Social Presence Visualizer: Development of the Collaboration Facilitation Module on CSCL

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Abstract. This study aims to develop and evaluate a visualization function of CSCL that is based on social presence. This function automatically categorizes the postings from learners and visually presents social interaction following a social presence indicator. Furthermore, this function seems to enhance social presence and encourage learning behavior, such as active discussion. In order to investigate the validity of auto-categorization, the inter-rater agreement rate and the ability to predict the quality of the discussion were analyzed and compared to the human-categorized data. The results demonstrated that there are several social presence indicators that have high and low inter-rater agreement, but the categorization of the function developed in this study had more prediction power than the human-conducted categorization.

Keywords: Community of inquiry · Social interaction · Social presence · Computer-Supported Collaborative Learning (CSCL) · Visualization

1 Introduction

There has been growing interest in collaborative learning in higher education. Collaborative learning requires the active participation of students, and thus fosters high-end learning skills. However, there are several challenges to the implementation of collaborative learning in educational settings: Nishimori et al. [1], for example, have pointed out the difficulty in tailoring collaborative learning schedules around the various other class commitments of learners, as doing so poses a potential threat to group cohesion and delays the progress of learning.

In the age of technological innovation, one increasingly popular solution to this problem is the use of computer networks for Computer-Supported Collaborative Learning (CSCL). Computer-Mediated Communication (CMC) tools, such as Bulletin Board Systems (BBS) are particularly useful in supporting collaborative learning outside of the classroom.

The background of CSCL is based in socio-constructivist pedagogical theory, which posits that knowledge should be constructed and re-constructed through interaction between learners, or between learners and artifacts [2]. In support of this perspective, it is important to consider how one may enhance interaction between learners who work collaboratively in a virtual setting when designing CSCL. This study aims to

develop the visualization tool for CSCL based on social presence in order to contribute to the enhancement of learning motivation and achievement in support of collaborative learning programs.

2 Community of Inquiry (CoI) Framework

2.1 Definition of CoI Framework

Garrison and Anderson [3] constructed a "Community of Inquiry (CoI)" framework in which teachers and learners interact in text-based, online communication. The CoI framework consists of three elements: social presence, cognitive presence, and teaching presence. Social presence is defined as "the ability of participants to identify with the community, communicate purposefully in a trusting environment, and develop inter-personal relationships by way of projecting their individual personalities" [3]. Social presence is regarded as a necessary element for creating a secure environment for interpersonal communication in order to foster an open environment that is conducive to discussion. Shea and Bidjerano [4] suggest that social presence is an important factor in predicting the level of cognitive behaviors. They reported that learners who are regarded as high-level cognitive learners treated low-level cognitive learners by responding to them using social presence. Cognitive presence is defined as "a vital element in critical thinking, a process and outcome that is frequently presented as the ostensible goal of all higher education" [5]. Teaching presence is defined as the design, facilitation, and direction of cognition and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes [6]. Two of the three CoI elements and indicators. CoI is enhanced by integrating the three presences in the teaching of projected learners [7], as doing so promotes metacognition for collaborative learning [8]. Goda and Yamada [9] investigated the relationship between these three presences in Asynchronous Computer-Mediated Communications (ACMC). Their findings reveal that the teaching and cognitive presence were significantly correlated with discussion satisfaction, and social presence was positively associated with the number of utterances.

Many researchers used the CoI framework for the evaluation and investigation of the effects of the learning community (e.g., [10, 11]), but this framework can also be applied to collaborative learning environment designs. Several studies have tried to design and develop a CSCL system that is either based on CoI or that is comprised of CoI components (e.g., [12]). The present study aims to develop the function, in particular, of visualization, which is based on the "Social Presence" CoI element.

