Communication Jigsaw: A Teaching Method that Promotes Scholarly Communication

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Abstract—This study examined the Communication Jigsaw as a novel, applied jigsaw strategy aimed to extend scholarly communication between university students. As the defining characteristic of the Communication Jigsaw, writing sheets were used as resources for reports and discussions. This documentation method enabled students to access all reports. In addition, a comment session was introduced to provide educational access to all subtopics. Contents were entrusted to each student and a student's actuation for self-directed, deep learning appeared in the quality of their comments and their selection of reports for comment. All reports and commenting activities were facilitated by e-Learning technologies and monitored. Then, collected data were analyzed using social graphs.

This study revealed that the comment session nurtured critical competencies toward applying acquired knowledge and finding information. Additionally, the Communication Jigsaw enabled the identification of outstanding performances among students and their connections. The Communication Jigsaw facilitated finding and analyzing the process of forming academic hubs and cliques within the scholarly community. The distribution spectrum of connections in the comment section did not conform to Gaussian distribution principles but rather the distinct distribution pattern characteristic of social communication. Taken together, this study showed a concrete example of lesson design and evaluation method to be adaptable to the flat world communication.

Keywords—active learning, cooperative learning, jigsaw technique, scholarly communication, social graph, written reports

1 Introduction

The "jigsaw" technique is a cooperative learning strategy based on group dynamics and social interactions [1]. This subset of learning techniques is the most well-studied and most frequently used of the cooperative learning approaches to date [2, 3].

There are currently six types of jigsaw strategies applicable to the classroom environment:

1. Original Jigsaw, usually called Jigsaw I, developed by Aronson [1]
2. Jigsaw II developed by Slavin [4, 5]

3. Jigsaw III developed by Stahl [6]
4. Jigsaw IV developed by Holliday [7]
5. Reverse Jigsaw developed by Hedeen [2]
6. Subject Jigsaw developed by Doymus [3]

All jigsaw strategies have been used in group-based learning environments and involve students cooperating with their peers toward an educational goal. The basic procedures of the six strategies are the same and incorporate the structured interaction of groups of students. The students are initially divided into original groups. Then, the academic material is divided into subtopics that are assigned to the members of each group. After students report the results of their investigation and discuss with their original group, they are reorganized into expert groups. These new expert groups discuss their shared subtopic toward elucidating a final answer. The students then return to their original group to report on the conclusions of each subtopic and amass what they have learned.

Some changes have been made to the application of the jigsaw process since its inception in 1978.

Jigsaw II includes a final test of expertise given in addition to Jigsaw I. Jigsaw III incorporates a form-based evaluation process. Unlike Jigsaw I, II, and III, Jigsaw IV recommends that quizzes are given to students in order to check their learning, and instruction by a teacher is provided to cover missed information at the end of Jigsaw process. While Jigsaw I, II, III, and IV emphasize the student's comprehension of the subject material, the Reverse Jigsaw focuses on their interpretation (e.g. perceptions, judgments). The Subject Jigsaw involves mixing both the subtopics and the students. Each original group is assigned a different subtopic and, therefore, the students in an original group engage the same subtopic and an expert group is composed of students with different subtopics.

The jigsaw technique is known for enabling students to actively participate in the learning process. Studies have determined that jigsaw is highly effective because it engages students twice (in their original groups and in their expert groups), encourages learning from one another [8], increases self-esteem [9], makes students responsible for teaching in their groups [10], improves social/relationship skills [11], increases student engagement, short-term and long-term retention of the subject matter, facilitates the frequent use of critical thinking, and results in a greater likelihood of transferring the lessons learned from one situation to another [12, 13]. Furthermore, effective academic achievement using the jigsaw approach has been extensively documented (e.g. [14] [15]).

However, when we focus on access of students to resources, each student has one subtopic they are in charge of reporting but they learn about the other subtopics from the oral reports of their peers. For example, if a jigsaw of four subtopics is running, each student has only a quarter of chance to face the original reports. In other words, students have the responsibility for reporting on the same subtopic twice: once on their own investigation to the original group and then on the discussion in the expert session.

Therefore, our Communication Jigsaw was developed to expand students' access to information by introducing communication through time-independent written documents.

1.1 Expanding Scholarly Communication

As determined in a famous study by Granovetter (1973), only 16% of people decide important matters through a contact they see "often," whereas 84% make decisions through contacts they see only "occasionally" or "rarely" [16]. This result reveals the importance of communicating with weak connections more than with strong acquaintants. Buchanan (2002) observed this phenomenon as well and concluded that without weak ties, a community would be fragmented into a number of isolated cliques [17]. Thus, it is important to develop concrete methods to connect students over structured groups.

