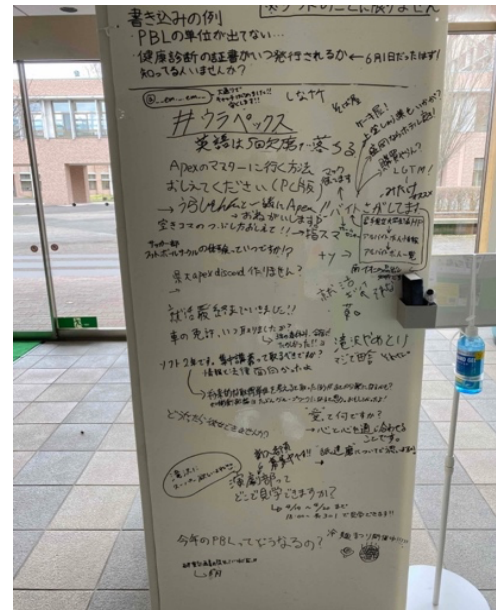


Figure 2. Installed whiteboard

3rd floors during each period. The 5 periods and conditions are as follows. Note that the 4th, 5th, and 7th weeks were excluded from the target period because they included weekdays with public holidays.

1) Period 1 (1st week)

The purpose was to investigate whether spontaneous posts would occur on new whiteboards without specific instructions. The observation started with the 2nd and 3rd-floor whiteboards in a blank state.

2) Period 2 (2nd week)

The purpose was to investigate whether spontaneous deletion would occur when there was no new writing space

on the whiteboards and to investigate the effects of keeping posts. The conditions were as follows:

- 2nd floor: The observation started with some of the remaining posts from Period 1. We would delete the posts if two days had passed since the last post or the whiteboard was 80% filled.
- 3rd floor: The observation started with the remaining posts from Period 1. We would not perform any regular deletion of posts.

3) Period 3 (3rd week)

The purpose was the same as that of Period 2. The conditions were as follows:

- 2nd floor: We regularly deleted posts following the same rules as Period 2.
- 3rd floor: The observation started with all of the posts from Period 2 deleted. We would not perform any periodic deletions.

4) Period 4 (6th week)

The purpose was to investigate whether the number of questions would increase. The conditions were as follows:

- 2nd floor: We would periodically delete posts. We also instructed participants to add a “Q” mark at the beginning of any question posts.
- 3rd floor: We would periodically delete posts.

5) Period 5 (8th week)

The purpose was to investigate whether the presence or absence of dividing lines would affect the number of posts. The conditions were as follows:

- 2nd floor: We would periodically delete posts. We also instructed participants to add a “Q” mark at the beginning of any question posts.
- 3rd floor: At the beginning of Period 5, all posts from Period 4 were deleted. We then implemented the same conditions for the 2nd-floor whiteboard, including periodic deletion and the instruction to add a “Q” mark to the beginning of questions. Additionally, we drew dividing lines on the whiteboard to separate different posts clearly (see Figure 3).

B. Observation Results

1) Whiteboard Usage

To investigate whether spontaneous posts would occur on a blank whiteboard without any specific instructions, we counted the number of posts on each floor (2nd and 3rd) during a period of 1 day. Table 1 shows the results. We did not distinguish between types of posts, such as questions and replies.

Table 1 shows that there were no posts on either the 2nd or 3rd floor on Day 1. However, from Day 2 onwards, there were posts on both floors every day. This confirms that posting can occur spontaneously on a blank whiteboard without specific instructions and that replies and comments to posts can also occur naturally.

Table 1 also shows that the number of posts on the 2nd floor on Day 3 was extremely high. To clarify this, we investigated the contents of the posts on Day 3. As a result, we

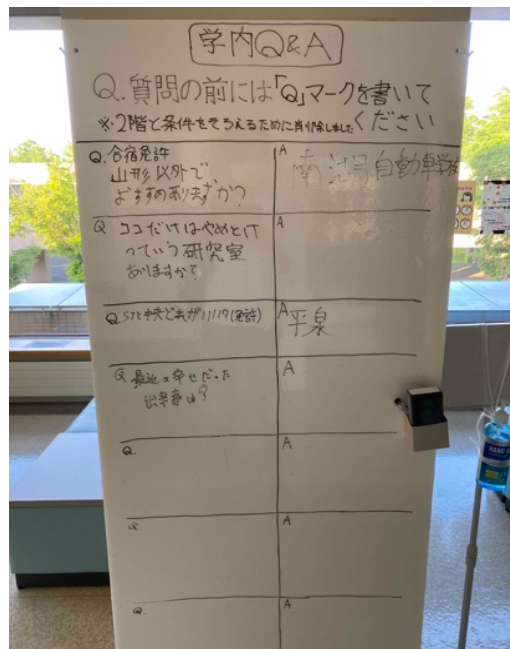


Figure 3. 3rd-floor whiteboard in period 5

found that posts were looking for part-time jobs and soliciting club membership, and there were many posts on these topics. We believe this is because the observation period coincided with the week when the new university semester began. Furthermore, we analyzed the contents of the posts after Day 3 to investigate why the number of posts increased. As a result, we found that many of the posts were about club recruitment. We can infer that this is because several people saw someone recruiting for a club on the whiteboard on Day 3 and started imitating them. Furthermore, an analysis of the correspondence between each post, i.e., the structure of the topic, revealed that multiple posts responded to a single question. This shows that whiteboards without specific instructions are environments with a high degree of freedom regarding the content of posts, as multiple users can freely respond to a single question.