2.2 Social Presence and Its Role in CMC

Social presence is a crucial factor in learning with CMC, in denoting perceptions of oneself and others, as well as in supporting social interactions within a community, promoting trust relationships, and playing an important role in the effective implementation of CSCL. Learners' perception of presence is affected by social presence, which Short, Williams, and Christie [13] describe as the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationship." In other words, social presence promotes the perceived proximity to real-time communication in a face-to-face setting, depending on the type of CMC tool used. Short, Williams, and Christie [13] further suggest that the two dominant factors in social presence are "immediacy," which is defined as the psychological proximity of the

interlocutors, conveyed, for example, through facial expressions, and "intimacy," which is defined as the perceived familiarity evoked by social behavior, such as eye contact and smiling.

Researchers have interpreted social presence in different ways, both in their experiments and in their practical applications. Gunawardena and Zittle [6] conducted a research project in which they investigated the effect of social presence on learning satisfaction, from the perspective of facilitating and moderating discussion and the perspective of the perception of interactivity in online discussions. Their research revealed that a high awareness of social presence has positive effects on learning satisfaction. According to this view, which focuses on the notion of interactivity rather than on perceived proximity to real-time communication, social presence depends on interaction between groups using the same CMC tool in their learning.

Other researchers have concentrated on the expressive functions of social presence, which is thereby framed as a type of communication ability. Garrison and Anderson [3] redefined social presence according to its expressive function in the establishment of group cohesion in asynchronous text-based communication. Garrison and Anderson [3], meanwhile, describe social presence as one of the elements in a "Community of Inquiry (COI)," in which teachers and learners interact in text-based online communication. Social presence is regarded as a necessary element for creating a secure environment for interpersonal communication and for developing an atmosphere that is open to discussion. Their study further proposes specific indicators of social presence in the asynchronous, text-based CMC, which serve to bridge cognitive behaviors for learning.

Enhancing social presence is effective not only in promoting learning satisfaction [6], but also in the promotion of cognitive learning behavior. Shea and Bidjerano [4] suggest that social presence is one of the most important factors in predicting the level of cognitive behavior. They reported that learners who are regarded as high-level cognitive learners treated low-level cognitive learners by interacting with them using social presence. In order to enhance social presence, a system in which learners reflect and adjust the current degree of social presence is needed. However, social presence is an unconscious feature; that is, learners are not always engaged in collaborative learning with the consciousness of social presence. Social perspectives, such as social awareness (e.g., "What role will I take in this group?" and "How will I interact with this group?"), which are formed in collaboration are difficult features to support using groupware [14]. Several researchers tackled this challenge by using visualization (e.g., [15, 16]). Mochizuki et al. [16] developed and evaluated a visualization system called "ProBo Portable" which visualizes the situation and progress of each group member's task on a mobile phone. This research reveals that the visualization of situation and progress in collaborative circumstances is effective in monitoring each other and in enhancing the learning community, as reflective feature.

The perspectives on social presence discussed above are useful in designing a CMC tool that enhances interaction between learners. An integrated view of social presence seems necessary for the purpose of designing and evaluating a CMC tool for collaborative learning, in which the system design can enhance social presence for the encouragement of learning behavior. This study aims to develop a social presence visualization system for CSCL. Thus, another aim of this study was to point out future directions for designing a function that promotes learning through the enhancement of social presence.

