Artifact-Mediated Collective Cognitive Responsibility in Learning Through Collaborative Designing

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Abstract: In knowledge-creation practices, collective cognitive responsibilities (CCRs) have been discussed to examine how effectively the instructional design or learning environments are conceived. This study examined how learners in a small group successfully exerted their CCRs in a new context of knowledge-creation practice, and artifact-mediated knowledge practice. A mixed-methods approach was taken by using a socio-semantic network analysis of discourse, as well as in-depth discourse analysis. Results suggested that various features of artifacts and the tools to make them significantly influenced CCRs in collaborative discourse. The tools that learners could not easily collaborate around constrained contributions by learners who did not manipulate the tools.

Background and research purpose

Knowledge-based practices beyond knowledge building

In a 21st century knowledge-based society, humans' necessary expertise comes not from memorizing factual knowledge and retrieving it for use in a given context, but creating new knowledge based on it. Toward that end, the instructional approach in education should be considered so that learners can be engaged in authentic knowledge-creation practices in their schooling and informal learning contexts. In the learning sciences, the studies of learning as knowledge creation have started with discussing three representative models (Paavola & Hakkarainen, 2005). Knowledge-building is the prevailing theoretical guidance for designing instructions for the classroom's knowledge-creation activities (Scardamalia & Bereiter, 2021). Instructional designs based on Knowledge-Building (KB) principles with Knowledge Forum as technological support for student inquiries have been examined for years, and results have revealed their effectiveness in improving learner competencies necessary for knowledge work in the future.

Beyond the knowledge-building approach, some of us (e.g., Seitamaa-Hakkarainen et al., 2010) have proposed artifacts-mediated knowledge practices as new opportunities for learners to experience the knowledge-creation practice. While knowledge-building theory has been developed based on the scientific community as the best model, knowledge-practice is oriented at learning by design. In the knowledge-practice approach proposed in this study, learners are provided a learning environment where they can collaboratively design physical products to make their ideas visible, and improve their work through collaborative discourse around artifacts. Learners' progressive inquiries are naturally mediated by their products, which represent their ideas. In this way, artifacts have material and conceptual aspects represented in them, such as learners' intentions and purposes (Engeström, 1999; Latour, 2005).

Analytics of the knowledge-creation practices

With the theoretical developments of knowledge-creation practices, researchers started to invent new analytics of the new type of learning. Due to the collective and temporal nature of knowledge shared among participants in groups, the traditional analytics approach such as "categorizing and counting" does not provide researchers with relevant results and interpretation of their designed learning environments. Oshima et al. (2012) proposed the socio-semantic network analysis (SSNA) of discourse for evaluating idea improvement in the knowledge-creation practice. The temporal change in a measure representing the vocabulary network structure was found to identify differences among groups in their idea improvement processes, and how much contribution each group member could have to their group idea improvement. The recent development of an algorithm by Oshima et al. (2021) towards this end, successfully demonstrated how learners engaged in their collective cognitive responsibility (CCR) by comparing individual contributions.

Research purpose

Although studies have examined learners' CCR in the knowledge-building environment, few studies have paid attention to artifacts that may mediate knowledge-creation practice. Therefore, this study aims to use SSNA as an analytics tool to examine the CCR in the artifacts-mediated knowledge-practice where learners design and make their artifacts to improve their ideas. Toward that end, we mainly paid attention to who was in charge of manipulating their developed objects, and what roles the learner(s) manipulating the objects played in the collaborative discourse, compared with roles by other learners.

Method

Learning context

We analyzed a group of three Finnish 8th-grade female students designing a bag with a unique feature of protecting their mobile phones from cold temperatures (Figure 1). They engaged in their knowledge-practice in the course of voluntary craft education, with the task of everyday challenges. Their task was to select one everyday product, and improve it with new ideas. The school was an ordinary comprehensive school with a mission of teacher training. Every craft education session continued for 75 minutes two or three times a week (19 sessions in total). We selected this group of students because of the high evaluation of their product. Among the 19 sessions, we detected five sessions from ideation (1), prototyping (2), and making (2) for the SSNA of their discourse.

Figure 1
Artifact (Left) Designed by the Target Group (Right) in This Study

Collected data and analytics

All student activities in the class were video-recorded and transcribed for the mixed-methods approach: Socio-semantic network analysis of discourse, and qualitative discourse analysis.