2) Whether Spontaneous Deletion Occurs and Effect of Regular Deletion

During Periods 2 (2nd week, Days 8-12) and 3 (3rd week, Days 15-19), we periodically deleted the whiteboards on the 2nd floor, while we did not delete the whiteboards on the 3rd floor. The periodic deletion was performed when a post was 2 days old, or the whiteboard was 80% filled.

First, we checked whether spontaneous deletion was done by users. On the 3rd-floor whiteboard, where no regular deletion was performed, the whiteboard was filled with posts by Day 11, and there was no space for new posts. However, users did not delete any of their posts, as shown in Table 2; there were no posts on the 3rd-floor whiteboard on Day 12. This suggests that users are unlikely to spontaneously delete their own posts even when they cannot post new ones without deleting something.

On the other hand, the 2nd floor whiteboard, where regular deletion was performed, had posts every day during the

observation period, as shown in Table 2. However, the number of posts on Day 11 was only 2. This is likely because the whiteboard was 80% filled, and posts had less space than usual. These results suggest that regular deletion is effective in encouraging user posting.

3) Effects of Keeping Posts

At the beginning of Periods 3 and 5, all posts on the 3rd-floor whiteboard were deleted. As shown in Tables 3 and 5, the number of posts decreased for a few days after the deletion in both cases. However, once a new post was made, the number of posts tended to increase. On the other hand, on the 2nd-floor whiteboard, where we performed regular deletion, there was no day without posts except when there was little space left on the whiteboard. These results suggest that keeping a certain number of posts on a whiteboard can lower the barrier to posting.

4) Effects of Indicating Post Types and Gridlines

In Period 4, we added an explanation to the top of the whiteboard on the 2nd floor asking users to start question posts with the “Q” mark to clarify the types of posts. We did the same for the second and third floors in Period 5.

To investigate whether this increased question posts, we compared the number of question posts on the 2nd floor in Periods 1, 2, and 3 with the number of question posts in Periods 4 and 5 (see Table 6). The results showed that the number remained almost unchanged. This suggests that explicitly indicating questions with a “Q” mark and clarifying the types of posts did not have a significant effect.

In Period 5, on Day 57, we deleted all posts on the 3rd-floor whiteboard and drew a 2×7 grid to separate each post. We also added an explanation to the top of the whiteboard, as

TABLE 1. NUMBER OF POSTS (PERIOD 1)

	Day 1	Day 2	Day 3	Day 4	Day 5
2 nd floor	0	8	18	6	13
3 rd floor	0	4	10	2	9

TABLE 2. NUMBER OF POSTS (PERIOD 2)

	Day 8	Day 9	Day 10	Day 11	Day 12
2 nd floor	9	6	5	2	10
3 rd floor	1	3	4	6	0

TABLE 3. NUMBER OF POSTS (PERIOD 3)

	Day 15	Day 16	Day 17	Day 18	Day 19
2 nd floor	4	12	5	11	6
3 rd floor	4	0	1	8	6

TABLE 4. NUMBER OF POSTS (PERIOD 4)

	Day 36	Day 37	Day 38	Day 39	Day 40
2 nd floor	10	2	8	9	2
3 rd floor	4	4	0	2	0

TABLE 5. NUMBER OF POSTS (PERIOD 5)

	Day 57	Day 58	Day 59	Day 60	Day 61
2 nd floor	0	3	11	7	3
3 rd floor	0	0	6	16	5

in Period 4 on the 2nd floor, asking users to start question posts with the “Q” mark. Additionally, we added this mark to each grid to indicate that each grid was an area for posting on a single topic. On Day 58, we observed that users had spontaneously changed the “Q”s in the right column of the grid to “A”s to indicate answers (see Figure 3).

To investigate the effect of drawing gridlines, we compared the number of questions and answers on the third-floor whiteboard in Period 4 (with instructions to start question posts with “Q”) with the number of questions and answers in Period 5 (with instructions to start question posts with “Q” and with gridlines drawn) (see Table 7). The result showed that the number of questions and answers increased in Period 5. This suggests that drawing gridlines was effective in promoting question-and-answer posts.

Another interesting observation is that there were no posts for a few days after the deletion on Day 57. However, on Day 59, posts started to appear again. On Day 60, there were 16 posts, of which 11 were replies to the “Q” marks (see Table 8). This was the highest number of posts per day during the observation period. We believe this is because the clear structure of the question-and-answer pairs, topic flow, and the pre-allocated writing space effectively promoted question-and-answer posts.

5) Continuation of Thread

Regular deletion was implemented on the 2nd-floor bulletin board during Period 2. When there was a reply to a new post, the original post was also kept for two days from the date of the reply. As a result, deletion was only performed on weekdays, so there were some threads where the deletion period was longer than usual due to weekends. Table 9 shows the transition of a thread. Since this thread was originally active, replies continued even after a week. To keep such active threads, it is considered necessary to change the deletion period depending on the reply status of each thread instead of deleting all threads uniformly according to a regular deletion rule.

6) Writing and Reading by Two or More People

We frequently observed several people browsing the whiteboard during the observation period, as shown in Figure 5. In some cases, we observed multiple people filling in the whiteboard (that is, only one person was actually filling in the whiteboard while multiple people were discussing the topic).

