

Collaboration indices for monitoring potential problems in online small groups

Indicateurs de collaboration pour diagnostiquer des problèmes potentiels dans de petits groupes en ligne

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Abstract

The purpose of this study is to test the validity and reliability of three collaboration indices (*quantity, equality, and shareness*) proposed by Jahng et al. (2010). The present study repeated the quantitative assessment of Jahng et al., and performed a further qualitative analysis to identify possible factors that might be associated with the results of the quantitative assessment. In addition, membership trends, in terms of communication connections in whole class discussions, were examined and compared with results from both the quantitative and qualitative assessments. The quantitative assessment results were consistent with those of the qualitative assessment and the membership trends. Therefore, the study concludes that the three quantitative collaboration indices are valid and practical to be used for monitoring and identifying potential problems in small groups in online courses.

Keywords: quantity, equality, shareness, interaction, quantitative, index

Résumé

Cette recherche teste la validité et la fiabilité des trois indicateurs de collaboration (la quantité, l'égalité et le degré de partage) proposés par Jahng et al. (2010). La présente étude a répété l'évaluation quantitative de Jahng et al., et a effectué de surcroît une analyse qualitative visant à identifier les facteurs pouvant être associés aux résultats de l'évaluation quantitative. En outre, les tendances de participation, déterminées par les rapports de communication au sein des discussions de classe, ont été examinées et comparées avec les résultats des évaluations quantitatives et qualitatives. Les résultats de l'évaluation quantitative correspondent à ceux de l'évaluation qualitative et des tendances de participation. L'étude conclut donc que les trois indicateurs de collaboration quantitatifs sont valides et utiles pour diagnostiquer d'éventuels problèmes propres aux petits groupes dans les cours en ligne.

Mots-clés: quantité, égalité, degré de partage, interaction quantitative, indicateur

Introduction

The instructor is a key factor influencing satisfying and genuine collaborative learning experiences in small groups of online courses (Maushak & Ou, 2007). Many researchers have emphasized the importance of the instructor's active role in terms of carefully monitoring and evaluating collaboration processes to provide timely support and facilitation (Berge, 1995; Heuer & King, 2004; Kanuka, 2005; Palloff & Pratt, 1999). However, there is a paucity of research that has dealt with the practical question of how to evaluate and identify problems during collaborative learning processes (Jahng, 2012). The research reported in this paper aims to answer the question by employing a practical and feasible but reliable and valid method for examining collaboration processes.

The research questions are:

1. How can group collaborations be assessed by quantitative indices of “*quantity, equality, and shareness*” (Jahng, Nielsen, & Chan, 2010)?
2. What are the specific hindering/facilitating factors for less/more collaborative groups as assessed by the quantitative indices?
3. How are the group membership trends, in terms of communication connections in whole class discussions, associated with less/more collaborative groups as assessed by the quantitative indices?

Literature Review

Research Problem and Background

Collaborative learning in online courses has been examined through written communication in groups, as described in the literature (Garrison, Anderson, & Archer, 2000; Jahng, 2012). Communication quantity is most frequently used to evaluate collaboration (Lipman, 1991; Solan & Linardopoulos, 2011; Wenger, 2001). Researchers have regarded active and abundant communication as a fundamental component for creating and sustaining collaborative learning processes and as a prerequisite for high quality collaboration (e.g., Bauer & Anderson, 2000; Curtis & Lawson, 2001; Jahng & Bullen, 2012; Nistor & Neubauer, 2010). In practice, course management systems often provide communication quantity measures such as the number of log-ins, the period of log-on time, and the lengths of posted messages. However, these quantity measures rarely reveal any specific problems underlying collaboration processes and the quality of collaboration.

Recognizing the weakness of the existing quantity measures to evaluate collaboration in groups, many researchers have conducted content analysis for the last few decades (Hara, Bonk, & Angeli, 2000; Penny & Murphy, 2009; Rourke & Kanuka, 2009). Henri (1992), in particular, urges instructors to employ the content analysis method “as a pragmatic instructional tool to yield practical results which can be used immediately to coach and facilitate learning” (p. 134). She claims that content analysis provides information on the participants and thus the informed

educator is better able to offer immediate support to both the individual and the collaborative learning process.