Our Communication Jigsaw takes these findings into account by incorporating an additional session that allows students to access other original written resources. In this session, students can access their interested original resources or discover indispensable unknown points of view. The default setting for this comment session is a classroom, with time limits imposed for searching sheets on the table and recording comments [18]. Then, we scan the report sheets and distribute them in e-Learning.

2 Development of the Communication Jigsaw

The Communication Jigsaw was designed to introduce description-based scholarly communication and manage the following potential problems and restrictions of current jigsaw methodologies.

2.1 Descriptive Communication

Anderson (1993) summarized the following educational issues specific to Japanese students: (a) rarely initiated discussion, (b) avoided bringing up new topics, (c) didn't challenge the instructor, (d) seldom asked questions for clarification, and (e) didn't volunteer answers [19]. Furthermore, many additional articles have highlighted Japanese students' shyness and unwillingness to speak (e.g. [20, 21]). These observations are likely tied to cultural values: verbal messages are implicit and indirect; context (situation, people, nonverbal elements) is more important than words; one talks around the point and embellishes it [22].

Our description-based communication can help manage students' shyness. The method is intentionally developed as the affinity diagram, similar to the KJ-Method [23]. A report sheet in which student's result of investigation is recorded is designed. Through discussions in expert groups, similar sheets are grouped together. This sheet represents a medium that enhances students' discussion and enables ideas to be classified, named, voted on, and evaluated.

The original KJ-Method places emphasis on the ideas being relevant, verifiable, and important. In our affinity diagram, this method of description encourages less verbal students to participate. In addition, this approach allows groups to come to a democratic consensus using peer evaluation after the cooperative activities.

2.2 Switch to Students in Charge

The Jigsaw IV uses a test to confirm learning has been achieved by students in their expert groups [24]. However, for the Communication Jigsaw strategy, we ask students to switch charge of their reports. To do this, all students must prepare explanations of a report written by another student. Then, in the original group, they must listen to a report intently, read a description carefully, and ask questions until they understand the content. In addition to ensuring comprehension, this procedure enables peer review evaluation within the expert groups. Fair value judgment is expected.

2.3 Chance to Access All Subtopics

Unlike the other Jigsaw strategies, the Communication Jigsaw approach allows access to all subtopics. At this point, each student is in charge of two subtopics: a report sheet subtopic and an expert group subtopic. In addition, we introduced a comment session to allow students to write comments regarding each report sheet from the other subtopics. The student can select a target report sheet by interest, experience, and ability level; content of a comment is entrusted to and expected of each student.

This procedure is intended to introduce more free communication that is different from the activities in the original and expert groups. The emerging communication does not limit co-presence communication but adds communication through written documents. Even though both co-presence communication and written communication enable students to establish ties, the affordance of each method is rather distinct. Face-to-face interactions can provide rich communication experiences but are strongly bound by spacial constraints. On the other hand, written communication lacks the richness of physical interaction but allows for communication across space and time. Kostakos (2010) described the mixture of these spatial and trans-spatial communication modalities as a fused network that ultimately acted as an individuals' platform for social engagement [25]. The addition of the commenting procedure described in this study is not aimed at open-ended targets such as communication in social network systems (SNSs) but, instead, attempts to expand the academic reach to every member of a classroom, while e-Learning facilitates the selection of a target.

Accordingly, the purpose of this study was to examine the efficacy of the Communication Jigsaw strategy. Specifically, this report investigated the effects of written scholarly communication on a comment session.

3   Materials and Methods

To analyze scholarly communication among university students, two courses with the same content were carried out and monitored, and collected data included the introduced evaluations and social graph analysis.

The control group engaged in communication sessions at the end of each jigsaw in a classroom environment. The experimental group experienced the same lesson plan as the control group but its communication session was arranged using e-Learning.

Six jigsaws were executed in each course. For both courses, three evaluations were performed: an evaluation of the report sheet and the comment sheet from each jigsaw and a final examination at the end of the course.