This situation is not seen in types of online communication, such as chat rooms or electronic bulletin boards. We believe it is important to take advantage of the benefits of analog communication, as in this case, to activate information sharing.

TABLE 6. NUMBER OF Q&A POSTS (2ND FLOOR)

	Period 1	Period 2	Period 3	Period 4	Period 5
Question	3	7	9	11	9
Answer	18	17	13	16	12

TABLE 7. NUMBER OF Q&A POSTS (3RD FLOOR)

	Period 1	Period 2	Period 3	Period 4	Period 5
Question	2	3	4	4	9
Answer	21	8	8	5	16

TABLE 8. NUMBER OF POSTS BY TYPE (PERIOD 5)

	Day 57	Day 58	Day 59	Day 60	Day 61
Question	0	0	4	3	2
Answer	0	0	2	11	3
Others	0	0	0	2	0
Total	0	0	6	16	5

This situation is not seen in types of online communication, such as chat rooms or electronic bulletin boards. We believe it is important to take advantage of the benefits of analog communication, as in this case, to activate information sharing.

C. Results of Questionnaire Responses

After the observation period, we conducted an online questionnaire survey open to all students at our university. The purpose was to gather information that could not be obtained from the observation, such as the attributes of the whiteboard users and their motives for writing on the whiteboards, as well as to gather information on features that should be incorporated into our electronic bulletin board. There were 208 responses. This number of responses represents approximately 10% of the total students.

TABLE 9. EXAMPLE OF THREAD STRUCTURE

	Content	Post Date
Post	I'm looking for a part-time job	Day 2
Replies	MITAKE (place name) recommended!	Day 4
	How about KAMIDOU (place name) Shabuyou (store name)?	Day 5
	Morioka is a good hotel!	Day 5
	How about purchasing?	Day 5
	Iwate Prefectural University Co-op HP→Part-time job information→List of part-time jobs	Day 5
	Come to ODORI (place name) Happi (store name)!	Day 8
	Cake shop!	Day 8
	900 yen per hour to set out goods at Aeon (store name)!	Day 8
	Buckwheat noodle shop!	Day 12
	Home center	Day 12
	McDonald's is waiting!	Day 12

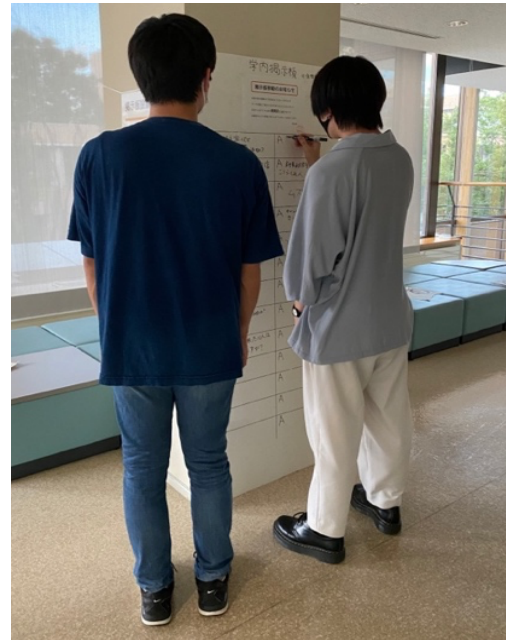


Figure 4. Multiple people writing on whiteboard

1) Dealing with Less Important Information

In response to the questionnaire question “Have you obtained necessary information or new findings from this whiteboard?”, 58.2% of the respondents answered “No.” The reasons were “I found it difficult to understand which information was important because there was too much unimportant information (44.8%),” “I felt the quality of the answers was low (22.9%),” and “I found it difficult to understand which information was important because there were many invitations to join club activities (9.5%).” Several responses said, “There was a lot of unimportant information, so I thought I could post any topic I wanted.” During the whiteboard observation, we left unimportant information as is to facilitate posting. In consideration of these responses, we need to proactively address less critical information on our electronic bulletin board to achieve useful, high-quality information sharing.

2) Duration of Display of Posts

As already explained, during the observation period, we periodically deleted posts. Since we did not indicate the posting period on the board, we received a request in the survey to clarify when posts would be deleted. Considering this answer, the electronic bulletin board we design needs to tell users the remaining time before their posts are deleted.

3) Bulletin Board Location

When asked where the best place to place a bulletin board for information sharing is, 54.5% of respondents said the common building (near the entrance for students who walk or take public transportation), and 45.5% said in front of the shopping area. This was because “active responses can be expected,” according to 71.7% of respondents. In other words, users believe that the bulletin board should be installed in a

high-traffic area, and they believe that the bulletin board will be more active if it is installed in a visible location. However, installing the board in a high-traffic area that is easily visible to others contradicts the phenomenon known as social embarrassment [14], in which users are less likely to take action because they are concerned about being seen by others.

D. Design Principles of Electronic Bulletin Board Based on Whiteboard Observations

This section describes how the observations of the whiteboard are reflected in the design of the electronic bulletin board.

1) Mechanisms to Promote Posting

The results of the whiteboard observation showed that the number of posts was low when there was no space for posting or when there were no posts. It was also confirmed that a system for periodically deleting posts while keeping some of the content effectively solved this problem. Therefore, the electronic bulletin board to be designed will incorporate a function for the system to delete posts periodically.

