Reciprocal Kit Build: Boundary Crossing with Concept Map for Collaborative Knowledge Construction

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Abstract: Collaborative knowledge construction needs to be carefully designed to allow learners to collaborate, not only co-present. Researches show that individual learners need to make a continuous effort to construct and maintain group shared knowledge. As a representational tool, concept map has been employed to address such needs during the discourse. To promote active inquiries, prior studies also suggested extending the collaborative concept map with individual externalization, concept map sharing and reviewing activity. We introduce Reciprocal Kit Build activity where students in dyads are creating an individual and collaborative concept map, exchanging their ideas through reconstruction, and discussing their comprehension facilitated by shared and difference maps. Unlike existing studies, our design activity supports learning at boundaries, by boundary crossing and utilizing multiple types of boundary objects. In this paper, we also explain some principles underlying our proposed activity and how this activity may assist learners to move across boundaries.

Keywords: collaborative learning, concept map, boundary crossing, boundary objects

Introduction

Researches have designed various instructional strategies, e.g. scripts, scenarios, representational tools, etc., to assist students while interacting in a collaborative situation [1, 2, 3]. A concept map is one of the representational tools that has been employed in collaborative learning activities to encourage students to cooperate. Since individual learners need to make a continuous effort to construct and maintain group shared knowledge [4], a concept map can support as a representation of the group shared knowledge. It reduces the ambiguity of utterances, rather than a dialogue only communication. Manipulating concept maps in collaborative learning has shown positive effects on students' learning outcomes as well as their attitudes [5, 6].

Active inquiry during collaboration play critical roles in knowledge construction. Researches on collaborative concept mapping have extended the activity to trigger active inquiry by externalizing individual prior knowledge, increasing knowledge awareness between group members, or reviewing individual representations [2, 7, 8, 9]. Creating a design of concept map individually during externalization have influenced learners to explain better during discourse [2, 3]. Knowledge awareness by exchanging individual maps have also increased the efficiency of problem-solving task since they have explored necessary information before collaboration [7]. They can focus on different representation or missing information only. Moreover, reviewing individual learners' representation have affected the broadness of a collaborative product [8].

We propose a Reciprocal Kit Build (RKB) approach to extend the collaborative concept mapping activity. Our design activity facilitates individual learners to externalize own thinking in a private space, to exchange and review individual maps through the reconstruction of partner's map and discussion of difference map, and to build on existing collaborators' works during group map creation. Different from other studies, our approach is focusing on the learning process at boundaries [10, 11, 12]. The map itself can be a boundary object and so do the map components, such as nodes or links [13]. Students should negotiate and integrate different individual perspectives, over boundary objects, to achieve a single group solution. In the individual world, the map components can serve as a starter kit, so that the students can work

independently at the beginning of a task. During the collaborative session, the boundary objects play as pieces to ground shared understanding and to trigger socio-conflicts when differences appeared. In this study, we formulate a research question to guide our study, as follow: "How is the design of learning activities with a concept map to support boundary crossing in a collaborative situation?".

Relevant Literature Studies

1. Collaborative concept mapping

Collaborative learning is a process where two or more people learning together [14]. Interactions play a key role in a collaborative situation. Concept map as one type of representational tools can be used to communicate ideas and maintain shared focus during the discussion. Various studies were conducted to employ a concept map for computer-aided collaborative learning [1, 3, 9].

To enable individual reflection and exploration, previous researches have encouraged individual preparation prior to collaboration [2, 3]. According to their studies, this individual phase influenced learners to explain their ideas better during the discourse. Students also elicited more information that was relevant to their uncertainties. Though the students had created an initial design of their map, they were not explicitly requested to share or review other ideas within the group.

The work of Engelman and Hesse suggested that awareness of collaborator's knowledge can reduce miscommunication and help them to collaborate more efficiently [7]. Stoyanova and Kommers also have shown that reviewing on other individual maps positively influenced the broadness of collaborative map [8]. In summary, the creation of individual maps before collaboration and knowledge awareness of group members have affected the knowledge acquisition process and results.

