Interactive System for Collaborative Historical Analogy

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Abstract. Supporting learning history has become an important topic in education research. To discuss social issues using historical analogy, group learning composed of two pairs is effective. In this paper, we propose a novel interactive system for collaborative historical analogy. This system first provides news articles to users from our database. Then, it uses a clustering algorithm that makes groups from what the users assign event categories for news articles. After assessing the result of the clustering algorithm, our system provides two functions for promoting collaborative learning: discussion spaces and archiving the discussions. The results of quantitative and qualitative evaluation show that our system have the potential to enhance group discussion and collaborative historical analogy in class.

Keywords: Collaborative learning · History education · Analogy · Grouping

1 Introduction

One of the goals of teaching history is to find meaningful connections or analogies over time, and supporting learning historical analogy has become an important topic in education research. Historical analogy allows learners to study how people in the past tried to solve issues, and then apply the acquired knowledge in order to propose alternative solutions to similar issues in other periods. Indeed, Staley claims that history provides not only information on the past but also alternative solutions to similar modern issues [1]. Teaching guidelines for high school education published by the Japanese government include the ability to apply historical knowledge and concepts to modern issues using collaborative learning [2]. Furthermore, to support collaborative historical analogy, researchers have developed

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effective learning methods [3,4], algorithms mining past events similar to a given present event [5], and an interactive system that is useful in class [6].

Finding similar past and present events plays a key role in promoting historical analogy. However, how people believe that a past and present event is similar is up to them [7]. Furthermore, Fischer found that historical analogies are often misused, and it is necessary to be cautious when using historical analogy [8]. According to [4], group learning composed of two-pair discussions in history has been found to be effective for collaborative learning, checking the validity of each historical analogy, and for improving each historical analogy with various points of view. Although the present study's findings also showed the positive potential for group learning, the gap that needs to be addressed is that no interactive system that makes groups for studying collaborative historical analogy currently exists.

In this paper, a novel interactive system for collaborative historical analogy is thus proposed. The proposed system first shows news articles describing present social issues to users. It then considers users' interests in specific issues and the particular aspects they focus on. From this information, the system groups users by combining similar users as pairs, and not similar pairs as groups. After this step, users can have a discussion within their own groups, and an online text editor and chat plugins to facilitate the discussions are provided. Finally, the system archives the results of the users' discussions and chat logs to use them for reflection in post-learning.

Contributions. The core contribution of the system proposed by the present paper is that it is *interactive*. There are several grouping systems that function as learning environments [9,10]; however, these require pre-testing to analyze what the users are interested in. The present system obtains the information by having users assign one or more event categories that are originally defined as connecting past and present events.

2 Related Works

This section compares the proposed system with two research fields: clustering algorithms and Computer-Supported Collaborative Learning (CSCL).

2.1 Clustering Algorithm

Clustering is an algorithm to make groups. This algorithm is an important and fundamental technique in NLP, ML, and other computer science related research fields.

One of the most popular algorithms is K-means [11], which divides data into groups satisfying the following two conditions: (1) each group must contain at least one object, and (2) each object must belong to exactly one group. K-means updates the centers of clusters by iteratively computing the averages of all points and coordinates representing the arithmetic mean until the specific criteria are satisfied.

Gaussian mixture model (GMM) [12] is another popular algorithm, which takes the assumption that each object in the same cluster is generated from several Gaussian distributions.

The main difference between our system and these past works is *objective*. Our system focuses on how to collect data for clustering and to output the results of the discussions, whereas the clustering algorithms focus on how to make groups. Thus, our framework is orthogonal compared to past clustering work.

2.2 Computer-Supported Collaborative Learning

Computer-supported Collaborative Learning (CSCL) is a major research topic in educational technology and learning sciences with recent findings showing that well-designed technologies can have positive effects on collaborative learning, as well as describing the contexts where students' collaboration and interaction were promoted through some technologies [13].

In CSCL, visualization and awareness are key point to promote collaborative learning. For example, it has been reported that the visualization of participation contributed more to performance with the designed tool that can visualize how much each group member contributes to his/her communication in online groups than without such tool [14]. Other research has shown that a designed online collaborative writing tool with a group awareness functionality, which can analyze and visualize their engagement, increased students' behavioral engagement conpared with students not using the tool [15].