In addition, the questionnaire results showed that there was a request to clarify the posting period. We believe that directly showing the remaining time until deletion for all posts may confuse users regarding readability. To avoid confusion, we need to consider a way to indicate the remaining time until deletion indirectly. Therefore, we will incorporate a function that indirectly conveys the remaining time until deletion, or the elapsed time of the post, by changing the font color to different shades.

Furthermore, the questionnaire results showed that users want the bulletin board installed in a place with high traffic and visibility. However, we believe that some users may feel uncomfortable posting in a place where they are visible and that we need to consider social embarrassment. In this regard, we will install the electronic bulletin board in places that are visible and considerate of social embarrassment, as well as places where users can post without being seen, and we will confirm the usage status at each installation location.

2) Mechanisms for Improving Quality of Posts

To realize useful information sharing, it is necessary for users to post information they want to know about and for appropriate responses to be posted. In addition, for users to easily find the information they need from the bulletin board, the visibility and readability of questions and answers need to be maximized.

In this regard, the results of the whiteboard observation showed that it is important for the quality of information to have post spaces prepared in advance and to be able to distinguish between posts that are similar to questions and posts that are responses to existing posts. It was also found that this is effective in promoting posting. Therefore, in the electronic bulletin board to be designed, post space will be secured in advance as a grid, and questions and corresponding answers will be placed next to each other.

In addition, the questionnaire results showed that many users felt that there was too much unnecessary information

and that it was difficult to find important information. In the whiteboard observation, we did not consider the importance of the post content, and we did not take any special measures other than periodic deletion. However, we will deal with low-importance information in the electronic bulletin board to be designed. As the importance of the content of a post varies from user to user, we will incorporate a function that allows users who have read the content to vote on whether it is important or not. Depending on the voting results, the time the post is displayed on the bulletin board can be increased or decreased according to its importance.

3) Mechanisms to Continue Threads

In the whiteboard observation, it was confirmed that some threads can last for more than a week. Although there is a possibility that threads will continue even with the automatic deletion function mentioned above, they will also be interrupted by the periodic deletion. Therefore, we will incorporate a process that reflects the response status of posts in the deletion period into the periodic automatic deletion function.

4) Reflecting Advantages of Analog Bulletin Boards in Electronic Bulletin Boards

During the observation, we observed elements such as multiple people reading the whiteboard while talking about the content of the posts and posting while talking. To reflect this advantage of analog bulletin boards in an electronic bulletin board, we will adopt a method for operating the board in which the content of the posts is displayed on a large display and posts can only be made from a terminal attached to the large display.

IV. DESIGN AND IMPLEMENTATION

In this section, we describe the electronic bulletin board we designed and implemented on the basis of our observations of whiteboard usage behavior described in the previous section.

A. Configuration and Usage Environment of Electronic Bulletin Board

This section describes an electronic bulletin board designed for lightweight and informal information sharing within a large organization on the basis of the whiteboard observation results. Figure 5 shows the configuration of the designed and implemented electronic bulletin board and the flow for processing posted data. Unlike a typical online bulletin board where new posts are added and displayed one after another, this bulletin board uses a method where new posts are displayed by overwriting the space where past posts have disappeared over time.

To incorporate the unique advantages of analog bulletin boards, such as the behavior observed in the observation where multiple people write while conversing about the content of the posts, the board we implemented is not a closed bulletin board online but provides a place for information sharing as a real bulletin board. Therefore, the system is designed to work only on the browser of a display terminal

(Raspberry Pi 4) connected to a large display. In addition, posts to the board can only be entered from a keyboard connected to the terminal. As described later, when posts, replies, and reactions are made, the results are stored in the Realtime Database, a database provided by Google's web development platform Firebase, via the Internet.

B. Layout of Electronic Bulletin Board

Our electronic bulletin board has a predetermined posting area arranged in a 3×3 grid. Specifically, as shown in Figure 6, it consists of two 3×3 grid-like post lists that are automatically switched every 50 seconds. Fortin et al. [8] explained that displays that appear to be frequently used while still having free space can attract people, so we decided to arrange the post list in a grid format instead of a list format. If all the grids on the post list are filled with posts and there is no space to post, users can manually switch to another post list using the switch buttons on the screen's left and right sides. After manually switching to another list, users can find an empty space and post.

Each grid is configured as shown in Figure 7, with the top half being for question-like posts and the bottom half for replies to the top posts. In addition, an input field and a post button are provided at the bottom of each grid. Furthermore, two reaction buttons, "I saw it" and "Delete it," are provided for each post in the top and bottom halves. The method of posting and the usage of the reaction buttons will be described later.

C. Posting Questions

To post question-like content on the board, select a grid with a post space on the post list in Figure 6 and click the input area at the bottom of the grid in Figure 7. Next, type the content you want to post using the keyboard connected to the large display terminal. After entering, press the Enter key or the Send button at the bottom right of the post area to post the content. The posted content will be displayed instantly.

As pointed out by Brignull et al. [15], to promote interaction with the system, it is necessary for the interface to be clear and visible from the beginning. Therefore, we decided to always display the input area and the Send button in the post area.

D. Replies to Posts

To reply to an existing post, enter and submit your response in the input area. The input process is similar to posting a question-like post.

If there is already one or more replies, a link, "Check the list (n other posts)" ("n" is the number of other replies), will be displayed above the input area (Figure 7). Click this link to the reply list (Figure 8) and view other replies. The reply list screen has a similar input area, allowing you to reply after checking other replies.