On the other hand, more recent research notes that content analysis may be “a technique more suited for researchers than for instructors” (Penny & Murphy, 2009, p. 805), because its coding process is “difficult, frustrating, and time-consuming” (Rourke, Anderson, Garrison, & Archer, 2001, p. 2). Considering the instructor’s workload and time commitment, the instructor may not be able to read all messages, let alone code them, to provide timely response or intervention to individuals or groups. Then, how can an instructor identify at-risk groups that require his/her facilitation and intervention?

Jahng et al. (2010) devised three quantitative indices (*quantity, equality, and shareness*) based on concepts of social network analysis and content analysis methods. The researchers measured collaboration rankings of four groups by the three indices and compared the group rankings with the achieved group marks. The collaboration rankings were consistent with the group marks. The researchers claimed that the indices reveal different problem aspects of group communication structure.

As Jahng and colleagues (2010) argued, the quantitative collaboration indices would be useful for instructors to monitor and support groups if the indices are valid and reliable in indicating critical problems in collaborative learning processes in groups. However, the author of the current study identifies some limitations of Jahng et al. (2010). First, the validity of the indices was not supported sufficiently by any other evidence, except for the group marks. Group marks in a graduate course may not necessarily be the genuine outcome of group collaboration. For example, the group product could be a compilation of individual pieces of work (i.e., cooperation, and not collaboration) or the product of one able individual with no collaboration or cooperation. Second, the study involved only twelve students in four groups, and two groups received the same group mark. Third, the reasons for lower or higher collaboration rankings were not identified or explained. For these reasons, the collaboration measures need to be further explored both to replicate the earlier work and to offer more practical application of the indices for instructors of online courses.

Recognizing the limitations of the previous study, the current study employs an in-depth qualitative analysis to identify hindering or facilitating factors related to less or more collaboration as measured by the three quantitative indices (*quantity, equality, shareness*). In addition to the qualitative assessment, group membership trends, in terms of communication connections in whole group discussions across the course timeline, are investigated as potential evidence for validity of the quantitative indices. This study will contribute to online teaching and learning by connecting research findings more directly to practice.

Collaboration Indices: Quantity, Equality, Shareness

Quantity indicates active interaction among group members during group collaboration. Jahng et al. (2010) measured communication *quantity* by the total number of words exchanged in each group. This measure was comparable because the number of members in each group was the same (n=3). In the current study, the quantity index measured the average number of words exchanged within a group because each group consisted of a different number of members (n=3 to 5).

Equality identifies participation variability among members. When a member dominates the communication, the others rarely participate in collaboration. Thus, the equality index reveals a skewed interaction structure. *Equality* is calculated as the standard deviation of the number of messages exchanged among members.

Shareness was coined by Jahng et al. (2010). *Shareness* reveals team-spirit/teamwork by calculating the portion of statements sent to all members. This index is a measure of how a group makes effort to establish a responsible and inclusive community. If group members send messages to all of the other members (i.e., one-to-group communication), the *shareness* index is higher than if more of the group’s communications are sent to individual members (i.e., one-to-one communication) rather than all the members. Even though the nature of the group forum space in the learning management system usually allows any member to read all postings, a member may not feel an obligation to respond to or think seriously about messages in which his/her name is not included. On the other hand, a message directed to all members may compel each member to think actively and participate in the communication process. According to Vaughan and Garrison (2006), sharing communication is necessary to establish a sense of community. This is important because in a well developed group, the communication structure among members is more open to enable information-sharing without isolating or excluding some members (Wheelan & Kesselring, 2005), which is, in turn, related positively to group performance (Barry & Stewart, 1997; Hyatt & Ruddy, 1997).

