

## Discourse Patterns and Collective Cognitive Responsibility in Collaborative Problem-Solving

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**Abstract:** In knowledge building, learners achieve collective cognitive responsibility (CCR) by exerting their shared epistemic agency. Although CCR has been discussed as a critical part of the learning process, few studies have established analytical frameworks to examine how learners develop CCR through collaborative discourse. This study analyzed the collaborative discourse of seven groups of three university students each, who were tasked with solving a Jasper Woodbury problem to determine how CCR took shape. It used a mixed-method approach. Its results indicated that there are three distinct discourse patterns related to CCR: (1) collective CCR, in which each group member engaged in discourse, (2) rotating leadership CCR, in which pairs of members flexibly engaged in discourse, and (3) fixed leadership CCR, in which a specific pair of group members led discursive activity. The study concludes by discussing which of these discourse patterns might help students develop and sustain CCR in collaborative problem-solving.

### Background and research purpose

In knowledge building, learners are encouraged to collectively advance their knowledge and continuously improve their ideas through collaborative inquiry (Bereiter, 2002; Paavola & Hakkarainen, 2005). Scardamalia (2002) described individual learners' intention to contribute to collective knowledge advancement as their epistemic agency and described collective intentions to do so as collective cognitive responsibility (CCR). As discussed in other studies (e.g., Chen et al., 2015; Damşa et al., 2010; Zhang et al., 2009), learners' epistemic agency should be exerted through their responsibility to construct collective ideas by making a judgment of the promisingness of their ideas and further improving them for solving their authentic problems.

Because knowledge building is a collaborative activity, it is challenging to evaluate knowledge building practices and processes. Several researchers have suggested that we must analyze how learners represent their collective knowledge and how these representations change over time in order to appropriately evaluate its advancement (Oshima et al., 2012; Scardamalia et al., 2012). Studies have attempted to develop methods of evaluating these representations. For instance, Zhang et al. (2019) suggested using idea thread mapping diagrams, which allow learners and instructors alike to assess learners' contributions to collective knowledge building over time in a network graph. Oshima et al. (2012) suggested using Knowledge Building Discourse Explorer (KBDeX) which provides learners with a vocabulary network and helps them ascertain which of their ideas are or are not connected. Other tools, such as Feng et al.'s (2019) idea-friend map (which was developed from KBDeX) helps students determine how their ideas are connected and how they can further integrate or elaborate upon their ideas.

Although previous studies have examined how collaboration between or within communities helps improve ideas, few studies have examined how individual learners contribute to collective knowledge advancement in CCR. Gutiérrez-Braojos et al. (2019) used scientometric analysis to assess the relationship between individual contributions and CCR. In their study, university students evaluated how the notes of their peers contributed to collective knowledge advancement. Each student's contribution value was calculated as the proportion of their notes which their peers recognized as helpful. While this approach allows us to represent CCR within a community and identify different types or values of contributions, it does not analyze how this process helps students improve their ideas. This study, therefore, aims to propose another analytical framework of CCR by extending socio-semantic network analyses (SSNA) of idea improvement so that both the idea improvement process and the degree of CCR exerted during this process can be evaluated. Below, we propose a new algorithm to represent CCR and demonstrate their analytical framework by examining discourse datasets from seven groups of three university students each.

### Method

#### Participants and setting

The study's participants were 21 university students (seven groups of three). Groups of three participants were asked to solve a Jasper Woodbury problem called "Rescue at Boones Meadow (CTGV, 1992)." In the problem, a

protagonist named Emily must bring a wounded bald eagle back to an animal hospital using a small airplane. Participants were asked to find the fastest route from the meadow to the hospital. The problem was presented in a 15-minute video and they were given 45 minutes to engage in collaborative problem-solving. They were also provided with an iPad (to watch the video) and a whiteboard (to write/draw their ideas). Their conversations and actions were recorded on video.