Our design activity let the learners to externalize their individual ideas and to review learning partner's map through the reconstruction of the partner's map and discussion of shared and difference map before collaborative construction of concept map. Similar to our approach, Maldonaldo et al. had designed a collaborative concept mapping activity at tabletop that allowed learners to draw a concept map in an individual space as well as a group space [9]. After working individually on a single desktop computer, learners would actively co-construct a concept map on a tabletop. The tabletop system provided nodes and links suggestions based on the integration of individual propositions. It also highlighted similarities and differences of each individual maps on separate layers. However, unlike their design, we consider learning at boundaries with a concept map that involves the use of common nodes and maps reconstruction activity. We expect that our approach is potentially triggered more cognitive conflicts, especially when the differences among the same objects are numerous. We assume that discussion on common references may help students to confirm their understanding and further reveal new knowledge.

2. Learning at the boundary with Kit-Build

Learning can be shaped by movement across boundaries [11]. Akkerman and Bakker defined boundaries as socio-cultural differences leading to a discontinuity in action or interaction [10]. Prior researches show that boundaries are not seen as barriers to learning, but also "spaces" with potential for learning [10]. The boundaries can be crossed by people, or by objects or by interactions between actors of different practices [10]. Boundary crossing refers to the process of "negotiating and combining ingredients from different contexts to achieve hybrid situations" [12]. Objects that cross boundaries are often referred to as boundary objects.

The term "boundary object" was introduced by Star in the field of sociology of science [13, 15]. It is a useful attempt at identifying mediating artifacts that may help overcome "groupthink" and fragmentation [12]. Boundary objects are objects that are both plastics enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain

a common identity across sites [13]. Boundary objects can act as "reminders" that trigger relevant knowledge, or as "conversation pieces" that ground shared understanding, rather than as containers of knowledge [16]. It is the interaction around a boundary object, not the object itself, that creates and communicates knowledge [16]. To support for creation and evolution of active boundary objects, Fischer suggested providing systems that can create awareness of each other's work, afford individual reflection and exploration, enable co-creation, allow participants to build on the work of others, and provide mechanisms to help draw out the tacit knowledge and perspectives [16].

Boundary objects can be abstract or concrete things, such as repositories, rules, forms, or maps. A map represented one's perspective is a type of boundary artifacts used for communication among different community of practices. Moreover, the map components such as nodes or links can also be boundary objects to help students to get started. Since it becomes easier to work on, students can work independently during the initiation of a project. By providing the same components, individuals can create concept maps with different structures to illustrate own thoughts. These components serve as a reference point for mediation and negotiation of meaning during the discourse.

A Kit-Build (KB) approach is a type of reconstructional concept mapping activity where students are requested to build a concept map based on the components defined by a teacher in his map (Figure 1) [17, 18]. Students need to find the map structure by themselves, then those of reconstructed maps will be compared with their peer's map or with the teacher's map. KB system will display similar propositions between students' maps and teacher map (as a shared map), and propositions composed only by students or a teacher (as a difference map). The teacher assesses students' understanding, then provides feedback based on those comparison results. The KB approach is a means to exchange ideas between two different community of practices at boundaries, so they can identify the intersecting practices or reflect on dissimilar perspectives.

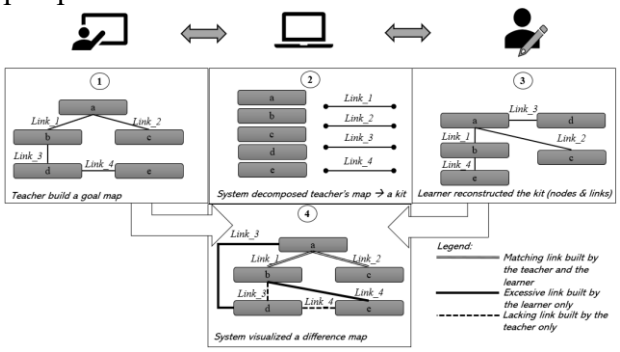

Figure 1 Kit Build approach

Our current study is an attempt to identify the KB approach for co-creation of concept map by a pair of students. In this study, the teacher will define common nodes to be discussed by the students and individuals will firstly draw a map on their private space. Next, the students will exchange the map components with their partner, so that the system can visualize shared map and difference map. Those maps are the objects that are useful for students to cross over boundaries, where they can negotiate and combine different perspective to achieve a hybrid solution. The last, they will construct a collaborative map representing the group understanding together.

