Is the Whole Greater Than the Sum of its Parts?

Examining Online Collaborative Learning as Visualized by Graphic Organizers

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Abstract

A plethora of research has shown the positive cognitive effects of Graphic Organizers (GO) for the construction of knowledge. Nevertheless, there is a dearth of research to how this activity is performed by individuals in small groups in the context of science and technology education. The current study's goal was to examine online collaborative learning outcomes, as visualized by GOs in the form of mind maps. Specifically, this study addresses the question: In what ways do collaborative mind maps represent group knowledge? The study included science and engineering students (N=154) who studied a course in instructional methods. The study applied the multiple-case theory-building method in the analysis of the mind maps' contents and graphical design. Additionally, group open-ended questions and semi-structured interviews were administered to better understand the way mind maps were collaboratively constructed with emphasis on group diversity and individual contribution. The analysis of 50 mind maps indicated two types of GOs: *Assemblage* - a collection of individual knowledge, and S*ynergism* - a synergy among the collaborators. The two types of GOs signify the tension between individual and collaborative perceptions of ownership, with regards to knowledge sharing in online environments.

Keywords: Graphic organizers, individual contribution, mind maps, online collaborative learning, ownership perceptions

Theoretical Background

In the last several decades there has been a global shift from an industrial/manufacturing society to a knowledge society (OECD, 2013). In this, knowledge workers deal with conceptual artifacts, process complex information, adapt to novel situations and work in various collaborative contexts (Maarten & Wolbers, 2014). Following this, Graphic Organizers (GOs) that facilitate the processing of complex information are important instruments for knowledge workers. Graphic organizers (GOs) are conceptualized as visual knowledge representations that display relationships among concepts or processes by means of spatial position and connecting lines (Nesbit & Adesope, 2006). The process of creating GOs is considered an effective strategy for promoting higher order thinking and meaningful learning

(Novak & Cañas, 2008; Novak, 2010). This occurs once learners actively incorporate new concepts within established, cognitive structures (Ausubel, 1968). On the whole, GOs include visual representations as concept maps, mind maps, tables, flowcharts, and timelines (Goodnough & Long, 2002; Ives & Hoy, 2003). GOs constructed collaboratively, may provide an ideal context for explicit negotiation of meaning and knowledge construction (Novak & Gowin, 1984).

Although GOs are frequently regarded as a representation of individual knowledge, sociocultural perspectives emphasize the social benefits of knowledge construction in mapping (Van Boxtel, van der Linden & Kanselaar, 2000; Rogoff, 1998). Suthers and Hundhausen (2003) maintain that when GOs are exercised collaboratively, the individual is more likely to notice inconsistencies between his/her own thoughts and the external representation. Moreover, the multiple perspectives brought to the task may include a variety of experiences, expertise, and approaches (Gilbert & Greene, 2002). This is based on the Vygotskyan concept of the Zone of Proximal Development (ZPD), in which scaffolding is seen as an individuals' way to accomplish tasks with the help of a capable peer (Vygotsky, 1978). Following, collaborative GOs are assumed to scaffold individual cognition and positively influence interaction and outcomes (Suthers and Hundhausen, 2003; Villalon & Calvo, 2011).

In recent years, research has suggested that individual as well as collaborative mapping may be especially effective while using interactive online software (Cañas et al., 2005; Novak & Cañas, 2008; Villalon & Calvo, 2011). This software frequently includes functions such as various graphical representations and a visual identification of the individuals' contributions (Dillenbourg, Järvelä & Fischer, 2009). Hence, software can reduce obstacles to editing collaborative GOs; provide simultaneous feedback; and present visually rich formats that enable complex structures (Nesbit & Adesope, 2006). Online collaborative creation of GOs may be conducted in a synchronous mode - participants working concurrently from remote locations at the same time on the same GO in an asynchronous mode - participants working separately in different times (Cañas et al., 2003).