## Analysis

The participants' conversations were transcribed verbatim and then subjected to two analyses. First, we modified and extended the original SSNA algorithm of KBDeX in order to analyze study participants' idea improvement and CCR. The original algorithm represents idea improvement as the aggregate change in the total degree-centrality (DC) of words in a given network, taking each turn in conversation as a unit of analysis. In the modified algorithm, we used the moving stanza-window method (Siebert-Evenstone et al., 2017) to conduct further analysis. Because every conversational turn is influenced by the previous turn and influences the next turn (Wells, 1999), we set a stanza-window of three conversation turns as a unit of analysis and then calculated the cooccurrences of words in all transcribed interactions. By modifying the algorithm, we made it possible to detect which conversational turns elicited ideas represented in other conversational turns, and thus made it possible to detect the origins and trajectory of idea improvement.

Second, we calculated each participant's idea improvement process by analyzing a discourse subset from each participant. We then compared each participant's contribution with their group idea improvement as well as all other students' contributions in order to evaluate how each participant contributed to idea improvement. After identifying various types of CCR, we conducted a discourse analysis of segments which SSNA identified as critical for examining discourse patterns.

## Results

### Idea improvement and CCR

For evaluating group idea improvement as well as individual contribution to it, our modified algorithm visualized the improvement processes as seen in Figure 1. The vertical axis represents the total value of the degree centralities in the word network. The steep increase in the graph means a pivotal point in discourse for improving ideas. In each group, we visualized four different lines representing the group as whole and three individual contributions. Through visual inspection, three types of CCR were identified: (1) *collective* CCR (two of the seven groups), (2) *rotating leadership* CCR (one group), and (3) *fixed leadership* (four groups). In the *collective* CCR groups, all three participants contributed equally to idea improvement at the group level (see the left graph in Figure 1). Participants' patterns of change in the total DC were similar to one another as well as the group improvement. In the *rotating leadership* CCR group, pairs of participants led CCR and the configurations of these pairs changed over time – i.e., each participant contributed to the group's idea improvement at different points in time (see the shaded areas on the right side of Figure 1). By contrast, a specific pair of students led discourse in the *fixed leadership* CCR groups.

### Discourse patterns and CCR

Here, we examine segments of a collective and a rotating leadership group's discourse in order to identify patterns of discourse by which students held their CCR. These segments were selected because the collective CCR group displayed a remarkable increase in total DC and because different pairs of students were responsible for the rotating leadership CCR group's increase in DC.

S, J, and I's collaborative discourse is presented as an example of a collective CCR group. The following is a segment of their conversation turns 562–567:

- 562: S: OK, I got it. [Larry and Emily are in the same town.]  
 563: J: It doesn't matter if we go to the gas station and come back to the town by car, does it?  
 564: S: Well, see...  
 565: I: You mean that Larry will drive a car [to the gas station] while Emily flies [to the wounded eagle's location]?  
 566: J: Yeah, Larry drives a car!  
 567: I: On the highway.

This discourse pattern reveals that I and J built on S’s understanding that two characters Larry and Emily were in the same town. S’s understanding helped the other participants consider a new solution to the problem. By taking turns in conversation, they shifted leadership around to different configurations of pairs (S–J, S–I, and I–J).

Y, K, and M’s collaborative discourse is presented as an example of a rotating leadership group. The following is a segment from their conversation:

390: Y: We consume 40 gallons [of gas] from here [the town] to there [the wounded eagle’s location].

391: K: And, we can only use the road from the gas station to the town.

392: K: Our problem is – how can we bring the eagle back to Boones Meadow... No, from Boones Meadow back to the town.

393: Y: We have to go back to here [pointing to the town on their whiteboard map].

394: K: We have to think of the route to bring the eagle back from Boones Meadow to the town.

395: Y: No, no. We have to start from the town then go back to the town.

396: K: Oh, we have to think of the round trip!