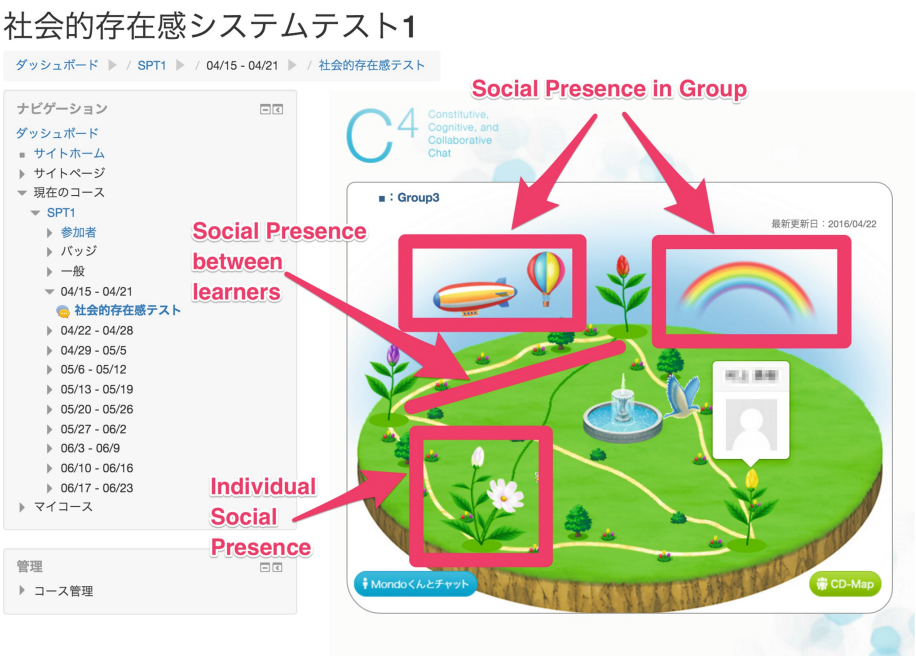

Fig. 1. Interface of social presence visualization

3 System

A visualization module was developed for the extend function of the chat tool with the permission of extension development from the researchers [17], which is also developed as the LMS “Moodle” module 2.9.X. Figure 1 shows the interface of this module. Figure 2 shows the fundamental functions for the support of social and cognitive

