

## Diversity in Learners' Contributions to Idea Improvement Processes Among the High Learning-Outcome Groups in a Knowledge Building Practice

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**Abstract:** Our previous work identified the conditions in which idea improvement processes operate to improve learning outcomes. This study further examined the differences and similarities in learners' contributions among high learning-outcome groups. We conducted a socio-semantic network analysis of three high learning-outcome groups' discourse to assess individual contributions. We found learners' individual contributions to discourse topics, critical for idea improvement, to be distributed among the group members, and the patterns of distribution to be diverse across the three groups. Thus, diversity in learners' contributions to their groups' idea improvement should be considered as a rotating leadership over multiple topics in a collaborative discourse.

### Theoretical background and research purpose

#### An analysis of idea promisingness and improvement process

The theory of knowledge building (KB) has been a leading model of learning environments in the learning sciences for decades (Scaladmalia & Bereiter, 2021). According to this theory, it is important for individual learners in learning environments to be able to contribute to the knowledge development of a knowledge-building community. There is always potential for further improvement in new knowledge, solutions, and ideas generated via the combining of knowledge (Bereiter & Scaladmalia, 2003). When it comes to creative problem solving based on knowledge building, learners generate multiple ideas, which are then continually developed and improved. In this process, ideas continue to change, and ideas that are no longer needed in the activity are sometimes eliminated. Subsequently, learners select the best promising idea for the problem and focus on improving it. In other words, it is important to determine how effective the idea is for the problem to be solved, and whether it will lead to a solution in the future. For this purpose, an evaluation index for idea selection is necessary. Recently, the concept of "promisingness" has drawn attention (Chen et al., 2015).

Our previous work (Kawakubo et al., 2020, 2021) focused not only on the selection of promising ideas, but also on the improvement process of those ideas, and examined their relationship to learning outcomes. Kawakubo et al. (2020) used the KBDeX (Oshima et al., 2012) socio-semantic network analysis tool to analyze the network of discourse in a computer-supported collaborative learning (CSCL) environment for Project-Based Learning (PjBL). In addition, they conducted cluster analysis based on the temporal changes in the degree centrality coefficients (DCs) of all nouns that appeared in the discourse. As a result, they found discourse topics as a group of nouns with similar temporal trajectories of DCs leading to high learning outcomes by comparing high learning-outcome groups with low learning-outcome groups. In summary, Kawakubo et al. (2020) identified the following promising idea selection and idea improvement processes as necessary for high learning outcomes: (1) a process that considers the possibility of improvement for selecting idea promisingness, (2) making a judgment of idea promisingness and selecting from multiple ideas rather than sticking to a single idea, and (3) making ideas more robust and convincing by examining rationales and collecting evidence for their claims. Kawakubo et al. (2021) also confirmed the results in further analyses.

#### Research purpose

Previous studies have provided aspects of discourse topics and patterns that lead to high learning outcomes in terms of idea promisingness and idea improvement. While they have listed the differences in the conditions of discourse topics leading to high and low learning outcomes, they do not detail how learners in high learning-outcome groups contribute to group idea improvement. It is thought that examining individual contributions can capture characteristics of the group and its members in more depth, and detailed teaching can be tailored to suit the group and its members. Therefore, this study examines the diversity and similarities in the contributions of learners in the high learning-outcome groups analyzed by Kawakubo et al. (2020). Another socio-semantic network analysis was conducted by calculating the temporal trajectories of the DCs of vocabulary in each learner's discourse by discourse topics as datasets to evaluate their contribution to the group idea improvement.

## Study design

### Study context

First-year university students in a Japanese public university participated in a knowledge-building practice as a PjBL course in the second semester of 2017 (70 students in 18 groups) and 2018 (75 students in 20 groups). This course was conducted in a face-to-face format. The course design was the same in both years. Students worked on their challenges in small groups of three or four. The course was designed as a creative problem-solving one with the task of proposing “an original happiness index.” Students’ final products were shared and examined among themselves during a poster session. In weeks 9 to 14, students wrote weekly group notes on the progress of their group activities in Knowledge Forum (Scardamalia & Bereiter, 2021), a CSCL environment. In the group progress notes, students described the ideas considered, and how these ideas were created and improved. They also wrote individual reflection notes, which consisted of personal comments on the group activity, including ways to further improve the group’s ideas, as well as other ideas to be considered in the following weeks.