3.1   Sheets

A6-sized report sheets (control group & experimental group) and comment sheets (control group) were used in this study. Both sheets contained entry columns on the front side to record the related two students' identification data and evaluated score into a computer; the students' descriptions were contained on the backside (Fig. 1).
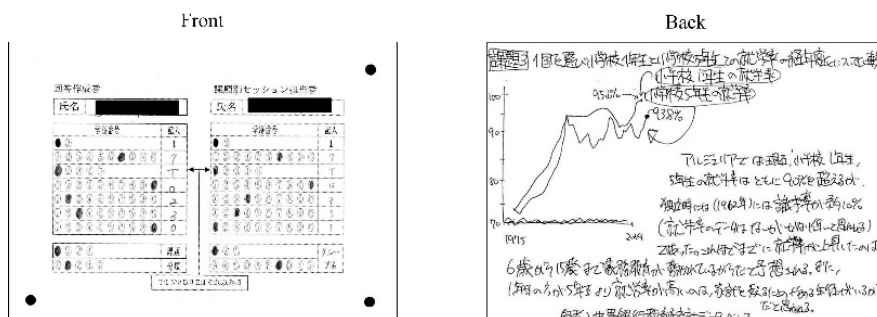

Fig. 1. Example of a report sheet

3.2   Evaluation Instruments

The following three evaluation methods were used to measure students' learning, and data from the comment sessions were introduced to the social graph analysis to understand students' scholarly communication.

Three Evaluations

— Report sheet: Each sheet was evaluated in the expert group activities using a peer evaluation method. A total of six report sheets per student were collected.
— Comment sheet: A teacher reviewed all comments, identified prominent or scholarly contributive comments, and scored them. A total of over twelve comments per student were reviewed.
— Final examination: After six Communication Jigsaw exercises, a paper examination was conducted to assess students' knowledge acquisition.

The students' scores for each evaluation measure were normalized $\in [0,100]$ and used for further analysis.

Social Graph Analysis. The two students' ID data from the comment sheet or e-Learning corresponded to a comment writer and a target student. This was the fundamental vector of scholarly communication between two students and was represented using social graph analysis. In social graph analysis, a "node" corresponds to a student and an "edge" reflects a comment from this student to another student. The social graph results from drawing the relationship between all nodes and edges. The graph includes hubs of nodes with aggregated edges, as well as clusters that are cohesive aggregations of more edges than are in the other parts of the network.

A vector operation of the directed graph method was used for this analysis. Drawing the social graphs and calculating the graphs' metrics were achieved using NodeXL Pro (Social Media Research Foundation, California, USA).

3.3 Communication Jigsaw Procedure

The applied process of the Communication Jigsaw was the same as other jigsaw strategies. However, the Communication Jigsaw introduced additional communication opportunities using written sheets, which, in turn, enabled the introduction of additional applied activities.

Table 1. The Communication Jigsaw procedure

Process	Place	Remarks	A	B	C	D
Introduction	Classroom	All members	Instruction			
Original group	Homework	Writing a report sheet	1	2	3	4
	Classroom	Explain	Group discussion 1			
	Classroom	Exchange sheets	2	3	4	1
Expert Group	Classroom	Explain Peer evaluation	Group discussion 2			
Original group	Classroom	Report findings	Group discussion 3			
Comment session	Classroom (control) / e-Learning (experimental)	Writing comments Teacher evaluation	3, 4	4, 1	1, 2	2, 3
Reflection	Classroom	All members	Classroom discussion			

A - D: Four students
1 - 4: Four subtopics

Table 1 delineates the Communication Jigsaw procedure.

First, all students were assigned to an original group of four members. Next, four subtopics were introduced and each student was instructed to complete a report sheet on one of the subtopics at home. In the following classroom session, the students presented their individual investigation results to the original group (Group discussion 1). As a specific characteristic of the Communication Jigsaw, students exchanged their report sheets with another student at the end of the original group session.

Second, the original groups were reorganized into expert groups according to subtopic; i.e. students joined together in groups with other students who had a report sheet on the same topic (Group discussion 2).

Third, all students moved back into their original groups and presented the findings from their expert groups (Group discussion 3).

As another unique characteristic of the Communication Jigsaw, we added a comment session to the next step of each jigsaw. At this point, each student engaged in two topics: a report sheet topic and an expert group topic. Then, each student was required to write comments on at least two other subtopics (Comment session). For the control group, each student wrote their comments during the lesson, in the classroom. For the experimental group, the teacher scanned and uploaded the report sheets to the Moodle Learning Platform and each student commented on an electronic message board on the site.

Finally, the students participated in a reflection session in the classroom environment to summarize a topic.

4 Results

4.1 Implementation

Two university courses were selected for inclusion in this study. The courses had the following characteristics:

― University: Chiba University, Chiba, Japan
― Course title: "International Understanding from Statistical Data" (a general education subject)
― Grade of students: First-year undergraduates from four colleges
― Course periods: October - November 2016 (control group) and October - November 2017 (experimental group)

4.2 Three Evaluations

Upon comparison of the results from the three evaluations, no significant differences between the groups were found (Table 2).

