# Differences in Idea Improvement Processes Between High and Low Learning-Outcome Groups in Project-based Learning

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**Abstract:** In learning as knowledge-creation, learners continuously improve their ideas. Studies have shown that (1) learners would more successfully engage in idea improvement when they were aware of idea promisingness, and (2) they would be more successful when they had appropriate epistemic frames of idea promisingness. This study examined group differences in idea improvement processes. Seventy first-year university students (18 groups) participated in Project-based Learning with Knowledge Forum as their reflection tool. Six types of idea improvement processes were identified through socio-semantic network analyses of vocabulary in participants' progress reports and a clustering analysis based on the temporal changes in degree centralities. Further comparative analysis with audio-recordings as additional data revealed that successful groups not only started with good judgments of idea promisingness but also continuously considered multiple ideas and jointly constructed coherent explanations based on evidence they searched.

## Theoretical background and research purposes

In learning as knowledge-creation, learners improve their ideas through collaboration rather than learning from their teachers in the classroom. The unique nature of learning as knowledge-creation requires learners to develop their competence to make an appropriate judgment of idea promisingness. However, the judgment of idea promisingness has not been sufficiently studied so far. Chen, Scardamalia, and Bereiter (2015) conducted an initial study examining the level at which elementary school students were able to make an appropriate judgment of their ideas in a knowledge-building classroom. In Knowledge Forum (Scardamalia & Bereiter, 2014), a CSCL environment, the students were encouraged to judge their ideas to select better ones for their further inquiries. They discussed which ideas were better and the criteria that could be used to judge the idea promisingness. Analyses of online discourses revealed that even elementary students had their own definition of promisingness and successfully developed their competence in making a judgment of idea promisingness through their inquiry-based learning. In another study, Chen (2017) further explored how students' competence to judge their idea promisingness was related to a conceptual understanding of their study topic through the development of their epistemic beliefs. In his design-based research with a sixth-grade classroom, it was found that students successfully developed their understanding and judgment of idea promisingness through repeated practices. As students developed their competence to judge promisingness, conceptual understanding and epistemic beliefs were also found to improve throughout the practice.

Although the promisingness of ideas has been found to be a key to successful learning as knowledge-creation, studies by Chen et al. (2015) had not dug into the criteria of idea evaluation. When students evaluate their ideas, its promisingness may have multiple meanings. In the field of design study, Blair and Mumford (2007) asked university students to evaluate ideas that might be funded by a non-profit organization. The analysis of the students' evaluation criteria revealed that they based their evaluation on the following: (1) whether "the ideas are easy to understand;" (2) whether they "provide short-term benefits to many;" and (3) whether they are "consistent with prevailing social norms." The undergraduate students disregarded risky, time-consuming, and original ideas. Original and risky ideas were found to be preferred only when students were not pressed for time. What we have learned from studies like Blair and Mumford (2007) is that people use multiple criteria to evaluate their ideas depending on conditions. In future research, therefore, we have to explore further research questions such as what criteria of idea evaluation, including promisingness, are used by learners? What are their individual or group differences for designing further support to engage in learning as knowledge-creation?

Toward answering the research questions above, Ikeda et al. (2019) examined university students' discussion in a project-based learning course. They conducted the epistemic network analysis (Shaffer, 2017) after coding students' discourse based on Blair and Mumford's criteria of idea evaluation. Their comparative analysis of epistemic frames to evaluate ideas revealed that: (1) either high or low learning-outcome groups mainly used the criterion of complete description, i.e., how their new happiness indicators should be described; (2) high learning-outcome groups considered the criterion of the risk and originality of their own ideas in later weeks compared with low learning-outcome groups that stayed at the criterion of easiness to understand and implement.

 

From the results, Ikeda et al. (2019) concluded that the idea promisingness toward successful learning should include dimensions such as whether the idea was considered sufficiently challenging, as well as reasonable to understand and implement. The balance between the two dimensions of idea evaluation might be the key for us to support students to be engaged in more creative work with ideas.