Vast research has been examining various aspects of GOs as individual and collaborative; face-to-face and from a distance, offline and online (Nesbit & Adesope, 2006; Novak & Cañas, 2008). In these aspects, many educational perspectives have been studied, including: conceptual understanding; information organizing, knowledge construction; and outcome assessment (Darmofal, Soderholm & Brodeur, 2002; Hmelo-Silver & Barrows, 2008; Ruiz-Primo & Shavelson, 1996). In the context of collaborative learning, GOs provide a platform for validation of individual and group ideas, verbalization of thoughts, and presentation of multiple perspectives (Steeples & Mayers, 1998). Nonetheless, little was studied in the context of identifying types of GOs and the individual contribution in the collaborative activities (King & Behnke, 2011).

Following the aforesaid, the goal of the current study was to examine STEM students' collaborative learning outcomes, as conceptualized and visualized by GOs in the form of mind maps. Specifically, this study addresses the question: In what ways do collaborative mind maps represent group knowledge?

Research Plan

Participants and setting

The study included 154 science and engineering students who studied a course of instructional methods. Data was collected from three consecutive iterations of the course. In each course, the students were divided into heterogeneous groups of 3-to-5 students, diverse in their demographic and academic backgrounds. The students were required to construct a collaborative GO in the form of a 'mind map', focusing on scientific concepts, such as: energy conservation or water purification. Each student was required to contribute five concepts to the shared map. In addition, they were asked to collaboratively answer open questions, describing the group's work process. Altogether, 50 GOs were constructed and analyzed.

Popplet (http://popplet.com), an online collaborative GO tool was used for group mapping activities. Popplet facilitates the creation of mind maps that include text, pictures, and videos. It allows students to save and download their completed mind map in PDF or JPG format as well as create relations between concepts. In this study, the application facilitated a multimedia representation of scientific and engineering concepts and principles. We used Popplet because of its ability to support a simultaneous collaborative construction of mind maps, its relative ease of use, and its ability to capture and document students' work in multiple forms.

Research Tools and Analysis

The study followed the multiple-case theory-building method that synthesizes between the Grounded Theory (Glaser & Strauss, 1967) and multiple-case studies (Eisenhardt & Graebner, 2009). In the current study, each small group map served as a distinct case, and was examined individually and also as part of a whole system (Yin, 2014). The research tools included the GOs produced by the students, semi-structured interviews, and group open-ended questions answered in a shared Google document. The students logged in to the online collaborative GO using their individual usernames, represented by different colors in the Popplet tool. This facilitated the analysis of individual contributions to the collaborative GO.

The multiplicity of tools enabled triangulation and verification of the corpus of data and the findings. Based on Lincoln and Guba (1985), trustworthiness of the study was asserted in terms of credibility established through peer checking and debriefing. Transferability was ensured by a 'rich description' of the research. Dependability and confirmability were addressed through the author’s research notes.

In analyzing the mind maps together with the participants' answers to the open questions and interviews, two types of GOs were indicated. One presents a collection of individual knowledge, roughly connected, and the other presents a synergy among the collaborators. Hereunder are examples of mind maps together with students' assertions.

Assemblage - a collection of individual knowledge

Data indicated that some groups viewed 'collaboration' as a collection of individual knowledge. They maintained that the group's diversity and the individual backgrounds should be visualized in the GOs. This is represented in designated 'micro-maps' in the large collaborative GO. In these cases, it is visible that students were careful not to 'invade' each other's visual space. Figure 1 demonstrates a mind map in which students' concepts are positioned in distinct areas, marked by colors. Alongside, an excerpt from an interview that asserts the visual representation of the work process.