Table 2. Mean values from the three evaluations

	Control	Experimental
Report sheet	70.19 (17.77) n = 88	65.21 (17.24) n = 66
Comment sheet	13.13 (11.64) n = 89	14.08 (18.32) n = 67
Final examination	64.25 (10.58) n = 87	65.55 (14.96) n = 64

Mean value, standard deviation in parentheses, and number of students

However, differences in the mean values among the three evaluations were seen in each group, because these evaluations varied substantially in both methodology and

evaluators. Notably, scores from the comment sheets had smaller means and larger standard deviations.

The scores of 63 students from the experimental group who engaged in all three evaluations were subjected to further analysis. There was a statistically significant difference between evaluations as determined by one–way ANOVA ($F(2,189) = 212.6$, $p < 0.01$). The Steel-Dwass post-hoc test was used to compare the three evaluations and revealed that the scores from the comment portion were significantly lower than from the report sheet and the final examination ($p < 0.01$). A continuous correlation analysis showed a weak but positive correlation among the three evaluation scores (Table 3).

Table 3. Correlation matrix of the three evaluations from the experimental group

	Report sheet	Comment sheet	Final examination
Report sheet	1	0.264 *	0.276 *
Comment sheet	-	1	0.405 **
Final examination	-	-	1

*p < 0.05, **p < 0.01

Distribution of the Three Evaluations. Figure 2 reflects the distributions of the three evaluations from the experimental group. Here, in addition to the difference in mean value, a distinct decay distribution of the comment evaluation was observed.
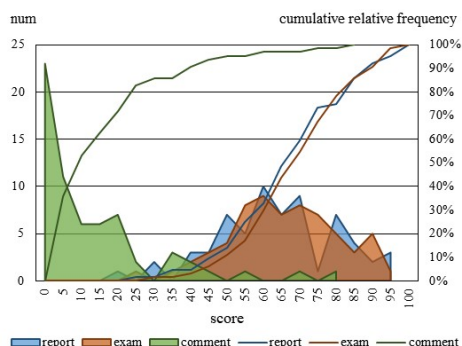
Fig. 2. Spectral distributions and cumulative relative frequencies of the three evaluations from the experimental group

Comparison of the Comment Sessions Scores. Toward illuminating differences in scholarly performance between the control and experimental group, the spectra of the comment session scores were compared (Fig. 3). This revealed that a majority of students in both groups were inactive in terms of scholarly performance. Neither distribution showed spectrum with normal distribution. The scores from the top students were counted four-times the mean in the control group and six-times the mean in the experimental group. Particularly, some scores were seen at discrete superior points in the experimental group.
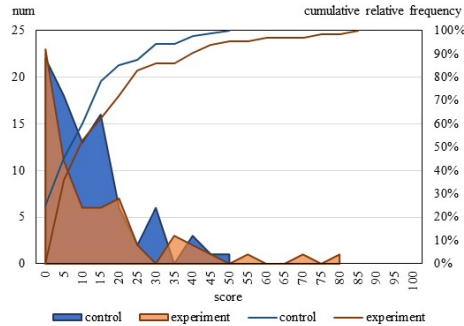
Fig. 3. Spectra comparison of the comment session scores from both groups

4.3 Social Graph Analysis of Comment Session

Data collected from the comment sessions of the experimental group were mapped using the social graph analysis. As a characteristic of the social graph analysis, we could involve all students from the course including those who did not complete the entire jigsaw procedure. Thus, the analysis processed all communication that occurred in the course including nodes with different edge numbers.

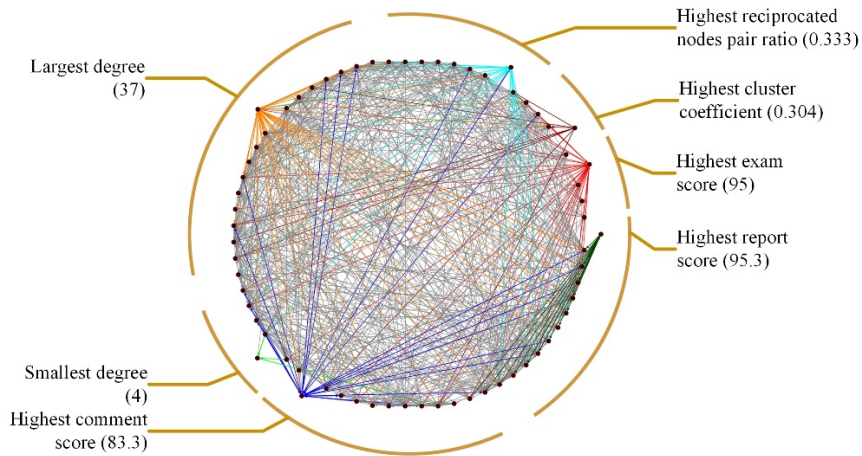Figure 4 presents the social graph of the comment sessions from the experimental group.