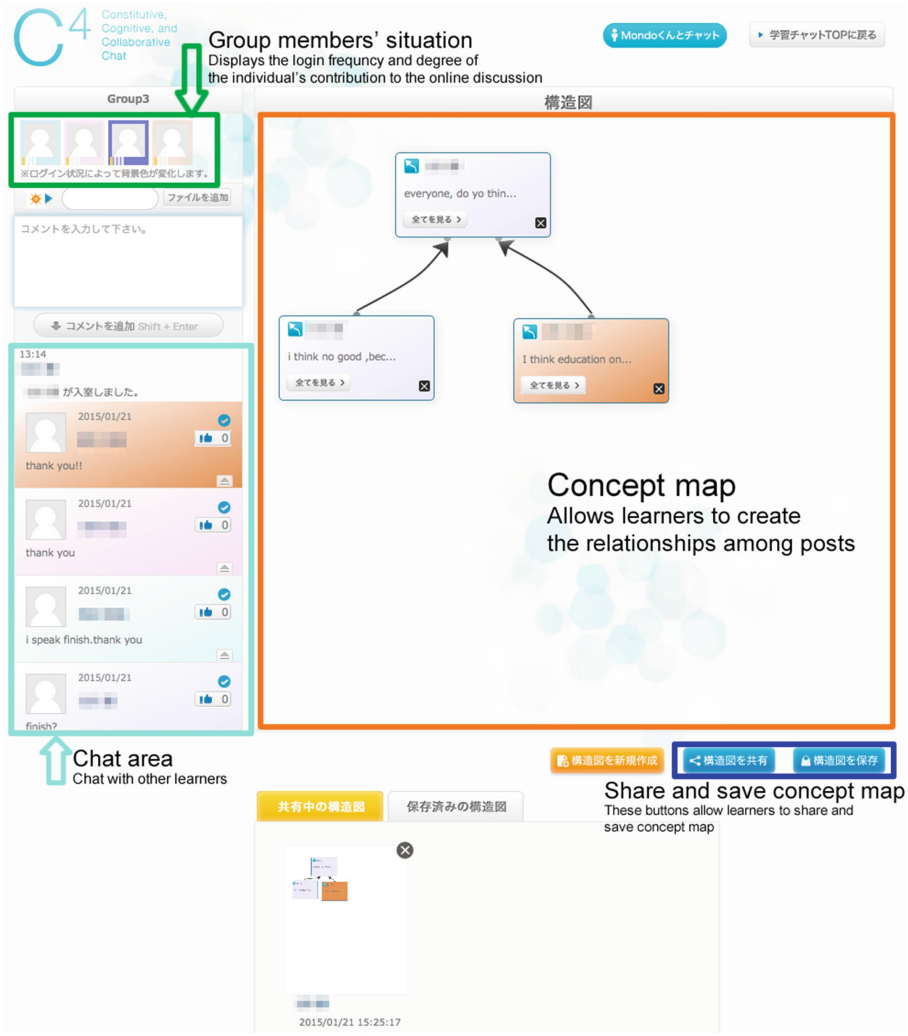

Fig. 2. Interface of chat, concept map and member's login time display [17].

communication [17]. After learners click the chat module link in the course, learners can move to the group chat entrance page displayed in Fig. 1. When learners click the "CD-Map" button, learners can move to chat page shown in Fig. 2.

This system consists of two functions; chat and concept map. Chat function allows learners to post their massages using emoticon and share the file. Learners can mark other posts as "favorite" by pushing "like" button. In concept map, leaners can click and drag a posting object in the chat area to the concept map area, and then show relationships between postings using arrow lines. Concept map function as a group cognitive tool allows learners to index the information on the concept map, thus is effective on the improvement of group memory [18]. The researchers indicated that the

system used in this research may be effective to enhance social presence and improve the discussion quality [17].

3.1 Calculation Method for Social Presence Scores

3.1.1 System Overview

Figure 3 presents an overview of our proposed system that evaluates the Social Presence Scores from users' comments in a chat group. The system stores every comment written by each user into a chat group thread and calculates the three types of Social Presence Scores: (a): Score of a user to a group, (b): Score of a user's reply to another user; and (c): Score of a whole group. The calculation of score (a) is based on every comment written by a user in a chat group thread. The calculation of score (b) is based on every reply made by one user in response to the comment of another user. For the calculation of score (b), the visualization system collects the data of the user name that sent the messages as variable name "MENTION." That is, the "Reply Symbol" in Table 1 means a kind of symbol appears in a text when a user replies to another user's comment in the proposed system. Only when the symbol appears in a text, the first value in the score is set as 1; otherwise, the value is 0. The calculations of score (c) are based on every comment written by every user in a chat group.

The proposed system has a national language processing (NLP) module for analyzing a text written by each user as a comment in a chat group. The core part of the system is implemented by using PHP so that the system can be easily implemented to cooperate with Moodle developed by PHP. Only the module is implemented by using Python because Python has many helpful libraries that support NLP. "Stanford CoreNLP" [19], a popular NLP library for analyzing documents written by English, is used in the module for the text analysis. The procedure that is used to calculate the Social Presence Scores starts with the core system's passing of one text written by a user into the module, which is followed by the module's calculation of a Social Presence Score of the text, which is based on several rules and is explained in the next section. After