This study further explores the process of idea improvement. As previous studies suggest (see for example, Chen et al., 2015), the continuous judgment of idea promisingness is a key to successful learning as knowledge-creation. On the other hand, studies such as Blair and Mumford (2007) and Ikeda et al. (2019) found that learners' criteria to evaluate their ideas must change depending on conditions. An examination of the idea improvement process would provide us with a complete model of how learners improve their ideas through a judgment of idea promisingness. We examine the idea improvement process by analyzing university students' written discourse in their progress reports in the Knowledge Forum during their participation in a PBL course. We applied socio-semantic network analysis of vocabulary by using KBDeX (Oshima et al., 2012) to analyze how students considered their ideas; we used clustering analysis with the Ward method to categorize 18 groups depending on similarities in temporal trajectories of degree centralities of the vocabulary. We also used audio-recordings of students' conversations to confirm our interpretations of different idea improvement processes we found through the quantitative analysis.

## Research design

### Study context

The target PBL course continued over 15 weeks and was designed with three main activity phases. After the first week, which was dedicated to course introduction, 70 first-year university students studied how to deal with datasets for creating their original happiness indicators in their original groups over a three-week period (weeks 2–4). Participants, were then engaged in their *expert* group activity, where one or two from each original group gathered as expert groups to learn different aspects of existing happiness indicators over a four-week period (weeks 5–8). Following their expert group activity, the participants returned to their original groups to further conduct their *jigsaw* group activity. This involved participants attempting to share different aspects of existing happiness indicators, find remaining problems with the indicators, and propose new perspectives to create their original happiness indicators. This took place over a six-week period (weeks 9–14). The final week involved a poster session, in which participants discussed their ideas with other groups in the form of poster presentations.

During weeks 5–14, students were encouraged to report their progress in idea improvement by writing down their progress in group activities, and then building their individual comments on their group notes each week (Figure 1). In their group progress reports, they described the ideas they had considered, the criteria they had selected to evaluate their ideas, as well as how they had created and improved upon their ideas. In their individual notes, participants reported their individual comments on the group activities by describing their thoughts on how to further improve their group ideas and what other ideas s/he might consider in the next week.

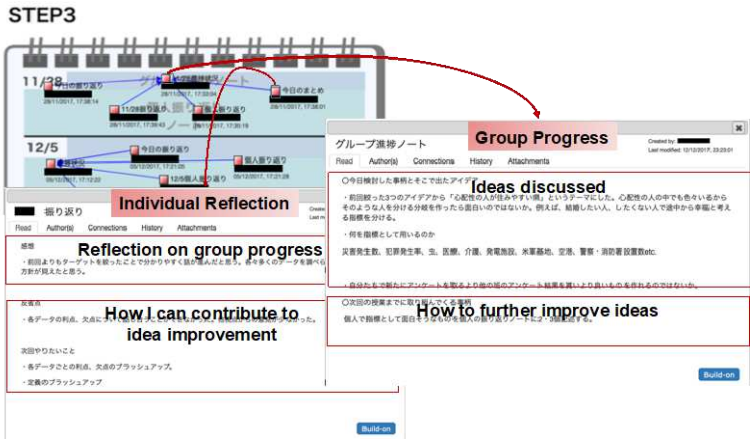


Figure 1. Students' reflection activities in the Knowledge Forum every week.

### Collected data and analysis

Evaluation of learning-outcomes (students' final proposals)

Students' final ideas were represented in their proposals during the poster session. Four independent raters, including the authors, evaluated their proposals based on the following criteria, with five-point Likert scales: (1) appropriateness of names of their indicators; (2) how well they described the unique natures of their proposed indicators; (3) how much evidence (data) was used to calculate their proposed indicators; (4) how structured the data were to represent the nature of their proposed indicators; (5) how well their ranking of prefectures in Japan based on their indicators were explained, (6) how well their results were presented, and (7) how well they discussed their results of prefecture ranking. All the correlations across raters on their scores of the seven criteria were significant ($r$s = .53~.91, $p$s < .05). Scores by each rater were standardized, and average scores across raters were used as the groups' idea scores.

### Social network analysis of vocabulary and clustering analysis

The authors analyzed students' written discourse in their progress reports in the Knowledge Forum. In particular, the analysis focused on participant discourse in a jigsaw group activity (weeks 9–14), where they shared what they had learned in the expert group activity and discussed what new indicators they would propose. In each week, a group of three (or four) students reported one group progress report and three (or four) individual reflection notes. The total number of notes for the analysis, therefore, was 24 (or 30) notes for groups of three (or four).