How to form an effect group has been getting more attention in CSCL research lately [16]. According to research reviewing Argumentation-Based CSCL (ABCSCL), many studies have focused on group composition and students' traits [17]. For this paper, the quality of performance in heterogeneous groups is better in homogeneous ones and there are important traits of students in ABCSCL: Gender, learning styles, willingness to argue, openness to argue, internal argumentative script. Moreover, new methods of forming groups automatically in CSCL have been proposed based on two criteria: the complementary skills on concepts and the learning styles obtained according to the Felder-Silverman model to make heterogeneous groups [18]. This research, however, did not evaluate the learning effect but showed its usefulness compared with random grouping. Similar research has provided other systems for clustering heterogeneous groups automatically [19]. This system used the students' grades and showed that this system could determine heterogeneous groups as good as groups created by a teacher.

To sum up, former CSCL research points out that the visualization of interaction that corresponds to the effect grouping with some students' important traits is essential for enhancing collaborative learning. However, there is no research to date about interactive system to visualize collaborative writing by using historical analogy.

Compared with these past works, our system can easily performs group learning in history. If group learning is required with changing news articles and/or users several times, it is possible to change the selections of the new data, and because the system does not require data to make groups, it is easy to set up classes.

3 Design of System

3.1 System Overview

Figure 1 shows an overview of process in our system. First, our system gets news articles from a database. We can dynamically determine which and how many news articles we will use. Note that we assume that teachers or lecturers prepare this database before using our system. After collecting the texts, this system

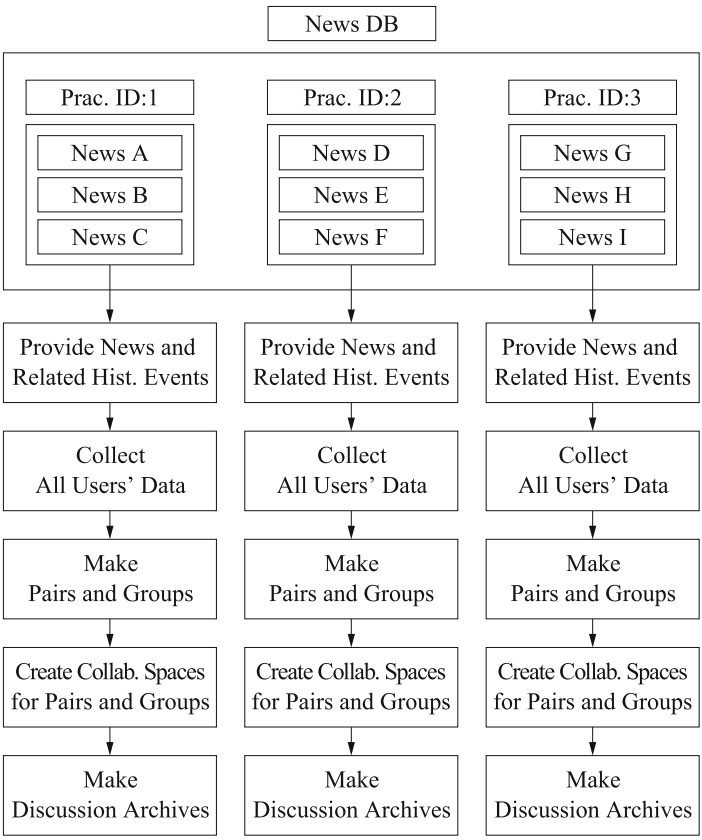

Fig. 1. System overview. Each practice has some news articles about modern social issues. According to selected news, historical events user selected, this system can make pairs and groups interactively.

performs five steps: providing news and related historical events, making feature vectors, making pairs and groups, making collaborative spaces for pairs and groups, and archiving results of the discussion. In the remainder of this section, we detail each step. If the database is available, we can quickly use this system by changing news articles and users.