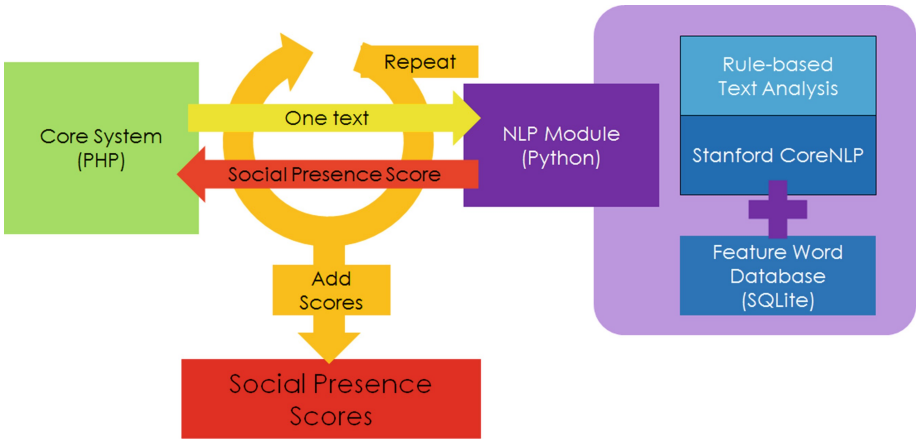

Fig. 3. Overview of the proposed system

this score is calculated, the score is returned to the core system. The returned score is expressed as a 19-value sequence (social presence and mention) of 0 or 1, separated with commas, e.g. 0,1,0,0,1,0,0,0,0,0,0,0,0,0,0,1,1,1. The 0 or 1 in the sequential value means a 1 is set on the bit flag only when the text contains a factor related to each category supporting the Social Presence Theory. Otherwise, 0 is set on the bit flag. The 17 categories of Social Presence are listed in Table 1. The core system repeats the pass-and-receive process until every comment in a chat group is checked. After the process, the system adds up every returned score and presents the Social Presence Scores.

3.1.2 Procedures of Rule-Based Text Analysis

The NLP module analyzes the texts by using rule-based procedures. Table 1 presents the rules that determine whether or not the text contains a factor that supports each category. The description of "Feature Word" in Table 1 shows that a text contains a feature word that supports the categories. The feature words were extracted in the pre-process phase from several sample chat data, which had 3,570 comments in 10 groups, and were also extracted from the WordNet database [20, 21]. The method used to extract these feature words is described in the next section. The description of the "Feature Phrase" in Table 1 refers to a certain phrase that frequently appears in a text supporting the categories. The phrases are selected by an expert who researches Social Presence based on his experiences by investigating phrase patterns of the sample chat data. Different from the case of the "Feature Word," the module checks the dependencies of each word on constructing the phrase. The following list explains in further detail the rule-based procedures for each category.

- Expressing emotions: an Emoticon Symbol appears in a text when a user uses an emoticon in their comment. This symbol is one factor supporting this category. Another factor is that of Feature Words extracted from WordNet Affect 1.1 [22].
- Use of humor: This category uses Feature Words and Feature Phrases to judge whether or not a text contains a factor supporting this category. There are only two Feature Phrases: "it is funny" and "it is humorous."
- Self-disclosure: This category also uses Feature Words and Feature Phrases for the evaluation. The Feature Phrases follow three patterns: "I am XXX", "I was born XXX" and "I live in XXX". In these phrases, the part-of-speech (POS) styles of verbs, namely the Present Tense Verbs in third-person or past-tense, were also taken into account for this category. The module checks the POS of the verb as well as the subject. Only when the subject is "I" does the module enable this category.
- Use of unconventional expressions to express emotion: This category uses Feature Words and several Additional Feature Words that frequently appear in a text supporting this category but cannot be extracted from the sample chat data or from the WordNet database. The words selected by the expert are only words that are followed by these five punctuation marks: "!", "• • •", "…", "*", "—".
- Expressing value: Only Feature Words are used for the evaluation.
- Continuing a thread: The module sets 1 on the sixth position of the sequential value only when users
- continuously reply to another one's comment more than two times.