### Data and analysis

#### Poster presentation as a learning outcome

The final posters were treated as the group learning outcomes. Based on the guidelines of the poster preparation presented to the students, the following evaluation criteria were formulated: (1) appropriateness of the names of their indicators; (2) how well they described the unique natures of their proposed indicators; (3) the amount of evidence (data) used to calculate their proposed indicators; (4) how well structured the data were to represent the nature of their proposed indicators; (5) how well their indicators explained the ranking of prefectures in Japan; (6) how well their results were presented; and (7) how well they discussed their results of prefecture ranking.

Four independent raters, including the authors, evaluated the posters using a 5-point Likert scale. Cronbach’s  $\alpha$  coefficients were calculated as the reliability coefficients for each rating. Given that high reliabilities were observed for all criteria ( $\alpha$ s > 0.87), the means of original scores of four raters were used for further analyses. The scores were further standardized within each criterion, and the total values of the seven standardized scores were used as the groups’ learning outcome scores.

#### An analysis of the individual contributions to idea improvement based on the discourse topics

Three high learning-outcome groups, ranked as belonging to the top 5% of all groups, were selected for the analysis (Groups A, B, and C). These groups consisted of four students each. Their individual contributions to collaborative discourse were evaluated via the use of their individual discourses in the Knowledge Forum (weeks 9–14) as datasets. We calculated the temporal trajectories of the DCs of nouns included in the discourse topics identified in our previous study with the individual learners’ datasets by KBDeX, then compared the students’ DCs trajectories with the DCs trajectories of their groups.