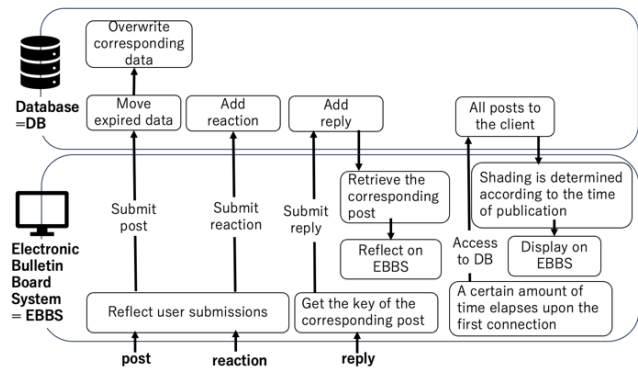


Figure 5. System configuration and data flow



Figure 6. 3×3 grid-like post list

When there are multiple replies to a question-like post, replies posted less than 12 hours ago or with the most "I saw it" button presses will be displayed first. This is to keep replies that are attracting attention from many users always visible. It also prevents low-importance information, such as graffiti or harassment, from being displayed prominently.

E. Reaction Buttons

Both question-like posts and replies each have two reaction buttons: "I saw it" and "Delete" (Figure 7).

- "I saw it" button: This button is used to indicate that the user has read a question that they found interesting, a reply that provides useful information, or simply to show that they have viewed the post.
- "Delete" button: This button is used to report inappropriate posts.

Initially, our bulletin board system used the commonly used UI of "good" and "bad" buttons. The "good" button was intended to be a way to show sympathy or to indicate that you had seen a reply, even if you did not reply yourself. The "bad" button was intended to be used to request that inappropriate posts or replies be deleted by a majority user vote.



Figure 7. Contents of grid



Figure 9. Our electronic bulletin board set-up



Figure 8. Reply list

However, we found that the names of these buttons did not clearly convey their intended purpose. Therefore, we changed the names and icons to “I saw it” and “Delete” in the middle of the operation period.

F. Posting and Reply Duration

All new posts and replies have a posting period. We initially considered a posting period of a few hours, similar to a station message board. However, after observing the whiteboards and the actual usage of electronic bulletin boards, we decided on a final posting period of 4 days. Additionally, posts made on Wednesdays and Thursdays were likely to expire on Sundays or Monday mornings when there are fewer people around. Therefore, we extended the posting period to 5 days for these posts.

Furthermore, the posting period is extended by 12 hours if the “I saw it” button is pressed and by 24 hours if a reply is received, and the posting period of a new post with the “Delete” button pressed is reduced by 24 hours. If the number of “Delete” button presses exceeds the threshold of 2, the post will be immediately hidden from the bulletin board.

For replies, if the number of “Delete” buttons pressed for each reply in the topic list exceeds the threshold of 2, that reply will no longer be displayed. The post will no longer be displayed, and the empty space will be available for other users to post again.

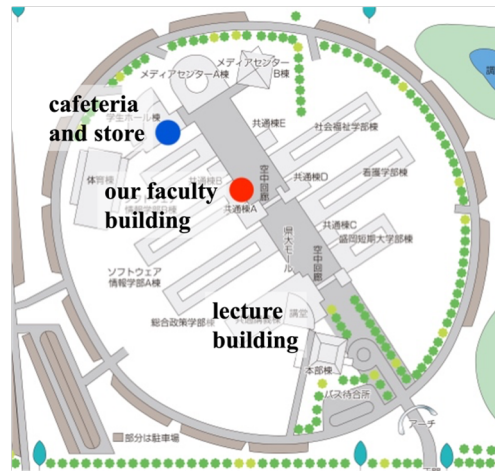


Figure 10. Campus plan of our university and locations of our electronic bulletin board

G. Changes in Font Weight and Background Color

In response to feedback from the survey conducted after observing the whiteboards, we implemented a system in which the font color fades in steps according to the remaining posting period (see Table 10). This was done to address the concern that users were unsure of when posts would be deleted.

Furthermore, we observed that users might not be aware of the fading font color. Therefore, we improved the system by changing the background color of each grid cell as well.

V. USER STUDY

In this section, we describe the procedures and results of a user study as an operational experiment of the electronic bulletin board we designed and implemented.

A. User Study Overview

We conducted a user study of the electronic bulletin board we designed and implemented for approximately 5 months to

confirm its usage. At the start of this user study, we installed the board (Figure 9) in the area with the cafeteria and shop of the university where the authors belong (blue area in Figure 10). One month after the start, we moved it to the lounge space on the 2nd floor of our faculty building (red area in Figure 10).

At the top of the list of posts displayed on the board, we posted the following three explanations about the use of the board to encourage posting and the use of reaction buttons:

- “Please post anything you want to share beyond the boundaries of your department, year, or lab.”
- “Posts will expire after a certain period of time.”
- “Use the ‘I saw it’ button to indicate that you’ve read and are interested in a post, and the ‘Delete it’ button to indicate that a post seems unimportant.”

To allow anonymous posting, the post entry field did not include a field for entering your name or affiliation.

In this study, we collected data on the content of the electronic bulletin board posts, the date and time of the posts, and reaction button logs (which buttons were used in response to which posts).