The modified version of the analytics proposed in Oshima et al. (2021) was used for identifying patterns of CCRs. In the previous study, each student's contribution to the idea improvement process was calculated as the total value of degree-centralities of words in a vocabulary network by using her/his discourse dataset. Comparison of vocabulary networks between different students' discourse and a whole group discourse was considered to show patterns of CCRs. The metrics, however, could not examine students' unique contributions to their group idea improvement that would not be attained without their engagement. Therefore, in this study, we paid attention to the displacement by subtracting a target student's discourse from the group discourse in calculating the student's contribution. In the figures below, a student's contribution is represented as an area of the displacement of the total value of the degree-centralities (on the y-axis) over conversation turns (on the x-axis) by leaving the student's discourse from group discourse. After quantitatively examining CCRs in the group over five phases, we further conducted in-depth discourse analysis. Finally, we focused on the comparison of what discourse moves students engaged in.

Results

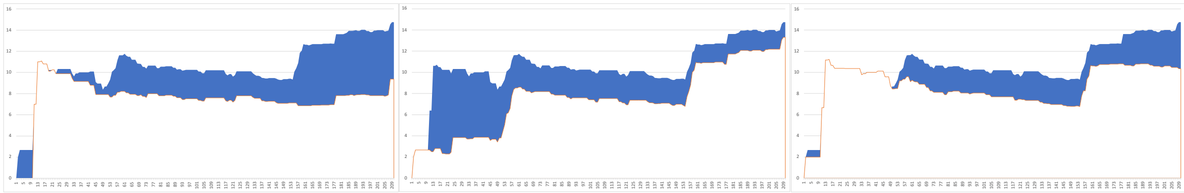
The students made their product to protect their mobile phones from the cold weather in Finland (Figure 1). Their product was composed of two artifacts: (1) a sensor device to detect the temperature, and (2) a bag that their phones are put in. Their developed sensor device is attached to their phones and sounds an alert at cold temperatures. Users are supposed to put their phones into the bag when they hear the alert. The process of making their products went through different phases: ideation, prototyping, and making. In this section, we report on their collaborative discourse around their developing artifact.

Ideation (2019.02.28)

In an ideation session, students discussed a variety of materials for their product. Their contributions to the group idea improvement are shown in Figure 2. After S2 explained what they would like to develop in the classroom, their contributions were evenly distributed among the three of them. However, S1 had more contributions than two others in the later stage, because S1 held the material they discussed.

Figure 2

Individual Contributions to Group Idea Improvement Process by Students (S1, S2, and S3 from Left) in Ideation Phase



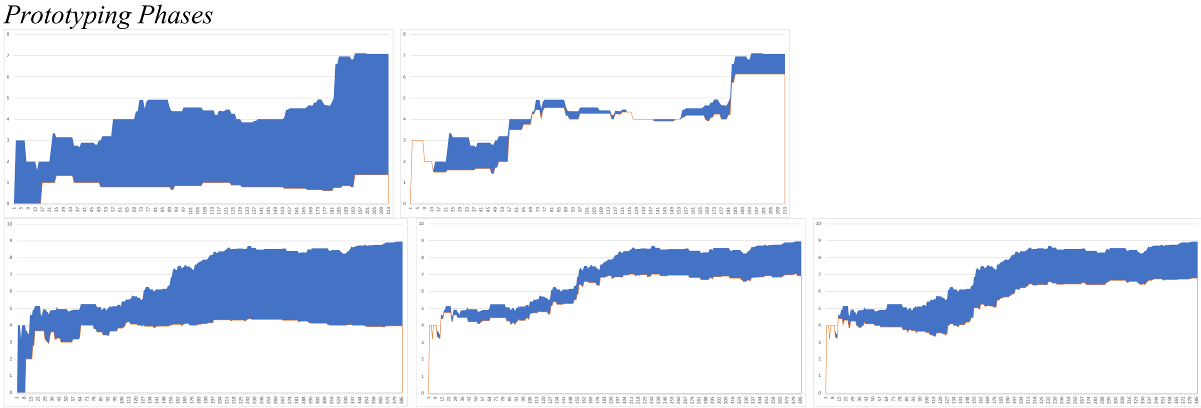
Prototyping (2019.03.07 + 03.12)

In the prototyping phase #1 (top of Figure 3), S3 was absent for some reason. However, S1 and S2 were engaged in their collaborative discourse about the programming of the sensor and making an object to cover the sensor by a 3D printer. Over the whole process, S1 contributed to the group idea improvement process more than S2. As seen in the ideation phase, S1 manipulated computers and the printer, while discussing with S2.