Fig. 4. Social graph of comment sessions from the experimental group.
Nodes are positioned using a circular layout and hand-positioned and colored to reflect nodes with important metrics and relevant scores.

This social analysis appears as a meshed graph. In the graph, important nodes are emphasized and related edges are colored, but we can distinguish the limited direct connections among these notable nodes. When we see nodes with the highest final examination score, highest comment score, and highest report score from the three evaluations, the numbers of out-degree (the number of comments) are 10, 15, and 10 respectively and close to the required minimum comment number of 12. In addition, the mean of reciprocated nodes to pair ratio in this network is small (Table 4). We can thereby understand the discrepancy between the top students in the three evaluations and the lack of communicational connection among them, even though the weak correlation is shown in Table 3.

Metrics. Table 4 shows the calculated metrics of the social graphs from the control and experimental groups. In both networks, the calculated diameters were small (3), and the maximum nodes in a connected component were equal to the number of nodes. Therefore, we concluded that both social graphs were small-world networks, as defined by Milgram [26]. In other words, students from the comment sessions in both groups were totally connected.

Table 4. Social graph metrics of communication in the comment session

Graph Metrics	Control	Experimental
Nodes	89	67
Unique edges	908	660
Total edges	1009	840
Reciprocated nodes paired ratio	0.121	0.192
Maximum nodes in a connected component	89	67
Diameter	3	3
Average shortest path length	1.76	1.68
Average degree	21.5	22.1
Average cluster coefficient	0.12	0.19

Distribution of Degree. By introducing comment sessions, the Communication Jigsaw enabled students to access the entire information of a course. Specifically, the experimental group used e-Learning for their activity. The emerging network was expected to be the fused product of both the co-presence network of face-to-face communication and the online network, such as communication in SNS.

The graph of a Gaussian distribution showed a bell-shaped curve, a tool used by most scientific studies on education. However, Barabási et al. (1999) found that human social activities follow power-law [27]. As a well-known example, the degree of distribution of communication in SNS is also considered to follow a power-law distribution [28]. Power-law distribution describes data that contain more extreme values than a Gaussian distribution, indicating the existence of hubs. Pan et al. (2011) investigated the characteristics of a fused network and found a decay spectra affected by the power-law distribution of SNS [29]. In fact, the Communication Jigsaw was designed to act as a fused network; however, to protect the safety of students' social

connections, the system offers a secure, controlled e-Learning environment (fixed members).
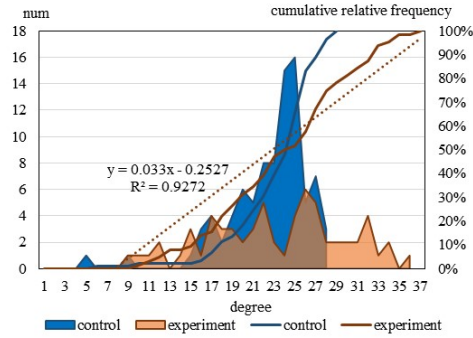
Fig. 5. Spectral distribution and cumulative relative frequency of degree in both groups

As such, the observed distribution of degrees in the experimental group had no peak and resembled uniform distribution ($R^2 = 0.9272$), as shown in Figure 5. However, similar to the results of Pan et al., we confirmed the expanding tail in a graph of the experimental group.

There are two potential reasons for the discrepancy between the results of Pan et al. and our experimental group. First, a student's minimum comment number was assigned in our session, and second, Pan et al. included freer social message communication such as friend messaging, wall postings, comments, and photo tags in Facebook.

The latent precondition for a student to write a comment for the experimental group was to be entrusted to each student. This style of commenting was regarded as an open question, which varied from student to student, without any pre-defined criteria for conducting a message. Thus, this learning environment would introduce a situation similar to an independent private value (IPV) auction. In the general auction, preceding studies have shown that the true valuation of buyers was a dominant strategy for each buyer. In this case, optimal price (evaluated quality) is independent of the number of buyers [30]. These prices of buyers then follow a uniform distribution [31]. This assumption could be applied to simplify the explanation of how students select target reports. Through preceding group discussion 1-3, each student had the ability to value the quality of the reports. However, the valued scholarly quality of a report was not always the same as the value to make a comment. When reports were regarded as ordered by the personal sequential ranking, the price of auction was comparable to a node selection in this study. Therefore, the distribution of nodes would have uniformity in degree.