Table 1: Example of the three indices revealing different problems in small groups

Example	Group A (no problem indicated)	Group B (problem identified in equality)	Group C (problem identified in shareness)	Group D (problem identified in quantity)
Communication structure				
Quantity (Active communication)	100	100	100	10
Equality (Equal participation)	Perfect (0.0)	None (3.0)	Perfect (0.0)	Perfect (0.0)
Shareness (Team-spirit/teamwork)	All (100%)	All (100%)	None (0%)	All (100%)

Table 1 provides examples of group communication patterns for generic groups demonstrating: (A) no problem; (B) *equality* problems; (C) *shareness* problems; and, (D) *quantity* problems. Group A does not indicate any collaboration problems on the three indices. The group demonstrates good communication in *quantity* (100 words per member), perfectly equal

participation, and perfect *shareness* of communication. The communication network structure is triangulated by the three indices to reveal solid connections without broken links. Group B communications reveal a problem in *equality*. The group communication is dominated by B₁ while the other two members never participate in the group communications. A potential problem in Group C is identified by the *shareness* index. All the members in Group C participate equally, but C₁ and C₃ never have direct communication. Thus, C₂ is centralized in the group's communication network structure. Group D reveals the same network structure as Group A. However, communication *quantity* is very low, which may signify a lack of engagement in the community.

Collaborative Learning vs. Cooperative Learning

Collaborative learning is often defined by comparing its characteristics with cooperative learning (Alavi & Dufner, 2005; Dillenbourgh, Baker, Blaye, & O'Malley, 1996). For the research reported here, collaborative learning was defined differently from cooperative learning. A collaborative group was expected to seek a solution as a team, undertaking more complex processes working together, instead of taking a simple divide-and-conquer approach (Ingram & Hathorn, 2004; Stacy, 1999).

Theoretical Model

The Small Group Collaboration Model (SGCM) (Jahng et al., 2010) provides a theoretical framework for the current study. The SGCM was developed out of the main concepts from three existing models: Community of Inquiry (CoI) (Garrison, Anderson, & Archer, 2000), Input-Process-Output (IPO) model (McGrath, 1964, 1984), and Online Interaction Learning Model (Benbunan-Fich, Hiltz, & Harasim, 2005). The model, as shown in Figure 1, illustrates potential variables of *inputs* and *outcomes* that may be associated with small group collaboration across the timeline. The *inputs* include members' prior knowledge, a group task as a catalyst for collaboration, other elements such as members' experiences, personalities, pre-existing friendship in a whole group community before entering small groups, and instructional design. A small group inquiry community is nested within a whole group community. This means that the students keep participating in whole group discussion activity as they are doing small group activity simultaneously. Thus, the relationship among small group members (called *membership* here) is assumed to be influenced by, and exert influence on, the whole group community. Some groups may have built up friendships among members while other groups may not have known or ever have communicated with each other before entering a small group. A group whose members have exchanged communication during whole group discussions before entering the small group activity may have developed stronger social and/or cognitive presence when compared to other groups whose members have rarely responded to other small-group members' postings during the whole group discussions.

According to the IPO model (McGrath, 1964; 1984), the collaboration process transforms *inputs* into *outcomes*. The goal and genuine outcome of a collaborative learning process can be said to be members' constructed knowledge. Throughout the collaboration process, group members presumably have contributed to members' constructing knowledge as well as establishing group membership. Examples of outcomes of group collaboration, therefore, can be learner satisfaction, perceived learning, the quality of the product of the task, and group membership. When the students experience deep and meaningful learning through a collaboration process, the

outcomes would naturally be positive with higher student satisfaction and higher levels of perceived learning, higher quality of the group work product, and improved membership in the larger community. Wenger (1998) asserts that learners develop group membership as they engage in the collective process of learning in a community of shared practice. According to Wenger’s stages of membership development, group members tend to keep in touch, communicate, and call for advice in a larger community after leaving the small group community.

In the SGCM, it is presumed that a group would produce more positive learning *outcomes* if the group members participate actively in the collaboration process (*quantity*); if their communication shows decentralized structure without being dominated by one or two members (*equality*); and if members communicate to promote team-spirit and create attachment among group members by including all group members in communication instead of isolating some members (*shareness*).