3.2 Provision of News and Related Historical Events

The objective of this step is to provide historical events to users. This system performs this using a search engine [5]. As this search engine takes event categories that connect past and present events, our system must show news articles to users before using the search engine. From these, the users select news in which they have an interest, and then assign one or more suitable event categories to the news. After obtaining historical events from the search engine, this system records the two kinds of information (the assigned event categories and histori-

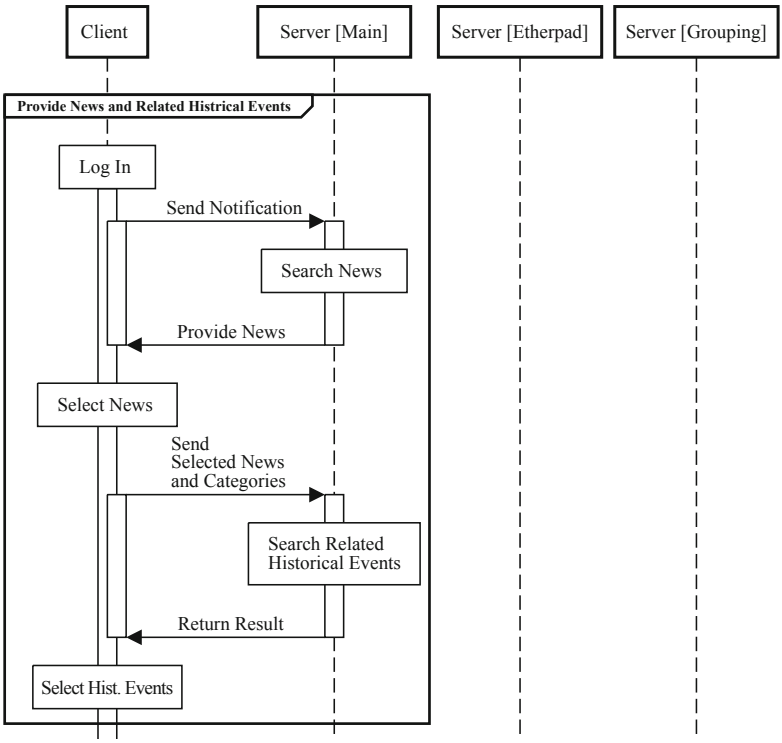

Fig. 2. Sequence diagram of providing news and related historical events. When a user logs into the system, the system server get news linked to user's practice ID from DB. After users selecting news and categories, the server searches historical events related to user interests. Users can choose one of historical events as a source of historical analogy.

cal events that are results of the search engine) for each user in order to make groups that are performed in the following steps. To make association between IDs of the users and the two kinds of information, our system first requires a log-in process. Figure 2 details the process between a server and clients.

3.3 Feature Vectors Creation

In this step, our system takes recorded results of the previous step, and then translates them into feature vectors to make pairs and groups for the next step. Given the complete event category list E, this step creates a feature vector for each user. If an event category $e_i \in E$ is stored in the results of the previous step, we use 1 as the ith element of the feature vector; otherwise, we use 0.

3.4 Make Pairs and Groups

This step inputs the feature vectors created in the previous step into clustering algorithms [20]. This algorithm outputs groups taking care to maximize improvements in discussions. This algorithm first solves maximizing problem to combine two users who focus on similar aspects for the same news. It then makes groups by solving minimizing problem to combine two pairs that focus on different aspects for the same news. Figure 3 shows processes for using the clustering algorithm. The main server sends users' future vectors to grouping program. Once the program receiving them, the program starts to make pairs and groups. Each pair contains two students who have the same concerns. In contrast to pair creation, each group consists of two pairs with different concerns. This pairs and groups creation method is designed to enhance discussion from various perspectives. When all pairs and groups are made, the grouping program sends the result of the creation to the main server. After the server receives data, the server collates the received result and user ID, and sends the number of their pair ID and group ID to clients.

3.5 Creation of Collaborative Editor Spaces for Pairs and Groups

After taking groups of users, our system prepares their discussions. The system creates collaboration editor spaces for both pairs and groups. The trigger for this creation is a log-in notification from the client who is the first to log into the pair discussion page. Clients send the number of clients in a practice. Once the main server acquires this number, the main server calls API to create a designated number of collaborative editor spaces and set instructional text into them. To create spaces, the system uses Etherpad-lite plugin. This plugin provides function such as coloring text and user chatting space to make collaborative editor environment. After these processes, the server sends a pair and group ID to each client. Once clients receive these IDs, clients use these IDs as a part of the URL of the collaboration editor embedded in discussion pages, then clients can access designated discussion pages.