After the user study period ended, we conducted an online survey open to all students at our university to confirm the posting frequency and browsing status, which could not be confirmed from daily observation and the acquired data. The number of responses was 307. This number corresponds to approximately 15% of all students.

B. User Study Results

1) Posting Status

Figure 11 shows the number of new posts (question-like posts) and replies per week during the study period. Data from the two-week winter holiday (Week 14 and 15) is excluded. The total number of new posts during the period was 171, and the total number of replies was 351. The total number of new posts and replies ranged from 19 per week to 51 per week. Since there were almost no posts on Saturdays and Sundays, considering that there are 5 days in a week, there were about 3 posts per day in the week with the fewest posts and about 10 posts per day in the week with the most posts. This shows that our electronic bulletin board was used daily during the study period.

TABLE 10. CORRESPONDENCE BETWEEN REMAINING TIME FOR POSTING AND DEGREE OF SHADING

Remaining Period	Shading Degree
More than 3 days	1.0
Less than 3 days	0.7
Less than 2 days	0.5
Less than 36 hours	0.4
Less than 24 hours	0.3
Less than 12 hours	0.2

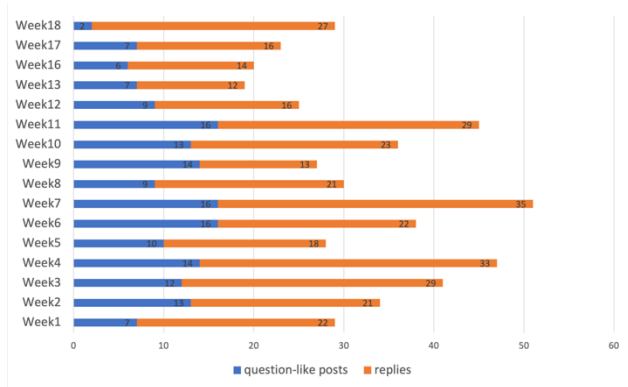


Figure 11. Number of new posts and replies per week

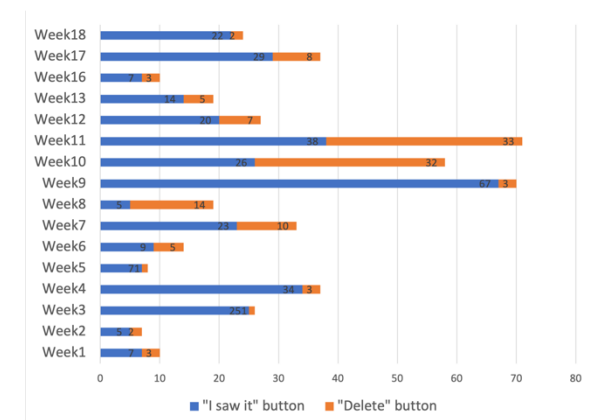


Figure 12. Number of times reaction button was used

C. User Study Results

1) Posting Status

Figure 11 shows the number of new posts (question-like posts) and replies per week during the study period. Data from the two-week winter holiday (Week 14 and 15) is excluded. The total number of new posts during the period was 171, and the total number of replies was 351. The total number of new posts and replies ranged from 19 per week to 51 per week. Since there were almost no posts on Saturdays and Sundays, considering that there are 5 days in a week, there were about 3 posts per day in the week with the fewest posts and about 10 posts per day in the week with the most posts. This shows that our electronic bulletin board was used daily during the study period.

We also found that the number of replies was overwhelmingly higher than the number of question-like posts every week. This suggests that multiple replies were made to each question.

In addition, Table 11 shows the frequency of use of the bulletin board as collected by the questionnaire. At the beginning of the installation, we were worried that some

specific users might dominate the posting and replying, but we confirmed that the posting and replying were not biased towards specific users.

2) Viewing Status

Table 12 shows the results of the survey on the viewing status of the electronic bulletin board. During the user study period, 26 out of 307 respondents (8.5%) did not view the bulletin board at all, but 281 respondents (91.5%) had the experience of viewing it.

3) Reaction Button Usage

Figure 12 shows the number of times the “I saw it” and “Delete it” buttons were used per week during the study period. Data from the two-week holiday period at the end of the year (weeks 14 and 15) was excluded. The total number of times the “I saw it” button was used during the period was 338, and the total number of times the “Delete it” button was used was 132. The combined number of “I saw it” and “Delete it” button uses ranged from 7 to 71 per week. Since there were almost no posts on Saturdays and Sundays, this translates to an average of 1 use per day on the low end and 10 uses per day on the high end, assuming a 5-day work week. This suggests that the reaction buttons were also used on a daily basis throughout the study period.

Regarding which button was used more, the “Delete” button was temporarily used more only in weeks 8, 10, and 11. Otherwise, the “I saw it” button was used overwhelmingly more often. Looking at the usage ratio of each button for all 522 new posts and replies, the “I saw it” button was used for 31.4% of new posts and replies. The “Delete it” button was used for 9.4% of new posts and replies.

Furthermore, looking at the number of times each button was pressed, the “I saw it” button was pressed 23 times, and the “Delete it” button was pressed 6 times. Looking at the post content for which the “I saw it” button was pressed 23 times, it was for the response “We are currently developing an on-campus-only matching service. We would like to release it by the time we graduate, so please try it out” to the post “Where can I find a boyfriend/girlfriend?” There were two posts for which the “Delete it” button was pressed 6 times. One was a new post that simply said “a,” and the other was for a new post that was posted multiple times with the same content. From this, it can be inferred that the “I saw it” button was used for posts that were considered useful, and the “Delete it” button was used for posts that were considered unimportant. This suggests that the buttons were used as we intended.