## Results and discussion

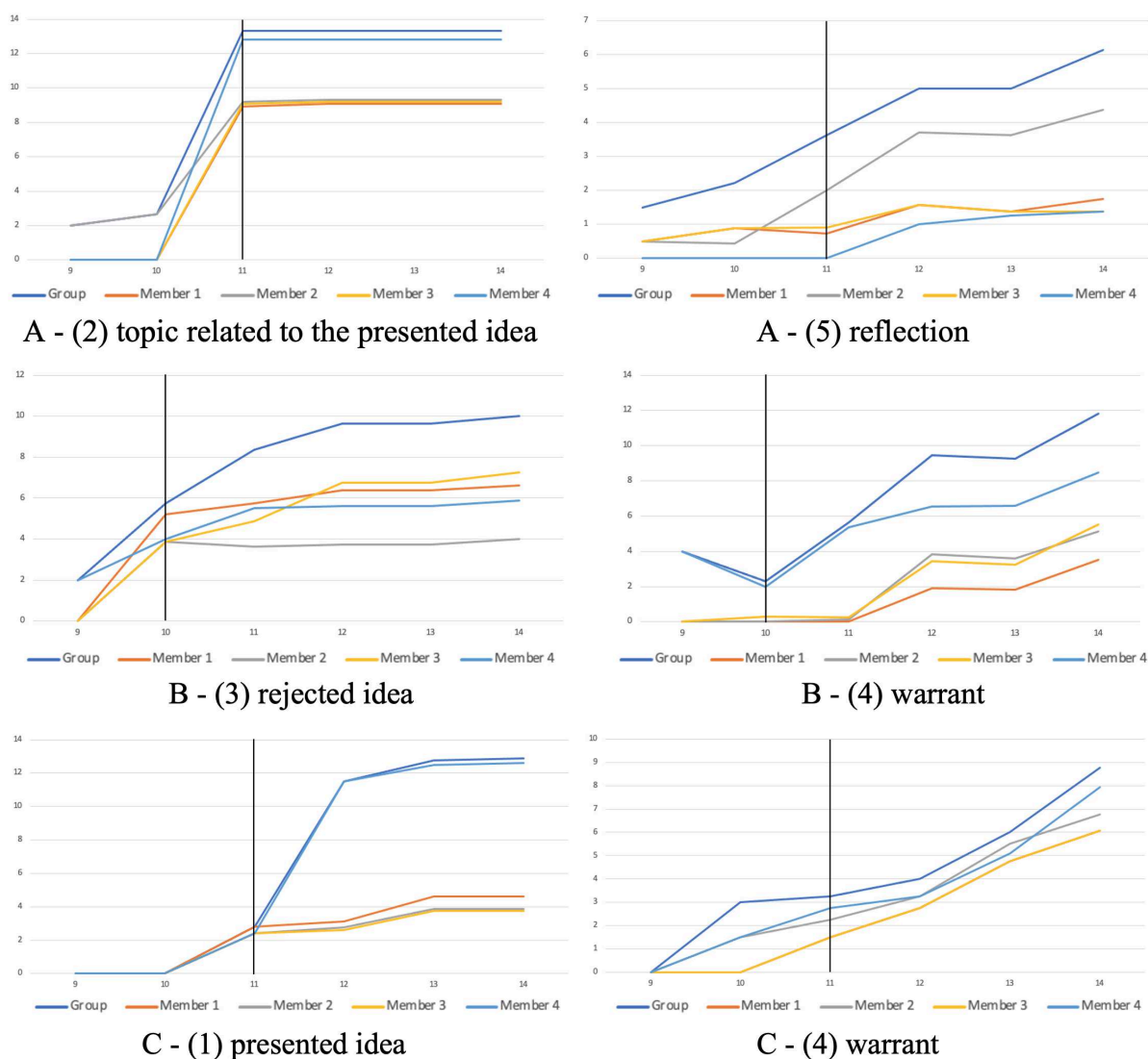
In our previous study (Kawakubo et al., 2021), the following discourse topics were identified via a cluster analysis of the temporal trajectories of the DCs of nouns used in the group discourse: (1) presented idea; (2) topic related to the presented idea; (3) rejected idea; (4) warrant; (5) reflection; (6) report; and (7) preparation of the presentation. Figure 1 shows the temporal trajectories of the total values of DCs each week. Of the discourse topics identified in our previous study, we show the discourse topics on which the students’ contributions were significantly different while identifying individual students’ contributions within the groups and examining the differences in the patterns of the contributions between the groups. Differences in contributions were found in the following: (1) the presented idea, (2) the topic related to the presented idea, (3) the rejected idea, (4) the warrant, and (5) the reflection in Group A; (1) the presented idea, (3) the rejected idea, (4) the warrant, (5) the reflection, and (6) the report in Group B; and (1) the presented idea, (3) the rejected idea, (4) the warrant, and (6) the report in Group C.

### Group members’ contributions to idea improvement based on discourse topics

With regard to the discourse topics taken up by Group A, the following diversities in members’ contributions were found. As seen in A-(2), members’ contributions closest to their group idea improvement were swapped in the middle of the process. Until week 10, the DCs trajectory of member 2 was consistent with the DCs trajectory of the group. However, after week 10, it was the DCs trajectory of member 4 which was closest to the DCs

trajectory of the group. The results revealed that member 2 might have suggested a topic related to the idea, and member 4 took the lead in sustaining the idea improvement using the proposed topic. In A-(5), the DCs trajectory of member 4 was below the trajectories of other members. In contrast, the DCs trajectory of member 2 was closest to the group's trajectory after week 10, and maintained higher DCs than those of other members. It may be summarized that member 2 took the lead in reporting the group's idea improvement as a coordinator.

**Figure 1**  
*Temporal Trajectories of the Total Values of DCs for Each Week*



*Note.* While the vertical line represents the total value of the DCs, the horizontal line represents weeks.

With regard to the discourse topics taken up by Group B, diversities in members' contributions were found in the (3) rejected idea and (4) warrant. In B-(3), member 1's trajectory was close to the group's DCs trajectory by week 10, when the proposed idea was decided upon. Because a candidate idea had been discussed in the discourse topic until the proposed idea was selected, the results revealed that member 1 continued to propose multiple ideas for group idea improvement. In B-(4), the DCs trajectory of member 4 was the closest to the group DCs trajectory in comparison to the other members, who persistently maintained lower values. According to the results, member 4 was the central contributor to the discourse topic, which was concerned with the objective indicators needed to support their ideas.