Proposed Design Activity: Reciprocal Kit-Build

We design learning activities for dyads to co-construct a concept map with two different phases, i.e. individual and collaborative phase.

1. Individual phase

a. Initial map construction
   Given a set of common nodes, students are requested to build a concept map represented their individual understanding of a topic. The expert selects essential concepts to be included in the students' maps. These nodes will serve as a boundary object for students to externalize their ideas, as well as to organize their discussion in the further step.

b. Reconstructional map building
   After students externalize their understanding, the KB system will then decompose students' initial map into

unconnected nodes and linking words. Those components will be a kit for their partner in reconstructing the initial map. The students need to actively manipulate the components (boundary objects) to find out how their partner think about the solution.

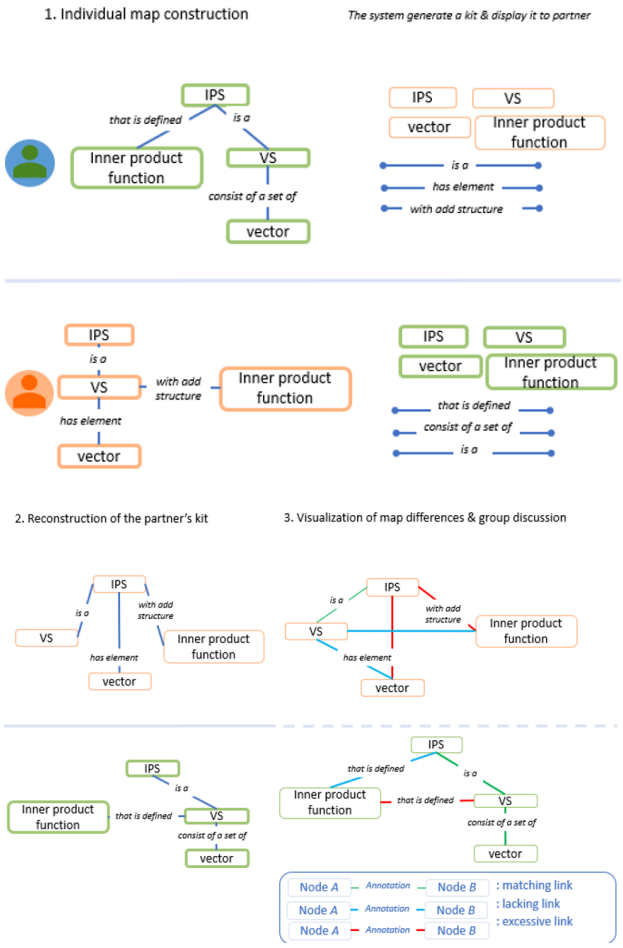

Figure 2 Illustration of Reciprocal Kit Build activities

2. Collaborative phase

a. Group discussion facilitated by shared and difference map

There are two reconstructed maps involving the same components which may have different structures. The system will then able to do similarity matching between propositions in the initial maps and the reconstructed maps. There are three types of propositions displayed i.e. matching links, excessive links, and lacking links. The matching links represent a similar proposition built by a pair. The lacking links are students' initial propositions that are not constructed by their partners, while the excessive links are the propositions built by their partner but not exist in the initial maps. A map consists of matching links is called a shared map, while the map of lacking and excessive links is a difference map. Both lacking and excessive links depict dissimilarities of map organizations. By looking over the difference map, individuals can reflect on their representation and explore different perspectives of their partners. The difference map, as a boundary object, presents anomalous information which is expected can trigger the group members to negotiate and integrate different meaning into a joint solution (boundary crossing).