4) Structure and Duration of Threads

Table 13 shows an example of the thread structure formed by new posts and replies on our electronic bulletin board. As shown in this example, most new posts have multiple replies, indicating a one-to-many relationship between new posts and replies. The new post with the most replies received 21 replies. The duration of this thread (from the new post to the last reply) was 18 days. We also analyzed the duration of five other threads with more than 10 replies to new posts, and we found that all of them lasted for more than

TABLE 11. POSTING AND REPLY FREQUENCY

	Number of People who Submitted	Number of People who Replied
Everyday	0	0
Several times a week	1	0
Once a month	0	4
Several times a month	2	3
Once every few months	7	9
Only once	20	17

TABLE 12. SURVEY RESULTS FOR ELECTRONIC BULLETIN BOARD VIEWING STATUS (N=307)

	Number of Answers
I did not view it at all.	18
I did not know there was a bulletin board.	8
I glanced at it when I passed by (not stopping).	116
I stopped in front of the bulletin board and viewed it.	89
I operated the mouse on the bulletin board and viewed it.	76

TABLE 13. EXAMPLE OF THREAD STRUCTURE ON OUR ELECTRONIC BULLETIN BOARD

	Content	Posting/Reply Day
Post	Tell me about a good niboshi ramen shop (other than Menya Iori and Niboshi SHINCHAN).	DAY 103
Replies	I don't know if it's only niboshi, but Hokuryu is delicious.	DAY 107
	Ikken!!!!	DAY 107
	Nibo Shin.	DAY 107
	Hinotori	DAY 107
	Garitto	DAY 109
	Tairen no Ryu	DAY 109
	Samurai Boogie	DAY 109
	Birdmen one choice	DAY 113

a week. These results suggest that threads on our electronic bulletin board tend to develop over a relatively long period of time, rather than progressing rapidly.

5) Impact of Installation Location

To investigate changes in usage due to the presence or absence of foot traffic, we moved the bulletin board from the area with our university cafeteria and shop to the lounge space on the 2nd floor of our faculty building after the 6th week. The area with our university cafeteria and shop has a constant number of people passing through from around 11:00 to 18:00. On the other hand, the lounge space on the 2nd floor of our faculty building is only used to pass through when moving around the campus, and few people pass through during lecture hours.

Looking at the trend of the number of weekly posts and replies for the entire period shown in Figure 11, there was no significant change compared with before the move.

6) Use of Electronic Bulletin Board by Multiple People

During our whiteboard observations, we noticed that people often gathered around it to read posts, discuss their contents, and even create new posts together. We wanted to

encourage similar interactions on our electronic bulletin board, so we decided to display posts on a large display and allow users to post only from connected devices.

To confirm whether people would actually use our electronic bulletin board in groups, we conducted two observation sessions at the bulletin board location during peak posting times (around 4 pm) during the user study period. We were pleased to observe that people did indeed use the bulletin board in groups on multiple occasions.

We interviewed the users using the bulletin board in groups to understand their motivations. They told us that they felt more comfortable using the board in a group because it allowed them to ignore the other people around them. Some even said they would not have used the board if they had been alone. These observations and interviews suggest that people may use electronic bulletin boards in groups to avoid social embarrassment.

VI. DISCUSSION

In this section, we further discuss the results of the user study of the electronic bulletin board described in the previous session.

A. Posting Status

The user study showed that most threads consisted of a single new post with multiple replies. There were no cases where one thread developed into another. However, an analysis of the collected data revealed some posts that appeared to be replies to replies. The current bulletin board system only allows replies to new posts, not replies to replies. All replies are displayed in the same thread. We may need to implement thread structure processing to address this limitation, such as moving replies to replies to separate threads. This would allow for more natural topic development and potentially facilitate creative information sharing, such as the generation of new ideas.

B. Posting Method

To recreate the advantage of analog bulletin boards where people can converse while posting, our electronic bulletin board can only be viewed on a large display, and posts can only be made from a terminal attached to the display. Observations of the usage of the electronic bulletin board confirmed our hypothesis that people would use it in groups, demonstrating that we successfully implemented an advantage of analog bulletin boards in the electronic version. However, the survey revealed a group of users who browsed the bulletin board using a mouse but did not post or reply. We believe this is due to the phenomenon of social embarrassment.

This is supported by free-response comments in the survey, such as “I find it difficult to stand in front of the bulletin board and read or write slowly (I’m self-conscious about other people’s eyes), so I would like to be able to access it from my smartphone or computer” and “I was self-conscious about people looking at me when I stood there and

wrote. It might be easier to use if I could write freely from my own device.” To balance the advantages of analog bulletin boards with avoiding social embarrassment, we believe we need to provide two environments: one that uses the current large display and one that uses personal devices.

C. Quality of New Posts and Replies

From the survey results of the whiteboard observations, we identified the need to address low-quality information. In our electronic bulletin board, we implemented two reaction buttons, “I saw it” and “Delete it,” to allow users to evaluate the importance of each post. The display time of each post is then adjusted on the basis of these evaluations.

An analysis of the usage of each reaction button confirmed that the “I saw it” button was used for content that was likely to be important, while the “Delete it” button was used for content that was likely to be unimportant. This indicates that the reaction buttons function as intended.