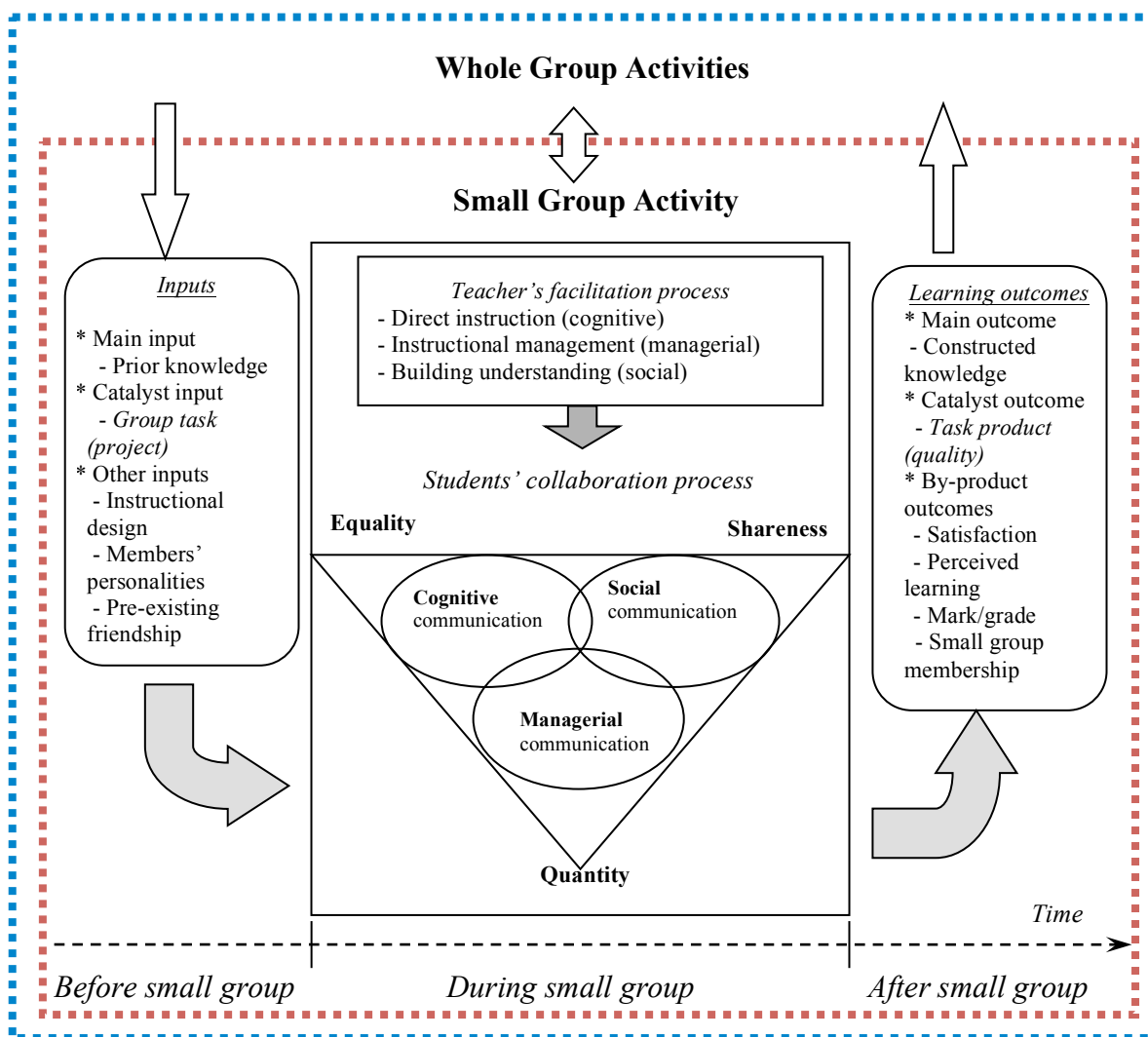


Figure 1: Small Group Collaboration Model (SGCM)

Methods

Data and the Context

A total of 2,029 messages were included in this research; 1,297 messages were retrieved from the whole group activity and 732 messages from the small group forum spaces from a graduate online course in an educational technology program. The course was delivered over 13 weeks in 2008 through the WebCT Vista course management system in a large western Canadian university. Twenty-four students (12 females and 12 males) were enrolled in the course. Most of them were full-time or part-time teachers or working professionals in the area of educational technology. The researcher was not involved in teaching or marking for the course.