5 Discussion

5.1 Connections of Scored Comments

Figure 6 shows the connections among scored comments in the comment sessions of the experimental group. This social graph included 20.7% of all comments. These comments were posted in e-Learning and recognized as the product of self-directed learning. Thirteen of the comments were of outstanding quality and the related community size was 29; when we considered all of the scored comments, these comments covered 59 students. This represented most students involved in the scholarly community but a concentration to a specific node was not observed. In addition, students of higher degree did not always have outstanding comments.
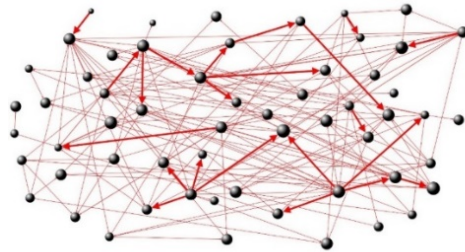
Fig. 6. Social graph of comment session communication from the experimental group. Node size is proportional to the degree and edge width is proportional to the score value of a comment. Opacity is filtered to highlight scored edges.

5.2 Characteristics of Observed Fused-Network
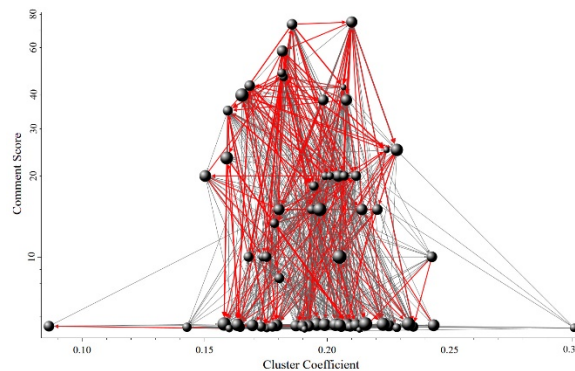
Fig. 7. Connections in comment sessions from the experimental group. Mapping cluster coefficient to the X-axis and comment score to the Y-axis (using logarithmic mapping). Red-colored edges indicated scored comments and gray-colored edges show comments of no score. Edge width is proportional to the score value the comment received. Node size is proportional to the final examination score.

In a social graph, the clustering coefficient is a property of a node that confers its connectivity to neighboring nodes. If the neighboring nodes are fully connected, the cluster coefficient is 1; a value close to 0 reflects a lack of connections in its neighborhood. In our social graph of the experimental group, the average cluster coefficient was 0.19, which was relatively low (Table 4) and most nodes that produced higher scores in the comments were around this number (Figure 7). Therefore, the network pattern of the comment sessions resembled that of a random network. On the other hand, many nodes associated with higher scores in the final examination existed in the low-scoring area of the comment evaluation. However, there was few low-scoring nodes in the final examination evaluation in the area nodes that scored highly in the comment evaluation.

Taken together, these results demonstrated that the final examination could be the fundamentals for applied competencies in the comment session, but higher scores in the final examination did not always translate to effective actuation of scholarly performance in the comment session.

5.3 Overall Effects of the Communication Jigsaw

The following is a summary of the effects of the Communication Jigsaw, particularly for the experimental group.

Distinctive Features

- The Communication Jigsaw encouraged the formation of a scholarly community of students in the unstructured and spontaneous communication environment provided by the comment session.
- Practical ability was an important element in the comment session, where learning was not aimed at acquiring fundamental skills and knowledge but, instead, at integrating their understanding and facilitating deeper comprehension.
- The comment session required students to increase their motivation. This part of the Communication Jigsaw capitalized on how spontaneous self-directed learning happens.

Observed Benefits

- The comment session enabled the identification and extraction of outstanding student performance.
- The comment session embodied the distinct distribution of degrees and scores (weighted degrees) that are characteristic of social communication, where the distribution no longer conforms to a Gaussian pattern.
- The comment session elucidated critical competencies to find information beyond what the students knew at that time.
- Learning through the comment session frequently includes searching and accessing unknown information in cyberspace. This is the potential benefit to using e-Learning in the comment session.

- Ties of scholarly comments covered connections between almost all of the students. This meant that even if only a portion of the students showed valuable scholarly performance, this learning was connected to all students.
- The Communication Jigsaw enabled finding and analyzing the process of forming hubs and cliques within the scholarly community.