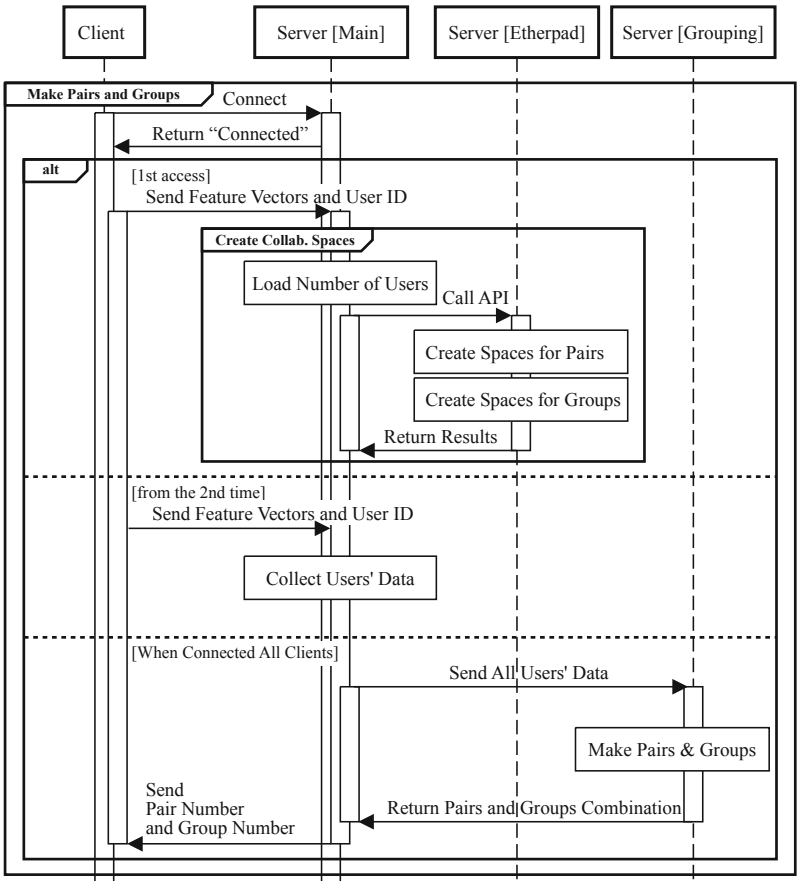

Fig. 3. Sequence diagram of making pairs and groups. In a practice, when a user reaches this phase first, the server get the number of users in this client sent from this user. The server calls API to Etherpad (collaborative editor plugin) server to make half number of users edit spaces for pairs, quarter number of users spaces for groups. After collected all users' data, the server sends this data to grouping program. The detail of this grouping algorithm, refer Ikejiri *et al.* [20].

3.6 Archiving Results of the Discussion

Figure 4 shows how our system archives the results of all discussions. This is performed if a member of a group decides to store their discussions. When the server receive the request of archiving from the clients, the main server calls API to the Etherpad server to make an copy of discussion. If the copying is successful, the server sends an URL of archive discussion and strings of discussion. Once clients receive the notification and data, they embed the data into the archive phase pages to ease the viewing of the results. We believe that this is useful when the users engage in post-study of the lecture.