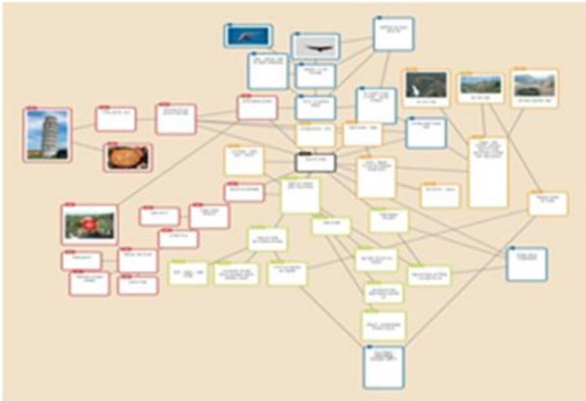
Textual assertions	A collaborative GO
"We come from different academic disciplines and have different experiences. Therefore, each of us brings different content and a different approach to the map and to the collaborative work overall…look! – this is my individual part in the map" (Jonathan, Iteration B, Group 5, semi- structured interview).	

Figure 1. A mind maps and students' assertion – The GO represents a collection of individual knowledge

Figure 1 shows a GO that contains 'micro maps', apparent visually and conceptually. It presents a collection of individual efforts, with little connections between concepts and limited interactions between learners. This presents a learning process that does not fully utilizes the educational benefits of online collaborative learning.

Synergism - a synergy among the collaborators

Data indicated that some groups collaborated in a more synergetic way by negotiating meaning and creating a seamless 'quilt of concepts' representing the shared knowledge. Analyzing the collaborative GOs in light of the textual data, asserted this notion of synergy. Figure 2 displays an example of mind maps' visual representations together with a students' answer to the open-ended questions and the interviews.

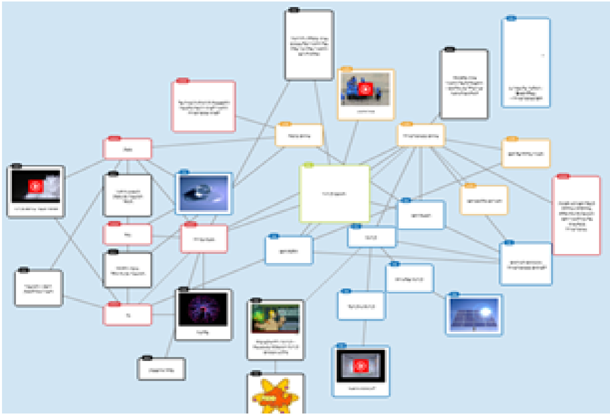
Textual assertions	**A collaborative GO**
"The big advantage of the map is generated from the many circles in which one student's view merges with another student's opinion. This created a lot of shared connections in the map. Each person has different opinions that deserve to be heard..." (Iteration B, Group 14, Group open-ended questions).	

Figure 2. A mind map and a students' assertion -The GO represents a synergy between the collaborators

Figure 2 indicates a GO with many connections and meaningful interactions between learners. This presents a learning process that fully utilizes the educational benefits of online collaborative learning.

Short Discussion

In a collaborative construction of a concept map, each group may cooperate differently (Gilbert & Greene, 2002). Identifying types of cooperation between groups, may contribute to understanding the role of the individual in the collaborative learning. This notion becomes clearer when presented visually in online GOs. In this study, we identified two types of collaborative GOs: The first - *Assemblage* - represents collaboration as a collection of individual knowledge, signified in separate and differentiated 'micro maps' in an inclusive GO. This may derive from habits of the mind regarding working individually even when working together (Levenberg & Barak, 2015). This can be further explained by perceptions of psychological ownership - the state where an individual feels that the target of ownership or a piece of that target is 'theirs' (Pierce et. al, 2003). The second - *Synergism* - views collaboration as a seamless 'quilt of concepts' integrating the shared knowledge. This may relate to the ability to create a joint outcome while displaying perceptions of collaborative ownership (Ghosh, 2005). Our findings contribute to the literature on collaborative GOs, and particularly to the understanding of the role of the individual in the practice of collaborative learning processes in small groups.

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