b. Group map construction

Each group is requested to build a single group map as a collaborative product. While they are constructing the map, the KB system will display suggestions based on the integrated shared and difference maps to help them to reach a consensus. The followings are some possible suggestions provided by the KB system (Figure 3):

a. *Nodes*. When constructing a map, ones would usually start from the root nodes. To determine the root, the KB system will calculate the centrality of each node based on the number of links connected to it. The most connected nodes will be placed on the center, surrounded by the clustered relevant nodes.

b. *Links*. By integrating two shared maps, the system will be able to detect the most desirable links from the matching links, since the group tends to keep these links in their final group map [19]. Following the excessive or lacking links in the difference maps, students may have the intention to choose either an excessive or a lacking link [19]. The number of

excessive links has a moderate positive correlation with the change of quality of the group map [19]. Therefore, we display those links as suggestions in a separate layer.

c. *Linking words.* The linking words from the difference maps will be shown to let students build upon the work of all group members. They may also define new linking words, if necessary.

Students can add or modify concepts, links, and linking words to enhance their group products with new ideas after consensus building. They also may adjust the map layout, accordingly.

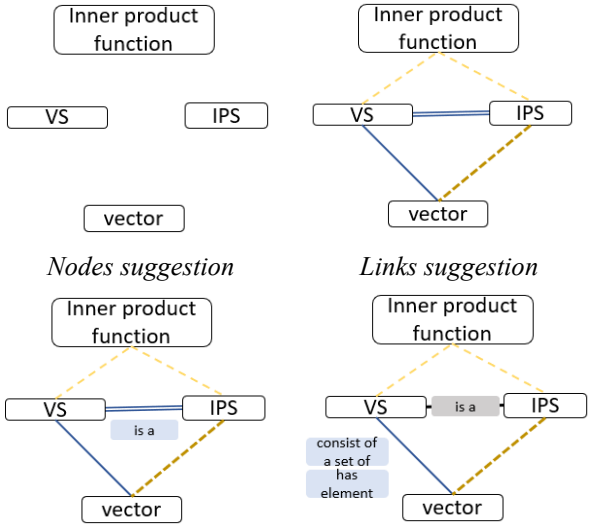

Figure 3 Samples of Kit Build suggestion to aid group map construction

Experimental Plan

1. Data Collection

We are planning to develop a web-based Reciprocal Kit-Build system where students can access the system online. Before the experiment session, we will let the learners try the system so that they are familiar with the user-system interactions. The data collected consist of concept maps, activity logs, questionnaires, and audio discussion. The concept maps constructed during individual and collaborative phase are recorded as learners' progress throughout the activities. We will also gather individual post-collaboration maps a week after the experiment session. The sequence of activities and learners' talk while building a map will be recorded and analyzed to investigate the process of collaborative knowledge construction. After the collaboration, we conduct a survey on group metacognition scale for online collaborative learning proposed by [20].

2. Measurements

Based on the data collected above, we will measure students' learning outcomes and the knowledge transfer from individual-to-group and from group-to-individual. There are two types of learning outcomes: at a group level and at an individual level. The group learning outcomes will be measured from the collaborative map, while the individual learning outcomes will be evaluated based on the score gain from initial maps to the post-collaboration maps. Knowledge convergence prior to, during, and after collaboration are assessed based on the similarity of group members' initial maps, the individuals' maps with the group's map, and the group's map with post-collaboration maps. The similarity of maps may represent two types of knowledge convergence measures, i.e. knowledge equivalence and shared knowledge [21]. As a process, the knowledge convergence within a group can be analyzed from the discourse and the log data. We will investigate students' metacognition on the group, specifically, we are interested to analyze items related to the group regulation of cognition [20].

Conclusion

We propose a Reciprocal Kit Build approach to support collaborative concept map construction. We describe its design process and how it draws upon the principles of collaborative learning with concept map such as can afford individual reflection and exploration, create awareness of each other's work, enable co-creation, and allow participants to build on the work of others. Our approach is unique since we are integrating some best practices on collaborative concept map activities and situate

the learning process with multiples boundary objects, e.g. maps, nodes, and links. Further, we need to realize these ideas, conduct some experiments, and evaluate our ideas.

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