For examining the idea improvement process in each group, the authors used all nouns in the students' discourse to detect ideas and other issues they discussed during a jigsaw group activity. By using KBDeX, a socio-semantic network of vocabulary was created based on the co-occurrence of nouns in each group. It was assumed that participants' ideas were represented as clusters of nouns used in discourse. The authors then calculated the *degree centrality coefficient*, a measure of cohesiveness of a network structure, of each noun every time one KF note in the dataset was added to examine the temporal change in the coefficient (Figure 2). Based on the datasets of temporal changes in coefficients, the authors further conducted a clustering analysis of nouns in each group with the Ward method.

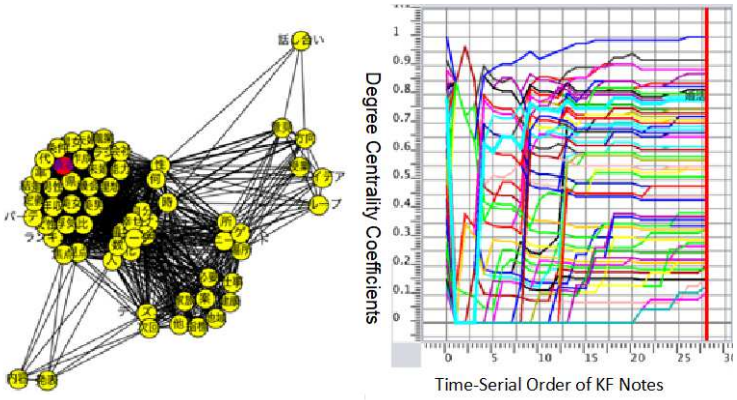


Figure 2. A socio-semantic network of vocabulary (left) and temporal changes in the degree centrality coefficients of vocabulary.

### Audio-recordings of students' conversation during their group work

Each week, the authors recorded participants' conversations during their group work. After categorizing their activities into different types of idea improvement processes based on KF notes, particular segments of participants' conversation were further examined to support our interpretations.

## Results and discussion

Through the clustering analysis of temporal changes in degree centralities, the authors identified six types of idea improvement processes. Type #1 (n=5) had their proposed ideas including more words than the average, higher mean degree centrality coefficients in the cluster than the average, less frequencies (than the group average) of words showing higher coefficients than their idea clusters, other idea clusters than their proposed ones, and low distance of merging the proposed idea and evidence clusters in dendrograms. Based on the results with another finding that type #1 of groups had the highest mean of standardized group scores (59.0), the authors concluded that type #1 of idea improvement was the best process where participants were focused on their ideas, compared multiple ideas to select better ones, and improved their selected ones by considering evidence to support their proposals. The other five types were summarized in comparison with type #1 in Table 1.

Table 1: Summary of six different clusters of idea improvement processes.

| | #1 (n=5) | #2 (n=3) | #3 (n=2) | #4 (n=3) | #5 (n=3) | #6 (n=2) |
|---|---|---|---|---|---|---|
| Frequency of words in the idea cluster | **Above average** | **Above average** | Below average | Below average | **Above average** | **Above average** |
| Mean degree centrality (DC) in the proposed idea | **Above average** | **Above average** | Below average | **Above average** | **Above average** | **Above average** |
| Frequency of other words with higher DCs than the proposed idea | **Below average** | Above average | Above average | **Below average** | **Below average** | Above average |
| Presence of other idea clusters | **Yes** | **Yes** | **Yes** | No | No | **Yes** |
| Distance of merging the proposed idea cluster and related evidence cluster | **Low** | **Low** | **Low** | High | **Low** | High |

Comparison of the type #1 groups with others suggested the following key aspects in the idea improvement process toward high learning-outcomes. First, participants need to focus their attention on their ideas continuously. Type #1 groups had large and highly structured clusters of proposed ideas and did not have many high coefficient words in other clusters. The examination of audio-recordings revealed that type #1 groups continued at their discussion of ideas while others had digressions in their conversations (#2, #3, and #6). Second, while continuing at their ideas in their activities, type #1 groups considered multiple ideas. Some groups (type #4 and #5) decided their proposed ideas at an early phase without considering other possibilities and failed to improve their initial ideas. Finally, participants also need to support their ideas with sufficient evidence (data). Their coherent explanations of why their new ideas are valuable can be constructed through an in-depth examination of ideas based on evidence (data) available.

## Concluding remarks

This study explored idea improvement processes and their relation to learning outcomes. Our social network analysis and clustering analysis revealed several hypothetical conditions of the idea improvement process leading to the high learning outcome. In future research, further design-based research is needed to examine the hypothetical conditions to establish design principles.

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