Future Considerations

- No remarkable aggregation to a specific node was observed in this study. However, this environment allows heavy users, influencers, and social butterflies to serve as hubs. In the future, continuous trials and monitoring will be needed.
- Students with the top examination score, the top comment score, and the top report score were not the center of communication. In fact, the target competencies of each evaluation were different, but the observed discrepancy requires further analysis to fully understand latent relational factors.
- The majority of comments showed dry communication of consent, praise, and impression, and 20% of the comments showed scholarly performance through primitive inquiry. This rate of 20% echoes the Pareto principle [32, 33] of only a few occupying major portions, but since scored comments covered most students in the course, further investigation is required to clarify the characteristics of the scholarly communication engendered by this novel approach.

The Central Council for Education in Japan reported a curriculum change in 2012 and active learning has since formed the basis of the next culture of education [34]. From this perspective, three major education enhancements have been defined for active learning: self-directed, interactive, and deep learning [35].

On the other hand, cooperative learning is an important component of active learning that structures students into groups with defined roles for each student and a shared task for the group to accomplish [36]. Therefore, the jigsaw technique has been frequently used in contemporary lesson planning.

However, a crucial question remains:

In the jigsaw-based learning process, can each student achieve self-directed deep learning?

It is demanded of educators that they teach by designing and associating both the teaching setting and settings that require students to think, judge, and express their knowledge [37]. In addition, using acquired skills and information, they need to develop a multifaceted, deep understanding of important concepts. Online activities, including comment sessions, could help realize access to multifaceted information and actualize complex, effective learning. Regarding theory, connectivism purports that learning and knowledge rest in access to a diversity of opinions [38]. Thus, the Communication Jigsaw represents a comprehensive method that challenges an integral part of active learning to engage the triad of self-directed, interactive, and deep learning styles in its process.

6   References

[1] E. Aronson, N. Blaney, C. Stephan, J. Sikes, and M. Snapp, *The jigsaw classroom*, Beverly Hills, CA: Sage, 1978.

[2] T. Hedeen, "The reverse jigsaw: A process of cooperative learning and discussion," *Teaching Sociology,* vol. 31(3), pp. 325-332, 2003. https://doi.org/10.2307/3211330

[3] K. Doymus, "Teaching chemical equilibrium with the Jigsaw technique," *Research in Science Education,* vol. 38(2), pp. 249-260, 2007. https://doi.org/10.1007/s11165-007-9047-8

[4] R. E. Slavin, *Cooperative learning: Student teams. What research says to the teacher*, 2nd ed., Washington, D.C.: National Education Association of the United States, 1987.

[5] R. E. Slavin, "Cooperative learning," *Review of Educational Research,* vol. 50(2), pp. 315-342, 1980. https://doi.org/10.3102/00346543050002315

[6] R. J. Stahl, *Cooperative learning in the social studies classroom: A handbook for teachers*, Menlo Park, CA: Addison-Wesley, 1994.

[7] D. C. Holliday, "The development of Jigsaw IV in a secondary social studies classroom," *ERIC Document Reproduction Service No. ED447045*, 2000.

[8] S. M. Tamah, "Jigsaw technique in reading class of young learners: Revealing students' interaction," *ERIC: Online Submission ED495487*, 2007.

[9] D. Kilic, "The effect of the Jigsaw technique on learning the concepts of the principles and methods of teaching," *World applied sciences journal,* vol. 4(1), pp. 109-114, 2008.

[10] K. D. U. Şimşek, A. Karaçöp, and Ş. Ada, "Effects of two cooperative learning strategies on teaching and Learning topics of thermochemistry," *World Applied Sciences Journal,* vol. 7(1), pp. 34-42, 2009.

[11] D. W. Johnson and F. P. Johnson, *Joining together: Group theory and group skills*, 4th ed., NJ: Prentice-Hall Inc., 1991.

[12] B. J. Millis, *Cooperative learning in higher education: Across the disciplines, across the academy*, Sterling, VA: Stylus, 2010.

[13] D. W. Johnson, R. T. Johnson, and K. Smith, "The state of cooperative learning in postsecondary and professional settings," *Educational Psychology Review,* vol. 19(1), pp. 15-29, 2007. https://doi.org/10.1007/s10648-006-9038-8

[14] D. V. Perkins and R. N. Saris, "A jigsaw classroom technique for undergraduate statistics courses," *Teaching of psychology,* vol. 28(2), pp. 111-113, 2001. https://doi.org/10.1207/S15328023TOP2802_09

[15] Y. J. Dori, O. Yeroslavski, and R. Lazarowitz, "The effect of teaching the cell topic using the Jigsaw method on students' achievement and learning activity," presented at the Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco, 1995.