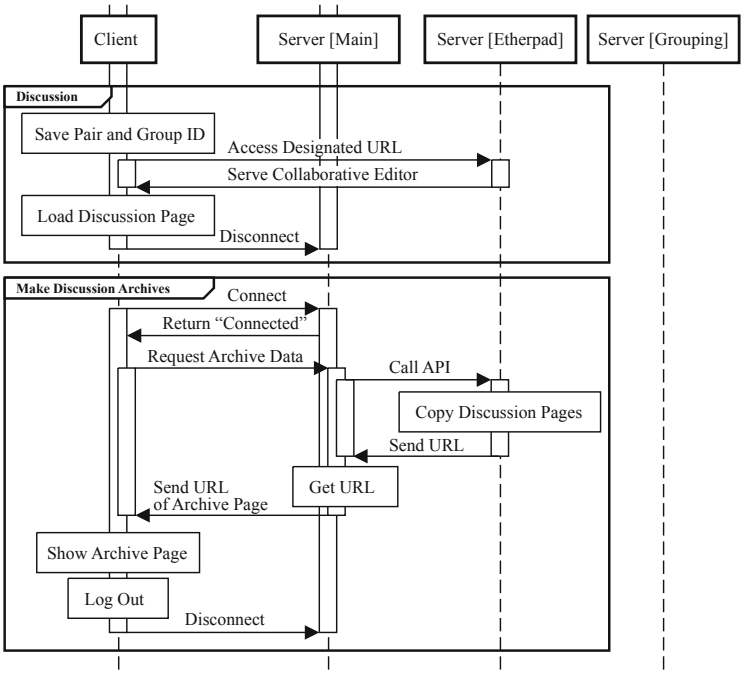

Fig. 4. Sequence diagram of discussion phase and making archives. In discussion phase, clients save received pair and group IDs. To access collaborative editor spaces, clients use these IDs as a part of URL.

4 Evaluation

In this section, we evaluate the usability of our system. We first evaluate *how fast our system outputs results*. From this quantitative analysis, we show that our system can be a useful learning system without making students frustrations in practice. We then perform qualitative analysis to understand *how well our system can enhance collaborative historical analogy in class*. This analysis investigates by asking teachers after using this system in practice.

4.1 Quantitative Analysis

Data Preparation. We evaluate our system by changing the numbers of clients from 4 to 40. As our system makes groups, we use the five different multiples of four: 4, 8, 16, 32, and 40. Note that each class usually has 40 students in Japanese high schools. As we focus on process times in this analysis, we created artificial data to perform our system. In other words, we randomly assign the event categories for the data by assuming that the data selected the categories to a present news. Then, we apply the clustering algorithm [20] described in Sect. 3.4. Analyzing qualities of the results obtained by the algorithm is reported in the paper, we skip taking care of the qualities.

Table 1. Average duration on server [ms].

	Number of clients						
Process	4	8	16	32	40	Ave.	S.D.
Create collab. spaces	1.878	4.093	7.718	12.362	16.009	8.412	5.199
Make pairs & groups	136.922	115.857	128.041	136.637	113.893	126.270	9.856
Discussion	0.552	1.095	1.976	3.329	3.729	2.136	1.231
Make discussion archives	3.154	1.826	2.579	4.082	5.117	3.352	1.150
TOTAL	142.505	122.872	140.314	156.410	138.748	140.170	10.681

Table 2. Average duration on clients [ms].

	Number of clients						
Process	4	8	16	32	40	Ave.	S.D.
Make pairs & groups	193.800	191.037	163.669	172.378	167.948	177.766	12.308
Discussions	297.775	387.762	289.906	361.322	384.235	344.200	42.182
Make discussion archives	389.300	377.538	366.062	375.691	348.444	371.407	13.653
TOTAL	880.875	956.337	819.637	851.206	894.202	880.452	45.829

Measurements. For each the number of clients, we prepare desktop computers whose OS is Windows 10. To measure process times, we use log files stored in the server or clients. Tables 1 and 2 show results of average of process time of server and clients, respectively. We can see that each process in the server outputs results within 140 ms and each process in clients outputs results within 400 ms.

Process Times on the Server. We show that each process in our system outputs results of making pairs and groups within 140 ms in the case where there are 40 users in Table 1. Results also show total process time the on server side is within 160 ms in the same case. This result indicates that we can use our system in practical situations because each class has on average 40 students in Japanese high school. The process times of Create Collab. Spaces and Discussion are linear orders with the number of users. This may be caused by the amount of clients.

Process Times on Clients. Table 2 shows that the average duration of each phase is within 150 ms, and the average of total process time is 880 ms. Even the case when 40 clients connect to the server, an average of total process time is within 900 ms. It means this framework has a stability and a scalability for various cases.

4.2 Qualitative Analysis

Procedure. We hold an interview for a high school history teacher. The purpose of this evaluation is to verify whether this system is useful for collaborative

historical analogy. For the evaluation, we set an online environment in which the teacher can experience each phase we presented above. To let the teacher experience a pair discussion and a group discussion, we let researchers who have an ability of historical analogy. This evaluation held the following steps: Description of this evaluation, the purpose, and the usage of this system (10 min.), Using this system actually (50 min.), Interview to the teacher about this system (30 min.). We asked to the teacher from two perspectives:

- Which part of this system can be effective positively for collaborative historical analogy?
- Which part of this system should be modified for enhancing collaborative historical analogy?