- Referring explicitly to others' messages: The Feature Phrase of this category is "XXX said *". XXX is a subject in a text. At first, the module, checks a verb in a text, and if the verb is "say", present-tense verbs in third-person or past-tense are taken into account. Next, the dependency modifier of "nsubj" or "nsubjpass" is checked. These technical terms express a relationship of dependency according to "Stanford typed dependencies" [23]. Lastly, the module checks the POS of the subject for the evaluation. Only when the POS is a PRP (Personal Pronoun) or a NNP (Proper Noun, singular), is the module set on 1 in the seventh position in the sequential value.
- Quoting from another's message: This category is enabled when a user writes a comment containing the same comment written by another user within the previous 20 comments. The 20 comments do not take into account comments constructed in less than five words or comment supporting the SALUTATION category.
- Asking questions: The only factor that can enable this category is a question mark.
- Complimenting expressing appreciation: This category uses Feature Words for the judgment.
- Expressing agreement: The module uses Feature Words for the judgment and also checks dependency relationships to decide whether a text contains Positive, Negative or Neutral sentence. This category becomes enabled when a text contains a feature word and is a positive sentence, or when a text contains a feature word of DISAGREEMENT and is a negative sentence. Two additional phrases, "me, too" and "me too", were also taken into consideration for the evaluation.
- Expressing disagreement: This category is the counterpart of the AGREEMENT category.
- Personal advice: This category is enabled when a text is a positive sentence and contains Feature Words supporting this category.
- Vocatives: For the evaluation of this category, the module extracts the subject in a text based first on a dependency analysis, and then checks whether or not the subject is the Named Entity of a person. This category sets 1 in the fifteenth position in the sequential value only when the subject is named entry of a person and depending on if the word is "Mr." or "Ms." As for "nickname," it is enabled when a text contains a Reply Symbol because the proposed system adds the nickname of a user in a text when a user replies to the user's comment.
- Addresses or refers to the group using inclusive pronouns. Only six words, namely "we," "our," "us," "they," "their," and "them," are factors supporting this category.
- Phatics, salutations, and greetings: This category uses Feature Words for the evaluation. "How are you" is the additional feature phrase for this category.
- Course reflection: The module set 1 on the last position of the sequential value when a text is a positive sentence and contains Feature Words supporting this category.

Social Sharing, which is one of the social presence indicators, was not implemented for the visualization because there is no data in the categorization result, thus implying that there is no feature word.

3.1.3 Extraction Methods for Feature Words

The feature words introduced in the previous section are extracted based on two types of methods: (a): the Statistical Method and (b): the WordNet database. Method (a) uses the tf–idf (term frequency–inverse document frequency) method, which is one of the popular statistical methods to extract feature words in documents. The feature words extracted from the sample chat data containing 3.570 comments in 10 groups comprised of university students. Every comment in the sample data has the Social Presence Score evaluated by several experts. For example, 0,1,0,0,0,0,0,0,0,0,0,0,1,0,0,0,1,0,1 is the same format of the score returned from the module. In this research, the extracted feature words for a certain category show that the word appears in 6 times in a text supporting the category in the whole document and appears less than 70 % of the time in texts throughout the entire document. A total of 345 words were extracted by the statistical method. However, several extracted words were removed by the experts because these words were influenced by the topic of the sample data.

Finally, 132 words were registered as feature words using method (a). Method (b) is a method that extracts feature words from the WordNet 3.0 database, which is a popular database that describes the relationship between words. In the first step of the procedure, the expert selected several seed words that frequently appear in a text supporting a certain category, and then he or she extracted feature words contained in the same "Synset" of the seed words. The "Synset" is a kind of Synonym group defined in WordNet. The list of seed words supporting each category is shown in Table 2. A total of 279 words were extracted by this method. But, similar to the procedure of method (a), several extracted words were removed by the expert because the word contained different meanings across the seed words. For example, the seed word "reflect" has four Synsets. The actual Synset ID and typical word in the Synset are here: 2136892 (reflect), 630380 (think_over), 2136271 (reverberate), 2765924 (shine). The seed word "reflect" does not contain the meanings "reverberate" and "shine." Therefore, these words in the Synset ID, namely 2136271 and 2765924 were removed by the expert. Finally 268 words were extracted this procedure. Feature words supporting the EMOTION category were extracted from WordNet-Affect 1.6. A total of 2,272 words were extracted from the database. In the WordNet database, phrase words are expressed as the format that connects each word by underscores. These words are separated and registered as a feather phrase. As a result, 2,540 words were registered in the WordNet database. Additionally, 21 words, which frequently appear in a text supporting a certain category but which could not be extracted by employing the above procedures, were selected by the expert and combined with the feature words. The 21 words are also shown in Table 2. Finally, 2,693 words were registered as feature words.