The course included two major learning activities: whole group discussions and a small group activity. For the whole group discussion activity, a discussion topic was posted each week on the course bulletin board where students were required to add thoughts and opinions based on suggested readings and in response to classmates' messages. There were four units of discussions including Unit 1 (self-introduction, biographical activity) and Units 2, 3, and 4 (topic discussions). Instructors participated in the whole group discussions by answering students' questions, clarifying confusion, and facilitating students' discussions.

For the small group activity, students were asked to form their own groups to write a group paper as an assignment of the course. Groups could choose from two topic options. As described on the course website, topic option #1 was to analyze "a real example of institutional planning for e-learning and the use of learning technology." It required the group to read and analyze a series of real documents that had been produced as part of the planning process in an educational institution. In addition, they needed to do some background research on the institution to fully understand the context. Topic option #2 was to create "an imaginary case to recommend a vision for the use of e-learning."

Groups communication mainly occurred in the group forum space on the course website. While the instructor monitored communication in these forums, they rarely posted messages unless a group specifically asked for their help. Additionally, some groups communicated synchronously through Skype, course chat rooms, and/or instant messengers. All the groups used either Google Docs or Wiki to edit the group paper.

Analysis Procedures and Methods

Both qualitative and quantitative methods were employed in the current study. In conducting a content analysis, the coding framework reported in Jahng et al., 2010 (Table 1, p. 46) was used to categorize the communication into cognitive, social, or managerial categories. Two coders independently coded 20% of the small group communications (162 messages/10,169 words). The overall agreement rate between the coders was 87%, with a Cohen's kappa of 0.79, which is in the range of "substantial" strength of agreement (0.61-0.80), according to suggested benchmarks by Landis and Koch (1977). The coded data were measured by three indices, on which the six participating groups were ranked from the most collaborative group (ranking 1) to the least collaborative group (ranking 6).

Followed by the quantitative evaluation of group collaboration, an in-depth qualitative analysis was performed to identify any hindering or facilitating factors that potentially influenced the collaboration rankings as assessed by the quantitative indices. Each group's text communication was read repeatedly and summarized across the timeline of the course in terms of: (1) when and how a group initiates the group activity (ice-breaking stage); (2) what approach a group takes for dividing the task (brainstorming); (3) how group members exchange information and develop ideas (developing ideas); (4) how a group synthesizes to complete the task (compiling and editing); and (5) how members feel after completion of the collaboration (adjourning with satisfaction).

Throughout the process of reading the forum messages, the researcher was mindful of any collaboration that might be found in the other communication data. She paid careful attention to groups' communications about synchronous chats and Google Docs/Wiki activities occurred outside of the group forum. The researcher tracked and noted the forum communication to examine how these groups arrange, debrief, and assess their synchronous meetings and Google Docs/Wikis activities.

Finally, group membership development was examined by tracing communication relationships among small group members revealed from the whole group discussions before, during, and after the small group activity. As depicted in the Small Group Collaboration Model (Figure 1), a stronger pre-existing (before) friendship presumes more collaboration in a small group. In post-group (after) membership, members who experienced more collaboration would tend to continue communication after the small group activity.

Results

Quantitative assessment using quantity, equality, and shareness

For the purpose of quickly identifying potential problems in groups during group collaboration, a rubric table (Table 2) shows collaboration rankings in 9 domains as assessed by three collaboration indices (*quantity, equality, shareness*) in three communication categories (*cognitive, social, managerial*). The rank in each domain presents from the most collaborative group (rank 1) to the least collaborative group (rank 6).

The assessment results reveal that two groups (B and C) are not ranked as the least collaborative group in any of the nine domains. Meanwhile, the other four groups are ranked as the least collaborative group in one or more domains in the rubric table. Groups B and C can be identified as more collaborative groups than the rest of the groups. These two groups do not seem to have any serious problems and need not be red-flagged for instructors' careful attention.