In prototyping phase #2 (bottom of Figure 3), students discussed how to attach their sensor to the mobile phone after programming and making the sensor cover. They collaboratively discussed how to use the magnet to attach the sensor to a mobile phone by picking steel wires and plates. Their ideas were focused on the plate size, thickness, and shape. S1 again contributed more by picking and manipulating the materials.

Figure 3

Individual Contributions to Group Idea Improvement Process by Students (S1, S2, and S3 from Left) in Prototyping Phases



Note: In the first phase of prototyping (top), S3 was absent.

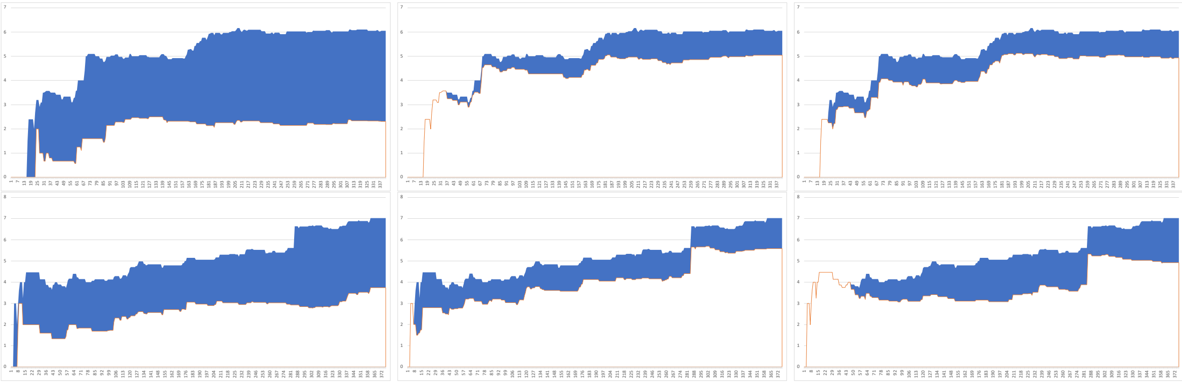
Making (2019.3.18 + 03.25)

In the making phases, students' primary engagement was to make a bag for a mobile phone. They discussed the size and the design of the bag flap in the making phase #1 (top of Figure 4). When a teacher asked how their discussion was progressing, S1 fluently answered the teacher. After the teacher asked students the color of the bag they were making, their discussion was focused on the bag color and size. Once they made their decision, they collaboratively engaged in measuring the cloth and cutting it into shape. While developing the artifact, they further unfolded their discourse to collaboratively monitor their initial plans by checking the size and shape they had made.

In the making phase #2 (bottom of Figure 4), students' main activity was moved from making parts of their bag to sewing them. While subtasks were distributed, their discourse further progressed in designing logo tags and selecting a zipper put on the bag.

Figure 4

Individual Contributions to Group Idea Improvement Process by Students (S1, S2, and S3 from Left) in Making Phases



Discussion

Based on our case analysis of three students' discourse around an artifact they developed, we found the following regarding how artifact-mediated CCRs happen. First, in each phase we analyzed in this study, all three students demonstrated their original contributions to the group idea improvement process. In this sense, their CCRs were categorized into the collective leadership identified in our previous study (Oshima et al., 2021). Second, how artifacts as products mediate learners' discourse for their group idea improvement depended on artifacts' features as tools that they used. For example, they used a PC for programming and a 3D printer as tools for making their product in the prototyping phases. In such contexts, students' engagement with the tools might constrain their CCRs through their collaborative discourse. S1 continuously took the lead to manipulate the tools in the prototyping activities and contributed much more to the group idea improvement than the other two group members. However, in the ideation and making phases, the students' contributions were somewhat evenly distributed. The artifacts as tools in those phases were more tangible for the students to share. Thus, the tangibility and sharing features of the tools should be considered for improving CCRs in collaboration.

This study examined artifact-mediated CCRs of one successful group (three students). As predicted, their discourse for the group idea improvement was organized as collective leadership, which is the most appropriate type of collaboration. In addition, we found a new insight that artifacts as products and tools influenced learners' CCRs. "Rigid" tools for making artifacts made it impossible for learners to manage their CCRs by appropriately distributing their work. Therefore, an instructional approach should be considered to support learners in rotating their work with tools in a meaningful way.

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Acknowledgments

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