In addition to reaction buttons, the number of replies to a new post can also be used as a clue to its importance. We, therefore, analyzed new posts with no replies. Out of 364 new posts, 33 met this condition. Of these 33 posts, the “I saw it” button was used for 2 posts, and the “Delete it” button was used for 8 posts. An analysis of the posts with “Delete it” button presses revealed that they included multiple posts of the same content, posts that provoked others, game opponent recruitment posts, and other content that some users might find unnecessary or offensive.

On the other hand, new posts with no replies and no reaction button usage were found to be solicitations, requests, or invitations that were difficult to reply to or questions so specialized that few people could answer appropriately. These posts will likely have a different level of importance than those with “Delete it” button usage.

Combining the number of replies to a new post with the reaction buttons can potentially improve the accuracy of evaluating low-quality posts. All new posts are categorized together, regardless of whether they are questions or other types of inquiries. By increasing the number of new posts, such as posts that require an answer, posts that do not require an answer but do require some action from the user, etc., we believe that the number of useful posts can be increased.

D. Information Sharing Beyond Daily Communities in Large Organizations

This study aims to support information sharing beyond small, daily communities, such as research labs, departments, or faculties, in large organizations like universities and companies. We examined the free-response survey results collected after the user study period to investigate whether our electronic bulletin board facilitated information sharing and interaction beyond daily communities.

The results revealed multiple responses indicating that information sharing and interaction beyond the usual faculty or department boundaries were indeed achieved. Some examples of such responses include:

- “I find it interesting because it gives me the opportunity to connect with people I wouldn’t normally connect with.”
- “Even though it was anonymous, I felt like I could interact with people from other departments, and it was enjoyable.”
- “I like it because it’s fun to look at and makes me feel connected to other students.”
- “I thought it was an interesting and useful tool because it allowed me to get opinions from people my age and get helpful information and words of sympathy. I didn’t post anything, but I enjoyed just looking at it.”
- “I found it very interesting to watch. I thought it was wonderful that there is a place for students to connect with each other, especially during the COVID-19 pandemic when communication has decreased. I thought it was great that you could connect with people inside and outside the university.”

These findings demonstrate that our electronic bulletin board successfully fostered positive impressions among users and facilitated meaningful connections beyond their usual communities.

E. Strengths and Weaknesses of Our Electronic Bulletin Board

On the basis of the results of the user study, we summarize the advantages and disadvantages of our electronic bulletin board. First, it has mechanisms to promote posting and to improve the quality of posting. The latter point is particularly important as our electronic bulletin board is intended for informal information sharing, which carries a high risk of lowering the quality of posts, and thus needs to be properly addressed. Second, it allows for our electronic bulletin board to be used by multiple users, which is an advantage of an analog bulletin board. The first advantage is realized by automatically deleting posts periodically and automatically extending and shortening of the display period using reaction buttons. The second is that users can post and view information via a large display, rather than from their personal terminals.

However, the disadvantage of this electronic bulletin board is that it is currently not possible to view and post from a personal terminal. This is in conflict with the second advantage mentioned above. The results of the user study show that users may avoid using or posting for a long time because they are afraid of being seen by others. To avoid this problem, we believe it is necessary to provide two environments, one through the current large display and the other through personal terminals.

VII. CONCLUSION AND FUTURE WORK

In this study, we hypothesize that by introducing an analog information sharing environment, such as a station bulletin board, into a digital information sharing environment, it will be possible to share information casually and informally across small community boundaries within a large

organization. Based on this hypothesis, we conducted observations of whiteboard usage for about 2 months to incorporate elements that enable casual and informal information sharing in the analog world into digital information sharing. Then, based on the results of the whiteboard observation, we designed and implemented an electronic bulletin board. We then conducted a user study for about 5 months to verify the effectiveness of the various functions of the implemented bulletin board and to test the hypothesis.

The results of the whiteboard observations revealed the need for mechanisms to promote posting, improve post quality, and deal with low-importance posts. We also observed a situation unique to the analog world, where users converse about the content of posts in front of a whiteboard and post while conversing. Based on these whiteboard observation results, we designed and implemented an electronic bulletin board that allows users to post and view content through a large display.

The results of the user study showed that there were an average of 3 to 10 posts per day, including new posts and replies. In terms of viewing, the survey found that about 90% of the 307 respondents (about 15% of all students) had viewed the bulletin board at some point, confirming that our electronic bulletin board is being used daily as an information sharing tool. In addition, the "I saw it" reaction button was used for about 30% of all new posts and replies (552 posts), and the "Delete it" button was used for about 10%. Analysis of the message content in conjunction with the reaction buttons showed that they contribute to maintaining the quality of posts and judging the importance of posts, confirming the effectiveness of the implemented functions. Furthermore, the survey found multiple responses indicating that information sharing across departmental boundaries was possible. This confirms that the hypothesis that by incorporating an analog information sharing environment, such as a station bulletin board, into a digital information sharing environment, it would be possible to achieve casual and informal information sharing across small communities within a large organization, is correct. Additionally, it was found that many users had a positive impression of our electronic bulletin board.

However, we found that users may avoid using or posting for a long time because they are concerned about being seen. To solve this problem, we will study a electronic bulletin board environment that combines the current environment using a large display with an environment using personal terminals such as smartphones and PCs.

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