The system developed in this study visualizes the social presence based on the flow mentioned above in three types (a, b, c), displayed in Fig. 1. This system visualizes each type of social presence score in several levels; five levels in two score types, from a user to a group and a use's reply to another user, and three levels in a score type, a whole group.

Table 1. Rule-based procedures for text analysis

Category	Indicator	Rule-based procedure
Affective	Expressing emotions	a Emoticon appears in a text a Feature Word appears in a text
	Use of humor	a Feature Word appears in a text a Feature Phrase appears in a text
	Self-disclosure	a Feature Word appears in a text a Feature Phrase appears in a text
	Use of unconventional expressions to express emotion	a Feature Word appears in a text an Additional Feature Word appears in a text
	Expressing value	a Feature Word appears in a text
Open communication	Continuing a thread	a Reply Symbol appears over 2 times in group chats
	Quoting from others' message	the Same Comment in past 20 comments
	Referring explicitly to others' messages	a Feature Phrase appears in a text
	Asking questions	a Question Mark appears in a text
	Complimenting expressing appreciation	a Feature Word appears in a text
	Expressing agreement	a Feature Word appears in a Positive sentence a Feature Word of DISAGREEMENT appears in a Negative sentence an Additional Feature Phrase appears in a text
	Expressing disagreement	a Feature Word appears in a Positive sentence a Feature Word of AGREEMENT appears in a Negative sentence
	Personal advice	a Feature Word appears in a Positive sentence.
Cohesive	Vocatives	Mr./Ms. depended a Named Entry of a Person appears in a text. a Reply Symbol appears in a text
	Addresses or refers to the group using inclusive pronouns	The Feature Words, "we", "our", "us", "they", "their" and "them" appear in a text
	Phatics, salutations, and greetings	a Feature Word appears in a text the phrase of "how are you" appears in a text
	Course reflection	a Feature Word appears in a Positive sentence

Table 2. The 26 seed words and 21 additional words supporting each category.

Category	Seed words	Additional words
Expressing emotions	–	
Use of humor	–	
Self-disclosure	remember, experience	
Use of unconventional expressions to express emotion	–	!, • • •,…, *, —
Expressing value	important, good, better, best, worse, bad, worst, poor, wonderful, beautiful, great	
Continuing a thread	–	
Referring explicitly to others' messages	–	
Quoting from others' message	–	
Asking questions	–	
Complimenting expressing appreciation	thank, appreciate, thankful	
Expressing agreement	agree, follow	I think so, "me, too", me too
Expressing disagreement	disagree	
Personal advice	advice	
Vocatives	–	
Addresses or refers to the group using inclusive pronouns	–	we, our, us, they, their, them
Phatics, salutations, and greetings	hello, hi, good-bye, bye, sorry	good morning, good afternoon, good evening, good night, good-night, ohayo
Course reflection	reflect	hey

4 Method

In order to evaluate the validity of auto-categorization, a comparison was made between the results of human-conducted categorization versus this system. Utterance data were collected in a university English class using the chat tool module as mentioned above. The procedure is explained in detail below.

4.1 Data Collection

Utterance data were collected in a Computer-Assisted Language Learning class. A total of 60 sophomores (42 males and 18 females) in the Informatics Department attended this class. The students were required to participate in an online English discussion for 40 min. The students were divided into 15 groups, each consisting of three or four students.

The discussion topic was "What is the ideal university-entrance test?", and it assessed students' interest in learning. The online discussion was conducted using the chat system [18], which has several integrated functions, such as a concept-map tool.

4.2 Analysis Procedure

The collected utterance data was stored in the database, after which the visualization module read the utterance data from the database and categorized them according to each social presence item. As for the human-conducted categorization, one researcher in educational technology and one in psychology independently categorized each learner's utterance into social and cognitive presence items. When the post contained a social and cognitive presence feature in each indicator, raters wrote down a 1, when they did not contain either feature, raters wrote a 0. Then, two researchers shared the categorization results and discussed the differences in categorization in order to combine results separated according to individual categorizations.