With regard to the discourse topics taken up by Group C, diversities in members' contributions were found in the (1) presented idea and (5) warrant. In C-(1), until the proposed idea was selected, the DCs trajectory of member 1 was the closest to the group's DCs trajectory. After their selection of a proposed idea, the DCs trajectory of member 4 was the closest to the group DCs trajectory, compared to other members' trajectories. The results show that member 4 made a central contribution to the idea's improvement, while member 1 generated the idea. In C-(4), the DCs trajectories of members 2 and 4 were close to the group trajectory, with their contributions switching week by week. In particular, member 4 has a lot of periods with higher values than member 2. According to the results, these two members (especially member 4) were the main contributors to the discourse topics.

## Conclusion

The results of this study found that individual contributions in high learning-outcome groups (A, B, and C) were different. In Group A, the student who raised the topic related to the presented idea assigned the development of the idea to another member as a group coordinator. In Group B, while one member ensured idea diversity in their group's idea selection, another member played a central role in improving the discourse topic's supporting ideas (warrant) after selection an idea. In Group C, one member worked as an originator of the presented idea, while another member was primarily responsible for improving and supporting the idea. Thus, there was considerable variety in the discourse topics contributed by individuals in each group. Given that the development of ideas is considered learning in KB, this study's findings suggest that KB activities may be established through various types of student contributions.

While there were diversities in the members' contributions to their group's idea improvement among the three high learning-outcome groups, a common feature was the group members' collaborative contribution to idea improvement by rotating leadership across different discourse topics. Their ability to focus on the discourse topics critical to idea improvement, as suggested in the previous study, as well as to distribute their cognitive workload appropriately may have contributed to the quality of their final ideas.

While the quantitative approach allowed us to analyze individual contributions in the process of idea selection and improvement, we are considering combining this with qualitative analyses for more accurate evaluation in the future.

## References

- Bereiter, C. & Scardamalia, M. (2003) Learning to work creatively with knowledge. In E. D. Corte, L. Verschaffel, N. Entwistle, & J. V. Merriënboer (Eds.), *Powerful learning environments: Unravelling basic components and dimensions* (pp.73-78). Oxford: Elsevier Science.
- Chen, B., Scardamalia, M., & Bereiter, C. (2015). Advancing knowledge-building discourse through judgments of promising ideas. *International Journal of Computer-Supported Collaborative Learning*, 10, 345–366.
- Kawakubo, A. J T., Oshima, J., & Oshima, R. (2020). Differences in idea improvement processes between high and low learning-outcome groups in project-based learning. In M. Gresalfi & I. S. Horn (Eds.), *The Interdisciplinarity of the Learning Sciences, 14th International Conference of the Learning Sciences (ICLS) 2020, Volume 1* (pp. 505–508). Nashville, Tennessee: International Society of the Learning Sciences.
- Kawakubo, A. J T., Oshima, J., & Oshima, R. (2021). Idea Improvement Processes Leading to High Learning Outcomes and the Development of Regulation in Collaboration. In Hmelo-Silver, C. E, De Wever, B., & Oshima, J. (Eds.), *Proceedings of the 14th International Conference on Computer-Supported Collaborative Learning - CSCL 2021* (pp. 169–172). Bochum, Germany: International Society of the Learning Sciences.
- Oshima, J., Oshima, R., & Matsuzawa, Y. (2012). Knowledge Building Discourse Explorer: a social network analysis application for knowledge building discourse. *Educational technology research and development*, 60(5), 903–921.
- Scardamalia, M., & Bereiter, C. (2021). Knowledge building: Advancing the state of community knowledge. In U. Cress, C. Rosé, A. F. Wise, & J. Oshima (Eds.), *International handbook of computer-Supported Collaborative Learning* (pp. 261–279). Cham: Springer.

## Acknowledgments

This work was supported by JSPS KAKENHI Grant Number 16H0187, 18K18639 and 20KK0046.