When examining the other groups, Group A is most frequently ranked as the least collaborative group. This group displays problems with members' active participation, as well as democratic contribution. Group D is ranked by the *shareness* index as the least collaborative group in all three communication categories. This indicates that members' communication tends to be one-to-one rather than one-to-group. By the *equality* index, Group E reveals the least collaboration in their social communications. By the *quantity* index, Group F is the least collaborative group in social and managerial communication and is also low on the *equality* index in all the communication categories.

Table 2: Collaboration rankings assessed by three indices

Index	Category	Group A	Group B	Group C	Group D	Group E	Group F
Quantity	Cognitive	6	2	5	1	3	4
	Managerial	6	2	3	1	3	6
	Social	6	2	4	1	2	6
Equality	Cognitive	6	2	1	3	5	4
	Managerial	6	3	2	1	4	5
	Social	3	3	1	2	6	5
Shareness	Cognitive	5	4	2	6	3	1
	Managerial	4	3	2	6	4	1
	Social	2	4	3	6	5	1

Note: Ranks 6 and 5 are shaded as potential at-risk groups in collaboration by the indices.

Qualitative assessment results compared with the quantitative assessment

Because of their low rankings in several domains, Groups A and F were identified as having problems in communication quantity and participation equality, as shown in Table 2. Qualitative analysis of the communication processes in the groups found that Group A started communication much later than other groups for the small group project. As a result, the group did not have time for ice-breaking communications at the beginning of the small group activity and rarely exchanged social communications over the rest of the time of their work together. One member led the group by simply splitting the group task into individual portions, while the other members followed this instruction. The individual parts were then compiled to complete the group work. It appears that the members avoided any deeper negotiations to either recognize or seek to overcome opinion gaps in the group process. Therefore, the group can hardly be assessed as a successful group that achieved the benefits of collaboration in terms of better and more learning by challenging one another's existing knowledge system to reach a higher level of thinking and to construct new knowledge.

Group F was ranked as the least collaborative group in the categories of managerial and social communication when measured by the quantity index (Table 2). The group also revealed a very low level of equality in all three communication categories. In-depth review of communication in Group F revealed that its biggest problem was members' indecisiveness and lack of leadership in the group. Every member was reluctant to take a leading role, so the group had a dilemma in making decisions for moving on to the next step. From the beginning, this group was stuck in choosing a topic for the group paper.

Group D was ranked as the least collaborative group by the *shareness* index. However, this group revealed the highest level of collaboration in terms of the *quantity* and the *equality* of communication. A closer reading of the group's communications showed that the members struggled with many technological problems including Internet access. These problems caused serious emotional conflict between two members, which led to more one-to-one communications rather than one-to-group communications, as shown in the group's low *shareness* ranking.

Group E was identified as having some problems in *equality*. This may have been a consequence of the group composition, as there were five members living in different time zones, and their initial communications reflected their struggles with the time differences and individuals' preferences for some communication tools over others. Nevertheless, the group seemed to overcome these issues as they proceeded to work more collaboratively.

According to the measures used in this study, Group B had excellent collaboration throughout the activity. The group members exchanged many social statements and maintained a team spirit throughout their work together. In addition, this group started their work together quite early (relative to other groups), where they exchanged social communications that seemed to help them develop a sense of teamwork. This early start seemed to be an important factor for the high collaboration in this group.

Group C was also a very collaborative group. This group was efficient in their use of synchronous communication tools along with the asynchronous forum provided on the course website. Because the members communicated through both synchronous and asynchronous methods, their style of working allowed ready combination of the individual parts of the assignment, including the negotiations, to make one final product.

Regarding the uses of synchronous chats and/or Google Docs/Wikis, there seemed to be no contradictory collaborations revealed in asynchronous communication. Only Group C successfully communicated through chats, which was evidenced in their forum communication. The group efficiently arranged synchronous meetings and posted summaries of their chats in the forum. Other groups discussed whether to have synchronous meetings but decided not to use synchronous tools because of perceived difficulties in setting a time and/or choosing an appropriate tool. All the groups' activity in Google Docs/Wikis showed similar patterns as were revealed in forums. For example, one member of Group F (the least collaborative group) posted a message in the forum to complain about no activity in the group's Google Doc that he had started. On the other hand, Group B (the most collaborative group) frequently attached revised versions to postings in the group forum that produced in the group's Google Doc.

