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Convergent Group Understanding: Indicator of Knowledge Integration?

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Abstract: This study investigates small group collaborative learning with a technology-supported environment. We aim to reveal key aspects of collaborative learning by examining variations in interaction, the influence of small group collaboration on science knowledge integration, and the implications for individual knowledge mastery. Results underscore the importance of high-quality science discourse and user-friendly tools. The study also highlights that group-level negotiations may not always affect individual understanding. Overall, this research offers insights into the complexities of collaboration and its impact on science learning.

Introduction

Computer-supported collaborative learning is influenced by multifaceted factors, such as the alignment of an individual's own understanding and the coordination of divergent ideas between group members (Järvelä et al., 2015). It reflects the intertwined nature of an individual's own learning and that of others in same small group (Stahl, 2015). Examining the dynamics of interactions in small groups being supported by distributed technological tools, such as actions, goals, and knowledge convergence toward shared understanding, can offer insights on the collaborative process (Damşa, 2014). Moreover, shared understanding does not merely result from aggregating individual ideas and actions in group collaboration (Roschelle, 2012). It raises the question of whether shared understanding and knowledge co-construction implies a more complex comprehension of science knowledge and phenomena, both for individual learning and for the products of group learning.

This study aims at (1) unfolding the various types of interactions among students engaged in small group collaboration, (2) investigating the extent to which students collectively integrated knowledge within groups, and (3) exploring how individual learning was influenced by the knowledge integration contributed by group members. We used the Knowledge Integration (KI) framework to examine knowledge components and their relationships (Liu et al., 2008). Our research questions were: (1) What were the key variations in collaborative approaches utilized by different groups in understanding scientific concepts and relationships during a design-based unit? (2) How does small group collaboration impact students' science knowledge integration? (3) What implications does group knowledge integration hold for an individual's learning?

Method

Context and participants

Eighteen 8th grade students from the midwestern United States engaged in a 13-day (50 minutes a day) curriculum unit entitled, "*Make Your Own Compost*". In the unit, students worked on a compost design challenge by building a physical decomposition bioreactor, conducting virtual experiments, and writing a final design recommendation. Their collaborative efforts were facilitated by various tools, including (1) a virtual compost simulation; (2) a digital interactive concept map (VidyaMap) for biology concepts, and (3) the Idea Wall that is interactive allowing students to see, move, vote, and combine notes. All tools were encapsulated within a digital Science Notebook to support individual's and group's scientific reasoning. Seven students from two groups (N_1=3; N_2=4) in one class were videotaped during four activities supported by these technological tools.

Data resources and analysis

Video Data was transcribed for analysis by turns of talk. The teacher's talk was excluded, resulting in 418 turns of talk (N_1=120; N_2=298). We utilized inductive and deductive techniques to code and capture interactions (Derry et al., 2010). A coding scheme (Table 1) with three themes emerging from eight codes was developed to capture how students (1) created joint attention & awareness that refers to the shared focus of individuals on the same object, (2) constructed shared science understanding that contributed to collective comprehension of knowledge, and (3) goal adaptations between individual and group goals to generate collective learning products (Damşa, 2014; Tissenbaum et al., 2017). Two raters achieved a Kappa of .80 for inter-rater reliability across 30% of the data. Disagreements were resolved and the rest of the data were coded by the two raters independently. A mixed approach that quantified the qualitative science discourse in the videos was used, creating an overview of the types of verbal actions in the interactions. The percentage of each code was calculated.

Table 1
Science Discourse Coding Scheme (SD-Codes)

Interactions	Actions	Descriptions	Examples
Joint attention & awareness	Narration	Share information from learning resources	"*209 grams of water*" (Read notes)
	Procedural clarification	Make inquiry about the procedural tasks in the activity and the responses to these inquiries	*"Will you guys look through the prediction?"*
	Tools Engagement	Talk about the use the tools (e.g., drag and relocate Ideas, note combination or deletion)	*"Yeah, put that into the combine zone." Or "Control deletes."*
Shared Science Understand-ing	Idea generation	Bring new ideas (e.g., hypothesis, predictions)	*"I want to say like aeration"*
	Idea negotiation	Ask peers to explain their ideas, suggest next steps for group actions or disagree with peers	*"No, … the amount of oxygen and hydrogen affects water."*
	Ideas taken-up	Agree or accept peers' input or explain their own ideas being accepted to group ideas	*"Yeah, that's material. I'll put down that."*
Goals adaptation	Individual goal	Describe, ask, or adjust their individual goal	*"I'm going to do abio-factors."*
	Group goal	Inquiry or report on the group learning process or group learning products	*"How much do you guys get done right now?"*