After the interview, we collect comments about features that may enhance collaborative historical analogy and improvements for enhancing collaborative historical analogy.

Results. The teacher referred to two features for enhancing collaborative historical analogy.

The first was *collaborative editing and diversified perspectives*. The teacher said that each student would be thinking about how their opinion could be connected to historical events.

Writing sentences with others was interesting for me. Students will demonstrate their thinking ability to edit sentences in his/her own way taking other members' feelings and what other members intend to write down into consideration. So, I guess that students will be thinking about how their opinion can be connected with historical events and to each other, although I don't know if they can achieve this type of thinking level. I feel it's very interesting that students can connect historical events with their opinions together with everyone in a group instantly and simultaneously, while I'm not sure if their final opinions can include other viewpoints of world history.

- Did you feel that students think differently between pair discussion and group discussion?

I think that working in pairs makes it easier to think, but more diversified perspectives are added into sentences when working in groups. In fact, because viewpoints in our opinion were increased after Y joined in our discussion, I think there is a merit to adding diversified perspectives in working in groups. I feel this is a good point.

The second is *coloring the authorship text*. The teacher also pointed out that the authorship color function on texts is needed for collaborative editing and could be helpful for facilitating an activity.

I think it's an essential function. [...] It's better to write sentences about their opinion by coloring text in which writers can be distinguished. If there is no feature for coloring sentences by each student, this activity would be difficult, I think. I guess students will fail to recognize the sentence he/she wrote.

On the other hand, the teacher commented about two improvements for enhancing collaborative historical analogy. The first is *decreasing consciousness to apply historical events while working in groups*. She said that when the teacher worked in pairs and groups, she tried to apply the historical events she selected to solve the modern issues but that could not be accomplished completely due to the amount of thought required.

Each pair would try to tell their intention to the other when working in pairs. However, they have to make a conclusion together based on the pairs' opinion when working in a group. Because of this, it was difficult for me to apply my intention from applying the historical event I selected, although a situation would be different if we chose a different historical event from this one. Asserting my opinion was difficult because working with four people required to think more diversely than in pairs. On the other hand, I also felt something new will be created from discussions in a group since various opinions in a group can be told.

The second is *spreading gazing while editing sentences and chatting in pairs or groups*. The teacher pointed out that some of students would not be able to both edit sentences in a collaborative editor window and participate in discussions in the chat window.

Let me see... comments... some impressions came up, but I worked on this activity desperately. Users have to watch both the edit window and chat window, right? While they are concluding their discussion about what should be in the future, the discussion is also proceeding in chat window. I felt it is more or less tough for unskillful high school students to work on editing sentences and applying the ideas in the chat window simultaneously.

4.3 Discussion

The result of measuring duration of process time proved that the system will not prevent working on a collaborative historical analogy even if the number of students increases up to 40. This proves the scalability of this system for enhancing collaborative historical analogy.

According to the interview for the teacher, we found that this system has the possibility of enhancing collaborative historical analogy in the part of providing collaborative editor spaces and coloring authorship text. These functions of the system can be effect positively on collaborative historical analogy.

From these evaluations both from quantitative and qualitative, we proved that this system has an eligibility for enhancing collaborative historical analogy held in high school history lessons.

We also found two improvements, (1) scattering gazing while editing sentences in editor window and discussing in chat window while working in pairs and a group, (2) decreasing consciousness of applying historical events. To improve (1), we may need to embed additional instruction in a lecture or in the system. To improve (2), showing text of selected historical events and future prediction user wrote in even if working in pairs and a group can be a solution.

5 Conclusion

Supporting collaborative historical analogy is becoming popular studies to enhance the historical analogy with checking the validity of its usage. In this paper, a novel interactive system for collaborative historical analogy was proposed. The proposed system creates groups from users' interests in specific issues and the particular aspects they focus on to the same news article. After the grouping users, they can have a discussion within their own groups. The results can be archived for reflection in post-learning.

Future work will identify (a) *how the system is useful for collaborative historical analogy with several users*. As it was confirmed that it is possible to provide a practical learning environment by checking whether the system can output results within a second, the authors will, in the future, investigate how this system can enhance collaborative historical analogy; and, (b) *how stable the system works in the case of simultaneous use in several classes*. By studying this, the system will be able to provide a collaborative historical analogy environment, not only in one high school, but with remote high schools also.

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