In the other selected segment (633–638), another pair, Y and M, engaged in discourse in the similar way. Thus, the rotating leadership group distributed their collaborative leadership in different configurations of pairs over time to advance their collective knowledge.

633: M: As a different idea, we can say, Emily flies to Boones Meadow [the place of the wounded eagle] then takes another flight to the gas station. But, she does not have enough [gas], so she must walk to the station after landing on the way [to the gas station]. After Emily gets to the station, Larry brings the eagle back to the hospital in his car.

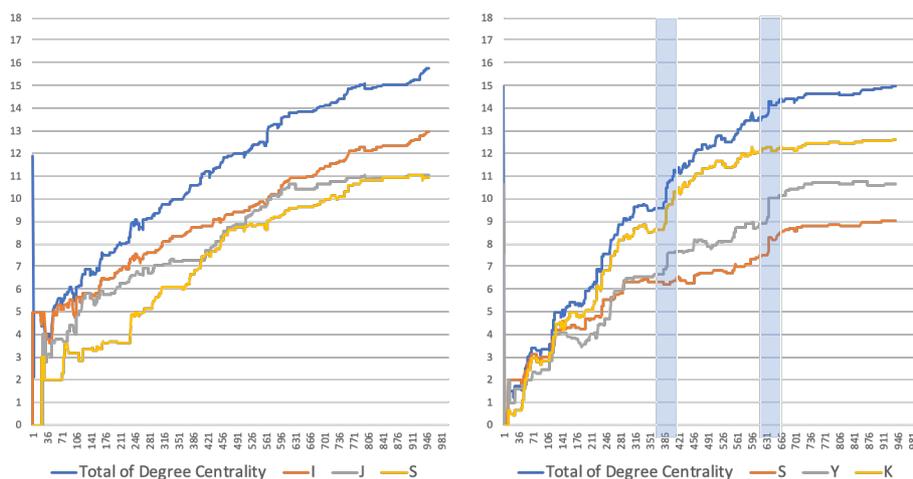
634: Y: What did you say after Emily gets the gas station?

635: M: Well, Emily flies from here [pointing the town on their map on the whiteboard] to here [pointing Boones Meadow on their map on the whiteboard], right? She still needs to move five miles [from Boones Meadow to the gas station].

636: M: While Emily flies to Boones Meadow, Larry can drive to the gas station. He waits for Emily’s coming with the eagle from Boones Meadow. He then brings the eagle back to the town in his car. Isn’t it the fastest route?

637: Y: But, we are not quite sure if she [Emily] can land on the way from Boones Meadow to the gas station, are we?

638: M: Yeah, you’re right. Not sure about it.



**Figure 1.** Temporal change in the total degree-centralities over conversation turns in a collective CCR group (left) and a rotating leadership CCR group (right).

## Discussion

First, our study’s modified SSNA algorithm articulated how students in a group engaged in CCR through collaborative discourse by identifying three modes of CCR. We expected that most participants would exhibit

collective CCR. However, only two groups exhibited this pattern. The majority of groups exhibited a fixed leadership mode of CCR. All study participants were engaged in CCR throughout the idea improvement process. Although Ma et al. (2016) reported a similar finding at the individual level, this study expands their findings to collective knowledge advancement.

Second, this study revealed critical differences in the discourse patterns of each of the three modes of groups identified above. In the collective CCR group, different pairs took conversational turns smoothly within the same sequence of conversation turns and performed as a whole. Such smooth changes did not occur over a single sequence but over multiple sequences in the rotating leadership CCR group. Both discourse patterns helped the participants attain CCR as a group. Of course, different discourse patterns are appropriate for different contexts and group cultures.

## Conclusion

This study examined CCR in collaborative problem-solving through a mixed-method approach. It identified different patterns of CCR and examined how study participants engaged in CCR through collaborative discourse. It found that that students attained CCR by sharing or rotating leadership of small groups. Future studies should examine individual-level factors which influence CCR or which discourse patterns should be encouraged to help fixed leadership groups transcend their current practices.

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