Group membership trends revealed in whole group discussions

Group B, which was identified as the most collaborative group by both the quantitative indices and the qualitative evaluation, revealed increased membership after the small group activity (Figure 2). Group E's membership dropped during the small group activity and recovered after the activity. Group C started the small group activity without any previous interaction, but indicated improved relationships after the activity. Groups A, D, and F, which were all identified as problem groups, did not communicate at all in the whole group discussions after the small group activity.

Discussion

Significance

As discussed in the introduction of this paper, there are common issues of efficacy and reliability of coding written data in conducting a content analysis (Murphy & Ciszewska-Carr, 2005). Thus, evaluating collaboration process by employing a content analysis technique may not be feasible

for instructors. To deal with this issue, the author attempted to calculate collaboration rankings by the three indices, using of the total volume of communication data without coding these into three categories.

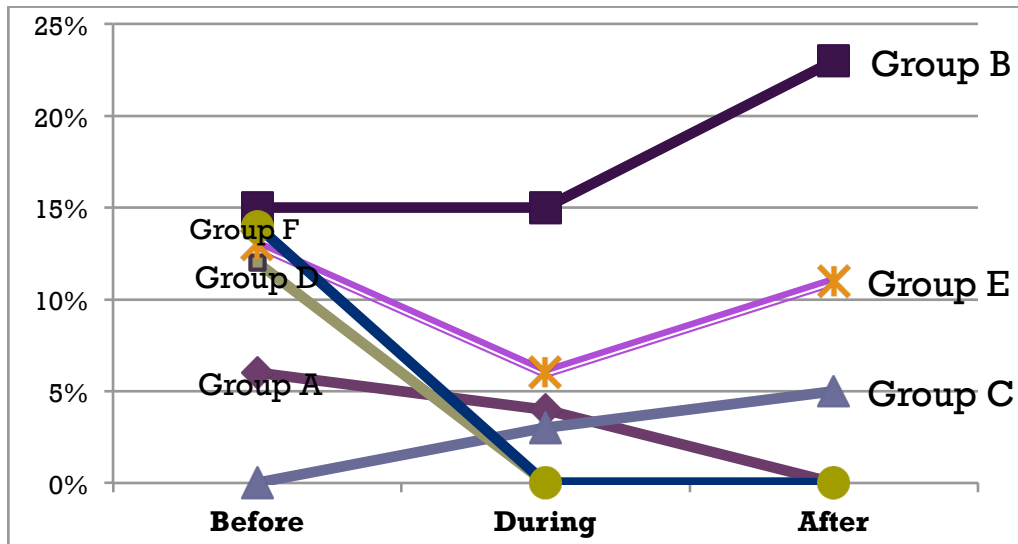


Figure 2: Group membership development trend in whole class discussions

Another important aspect of the indices is found in this study. The three indices are independent in terms of assessing different aspects of the groups’ collaboration processes. A high volume of communication measured in *quantity* is not positively related to *equality* (individual contribution), nor is it related to *shareness* (teamwork communication). In this regard, each index can be used for identifying potential problems. For instance, a high volume of communication is not always a sign of collaboration, but very little communication is often problematic. Perfect *equality* is not necessarily an indicator of successful collaboration, but a very unbalanced structure of group communication can be problematic. Full 100% *shareness* is not always ideal for good collaboration, but very individualistic one-to-one communication can be a sign of problems in the communication network within a group. To conclude, it can be said that a group has good collaboration when its communication has no problems indicated across all the three indices: *quantity*, *equality*, and *shareness*. If a group would reveal itself to be the least collaborative by any of the three indices, this suggests that the instructor should pay more careful attention to provide a possible support for the group.