5 Results

5.1 Inter-rater Agreement

The number of utterances for the analysis was 371. In order to evaluate the validity of the automatic social presence categorization, Cohen's Kappa coefficient (K) [24], which is used to measure the agreement between two raters, was calculated. The range of Kappa is −1 to 1. When there is perfect agreement, Kappa is 1. The criteria of Kappa [24] are, below 0.000: Poor, 0.000–0.200: Slight, 0.210–0.400: Fair, 0.410–0.600: Moderate, 0.610–0.800: Substantial, 0.810–0.999: Almost perfect, and 1.000: Perfect. The results are shown in Table 1. The results of "social sharing" and "course reflection" were eliminated because there was not data in both the visualization module and human categorization results. Table 3 shows the results of Kappa coefficient calculation. The results indicate the moderate agreement rate between the module and human in several indicators; however, there are indicators in which the inter-rater reliability is very low. Question has the highest coefficient (0.900), which indicates almost perfect agreement. The Paralanguage, Value, and Salutation indicator items are at a moderate level, while Agreement, Name and Inclusive pronoun are at fair level. The remaining eleven indicators are very low.

Table 3. Cohen's Kappa coefficient

Indicator item	*K*
Expressing emotions	0.013
Use of humor	0.000
Self disclosure	0.021
Use of unconventional expressions to express emotion	0.558
Expressing value	0.441
Continuing a thread	−0.007
Referring explicitly to others' messages	0.000
Quoting from others' message	0.000
Asking questions	0.900
Complimenting expressing appreciation	0.068
Expressing agreement	0.326
Expressing disagreement	0.046
Personal advice	0.000
Vocatives	0.201
Inclusive pronoun	0.375
Phatics, salutations, and greetings	0.432

5.2 The Relationship with Cognitive Presence

In order to investigate the power to predict the cognitive presence that indicates the discussion quality, a multiple regression analysis was conducted in which cognitive presence was established as the dependent variable, and the sum-up frequency data of module categorization and human categorization were established as the independent variables. The results are displayed in Table 4.

The results showed that the social presence frequency calculated by the module developed in this study had a positive causal relationship on cognitive presence; however, the social presence frequency calculated by humans had a negative relationship on cognitive presence. Thus, the prediction rate of the module was better than the human prediction rate.

Table 4. The results of multiple regression analysis

Indicator	Coef.	SE	β	p
Module	0.181	0.018	0.461	$p < 0.001$
Human	−0.172	0.588	−0.137	$p < 0.01$

Note: $F(2, 368) = 50.70$, $p < 0.001$,
$R^2 = 0.216$, Adjusted $R^2 = 0.212$.

6 Discussion and Conclusion

This research developed a social presence visualization system for CSCL. In order to evaluate the validity of automated categorization of learners' postings following the social presence indicator, two statistical methods were employed to compare the module with the human-conducted categorization. First, the Kappa coefficient was calculated. Second, a multiple regression analysis was conducted to investigate the power of the prediction for the discussion quality. The results showed that there are indicator items that have high and low agreement rates. The indicator items of criteria that were easy to categorize, such as questions, tend to have high agreement rates. Kappa coefficients of several items were almost zero because there were very few posts categorized as low-rate indicator items, such as "Quoting."

Interestingly, according to the results of the multiple regression analysis, the categorization results of the module had superior prediction power compared to the results of the human-conducted categorization. Including the results in the inter-rater agreement measurement, the accuracy and validity of auto-categorization should be improved in future works. The evaluation of auto-categorization and of extracting and adding featured words shall be required after collecting the utterance data in a long-term investigation.

The results showed that the social presence frequency calculated by the module developed in this study had a positive causal relationship on cognitive presence; however, the social presence frequency calculated by humans had a negative relationship on cognitive presence. Thus, the prediction rate of the module was better than the human prediction rate.

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