[16] M. S. Granovetter, "The strength of weak ties," *American Journal of Sociology,* vol. 78(6), pp. 1360-1380, 1973. https://doi.org/10.1086/225469

[17] M. Buchanan, *Nexus: small worlds and the groundbreaking theory of networks*, NewYork: WW Norton & Company, 2002.

[18] M. Yoshida, "Communication in graphs," *International Conference on Education and Learning*, Tokyo, Proc. pp. 367-378, 2017.

[19] F. E. Anderson, "The enigma of the college classroom," *A handbook for teaching English at Japanese colleges and universities*, pp. 101-110, 1993.

[20] P. Doyon, "Shyness in the Japanese EFL class: Why it is a problem, what it is, what causes it, and what to do about it," *The Language Teacher,* vol. 24(1), pp. 11-16, 2000.

[21] S. Nimmannit, "Maximizing students' oral skills: The Asian context," *The Language Teacher,* vol. 22(11), pp. 37-39, 1998.

[22] E. T. Hall, *The silent language*, New York: Doubleday, 1959.

[23] J. Kawakita, *An idea development method. For creativity development*, Tokyo: Chuou Kouron-sha, 1967.

[24] H. Turkmen and D. Buyukaltay, "Which one is better? Jigsaw II versus Jigsaw IV on the subject of the building blocks of matter and atom," *Journal of Education in Science, Environment and Health,* vol. 1(2), pp. 88-94, 2015. https://doi.org/10.21891/jeseh.43349

[25] V. Kostakos and J. Venkatanathan, "Making friends in life and online: Equivalence, micro-correlation and value in spatial and transpatial social networks," *2010 IEEE Second International Conference on Social Computing*, Proc. pp. 587-594, 2010. https://doi.org/10.1109/SocialCom.2010.181

[26] S. Milgram, "The small world problem," *Psychology Today,* vol. 2(1), pp. 60-67, 1967.

[27] A. L. Barabási, R. Albert, and H. Jeong, "Mean-field theory for scale-free random networks," *Physica A: Statistical Mechanics and its Applications,* vol. 272(1), pp. 173-187, 1999. https://doi.org/10.1016/S0378-4371(99)00291-5

[28] A. Mislove, M. Marcon, K. P. Gummadi, P. Druschel, and B. Bhattacharjee, "Measurement and analysis of online social networks," *7th ACM SIGCOMM conference on Internet measurement*, Proc. pp. 29-42, 2007. https://doi.org/10.1145/1298306.1298311

[29] S. J. Pan, D. J. Boston, and C. Borcea, "Analysis of fusing online and co-presence social networks," *2011 IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops)*, Seattle, USA, Proc. pp. 496-501, 2011.

[30] J. J. Laffont and E. Maskin, "Optimal reservation price in the vickrey auction," *Economics Letters,* vol. 6(4), pp. 309-313, 1980. https://doi.org/10.1016/0165-1765(80)90002-6

[31] K. Leyton-Brown, M. Pearson, and Y. Shoham, "Towards a universal test suite for combinatorial auction algorithms," *2nd ACM conference on Electronic commerce*, Proc. pp. 66-76, 2000. https://doi.org/10.1145/352871.352879

[32] V. Pareto, *Manual of political economy. A critical and variorum edition*, Croydon: Oxford University Press, 2014.

[33] G. E. Box and R. D. Meyer, "An analysis for unreplicated fractional factorials," *Technometrics,* vol. 28(1), pp. 11-18, 1986. https://doi.org/10.1080/00401706.1986.10488093

[34] The Central Council for Education, "Fostering qualitative change of university education to develop new future. Universities to develop learning throughout life and self-directed thinking," Tokyo: MEXT, August 28, 2012.

[35] The Central Council for Education, "About revision and needed measures for course of studies for kindergarden, elementary, lower and higher secondary schools and special education schools," Tokyo: MEXT, 2016.

[36] M. W. Keyser, "Active learning and cooperative learning: understanding the difference and using both styles effectively," *Research Strategies,* vol. 17(1), pp. 35-44, 2000. https://doi.org/10.1016/S0734-3310(00)00022-7

[37] The Curriculum Planning Special Sectional Meeting, "Report of points at issue rearranging in the curriculum planning special sectional meeting," Tokyo: MEXT, August 26, 2015.

[38] G. Siemens, *About: Description of connectivism.,* Web page, Accessed: October 21, 2015, Available: http://goo.gl/DTIajj, 2004.

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