The assessment results are presented in Table 3. Instead of nine domains without dividing communication into coding categories (see Table 2), three collaboration rankings indicate potential at-risk groups. In order to compare the results with qualitative evaluation and group membership trends, the findings reported in the above section are summarized in the table as well. The quantitative assessment results are consistent with the results from the qualitative assessment and group membership trend. This implies that potential problems will be revealed by the indices without coding the data into communication categories. This result has practical implications because a method that does not require conducting content analysis, and yet still identifies potential problems, through a built-in monitoring system of for a course, would be both feasible and useful.

Table 3: Summary of findings

Method	Index	Group A	Group B	Group C	Group D	Group E	Group F
Quantitative Assessment	Quantity	6	2	4	1	3	5
	Equality	6	3	1	1	5	4
	Shareness	4	3	2	6	4	1
Qualitative Evaluation	Hindering or Facilitating Factors	- Late start - Little social - No-ice breaking - Cooperative approach	- A lot of social communication - High team spirit	- Synchronous communication - Intensive collaboration	- Technology - Internet problems - Personal conflicts	- Overcome technical problems based on social communication	- Indecisiveness - No leadership - Little communication
Membership development	Interaction in whole class setting	Decreased	Improved	Improved	Decreased	Maintained	Decreased
Overall Assessment		Least collaboration; cooperation	Best collaboration	Good collaboration	Troubled collaboration; angry group	Okay collaboration; problem overcome	Failed collaboration; unable to collaborate

Limitations & Further Studies

The author acknowledges some limitations of this research. First, the research context was a graduate online course where small groups were required to work collaboratively on a group assignment project. Thus, the instructional methods and the theoretical model proposed in this article may be more useful for designing and facilitating collaborative learning processes in online courses similar to the research context than any other types of courses delivered by face-to-face or hybrid format.

Second, the data analyzed in this study were asynchronous communication data posted on course bulletin board and group forums. As reported in the Method section, other communication data that occurred outside of the course setting were not included in this research. If these data had been available for the analysis, they could have been useful to triangulate the findings of the research. Throughout the process of qualitative analysis, however, the author was aware of the potential problem caused from missing the extra data. As reported in the Results section, collaborative groups frequently talked about their synchronous chats or Google Doc/Wiki activities while less collaborative groups did not. This implies that a less collaborative group with little communication in an asynchronous communication setting tends to be less functional in a synchronous setting as well. In order to follow up this research, the author suggests further analyses including synchronous data as well as survey and/or interview data for the future research.

Third, outcome evaluations such as group marks, the quality of the group product (group paper), or student satisfaction were not included in this research. Although it is reasonable to expect that more collaboration would likely result in better outcomes, a more collaborative group might not always receive a higher mark or report higher levels of student satisfaction. The relationships between the learning process/outcomes and between inputs/outcomes may be research topics for further studies.

Lastly, the author assumes different weights may exist among the three indices. Quantity is the fundamental element for collaboration. Thus, the quantity index may be given more weight than the other two indices. In terms of communication categories, the cognitive category could be given more weight than social or managerial communications. In order to measure the degree of collaboration, a weighting formula needs to be developed based on analysis of a much larger data set in future studies.

Conclusion

This study assessed collaboration processes in small groups using three quantitative indices (*quantity*, *equality*, and *shareness*) proposed by Jahng et al. (2010). By repeating the methodological procedures and the coding framework employed by Jahng et al., written communication data posted in small group forums were coded into cognitive, social, and managerial communication and groups were ranked relatively according to the indices (Table 2). While Jahng et al. compared the evaluation results with group grades, the current study performed qualitative analyses to identify factors that might be associated with the assessment results according to the indices. The qualitative examination within individual groups described reasons for less or more collaboration as indicated by the indices. In addition, group membership trends were also examined (Figure 2). The communication network development revealed

consistent results with the quantitative and qualitative analyses. Therefore, it is concluded that the three quantitative indices of *quantity*, *equality*, and *shareness*, are valid evaluation tools that can be used to identify potential problems in small group collaboration processes. Furthermore, the indices are independent in terms of assessing different aspects of communication structure and thus they appropriately reveal potential collaboration problems without coding communication data by content analysis.

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