The Idea Wall log data from was retrieved, encoded, and organized at the unit of individual notes. Each note entry consisted of information on (1) *Group Name*; (2) *Note Content*; (3) *Vote History,* recording the manipulations of notes to "Yup", "No" or "Combine Zone"; and (4) *Note Combination,* records reflecting if notes were combined to generate a new note, such as the consolidation of two notes, "Moisture" and "dirt", into a single note, labeled "Dead frog". Forty-three entries were generated by two groups when they collectively reasoning about the factors influencing decomposition before (Day 3) and after (Day 10) compost investigations. The Knowledge Integration coding scheme (KI scheme), which uses a 0-5 score scale across six categories (*5-complext link; 4-full link; 3-partial link; 2-no link; 1-off task; 0-no answer*) to gauge the complexity of Knowledge Integration (Liu et al., 2008), was used to analyze the videos and note data from Idea Wall sessions, to reveal KI within group learning.

Application of the KI scheme to Idea Wall: 5-complex link indicates scientific explanations of how two more ideas are related influencing decomposition; *4-full link* is elaboration of a complete idea by synthesizing fragmented ideas on notes. We did not identify examples identified in our study for *5-complex* and *4-full link. 3-partial link* is new ideas by combing notes with fragmented similar ideas (e.g., Note *"Carbon: Nitrogen ratio" is generated by combining "Carbon to nitrogen" & "Green Brown*"); *2-no link* means merging notes with identical ideas (e.g., Note "Moisture" is generated by merging "moisture" & "Moisture"); *1-off task* indicates irrelevant ideas (e.g., Note "Car" is generated by combing "hello" & "Fisher"); *0-no answer* is not applicable to our data.

The compost design report provided students with a chance to explain factors (e.g., Moisture, Particle Sizes) influence decomposition and their design. Design reports written by students in Group 2 were analyzed. One student in Group 1 did not write the design report and was excluded due to the incomplete data. The KI scheme was also used to understand individual students' knowledge integration levels in written Compost reports.

Application of the KI scheme to Compost Reports: 5-complext link indicates scientific explanations of one decomposition factor relates to other factors in affecting compost; *4-full link* is the elaboration of one decomposition factor influences compost by specifying ideal range; *3-partial link* means implicit elaborations of one decomposition factor without giving ideal range; *2-no link* means stating one factor is related to decomposition without explaining how it relates; 1-off task means unrelated content. *0-no answer* is no response.

Results

Overview of interactions between two groups being supported by distributed tools

We observed that Group 2 (N_2=298) generated a higher number of science discourse turns in comparison to Group 1 (N_1=120). This disparity may be attributed to Group 2 having one additional student, potentially leading to more extensive discussions. However, upon closer examination of their interactions, we identified notable similarities between the two groups. Both groups engaged in numerous instances of *Narrations* (N_1=10.00%; N_2=10.40%) and *Tool Engagement* (N_1=13.33%; N_2=11.44%) to establish joint attention and awareness. Additionally, we observed similar patterns in which students tried to get an alignment of individual (N_1=7.05%; N_2=9.06%) and group goals (N_1=16.67%; N_2=15.10%). Much higher percentage of science discourses centered around group goals compared to individual goal potentially indicated the endeavors that students put in achieving shared group goals. Another commonality was the shared science understanding, where both groups contributed a similar percentage of science discourse in Ideas Generation (N_1=12.50%; N_2=10.74%) & Ideas Negotiation (N_1=25.00%; N_2=23.15), indicating the active engagement in discourse to co-construct knowledge from both groups.

The main differences were in (1) Procedural Clarifications (N_1=14.17%; N_2=25.17%) and (2) Ideas Taken-up (N_1=13.33%; N_2=5.37%). The additional student in Group 2 likely increased focus on understanding procedural stages and clarification. This complexity also heightened challenges in achieving consensus on divergent ideas, resulting in fewer individual ideas being integrated into shared science understanding.

Group-level knowledge integration using the Idea Wall

Eight out of forty-three note entries from the Idea Wall were created by merging existing notes. This combining of notes predominantly occurred during the initial use of the Idea Wall (Day 3). However, all the notes were coded at the "2-*No link*" KI coding level. Students demonstrated "3-*Partial Link*" connections during the second Idea Wall episode (Day 10) using the combine zone feature. We did not find any other levels of connection.

We further examined students' talk during group discussions to illustrate how the verbal negotiations and actions in the Idea Wall related to the instances of "No link" or "Partial Link" to gain insights on how group interactions were mediated by the Idea Wall. Table 2 shows how students negotiated what to keep when seeing identical ideas across notes as well as the verbal Science Discourse Code (SD-code). Table 3 shows students' talk as they created a note "Carbon: Nitrogen (Ratio)" by merging notes with similar ideas "Browns : Greens" & "Carbon/Nitrogen." Group members negotiated their differing ideas regarding whether "Greens to Browns ratio" and "Carbon and Nitrogen ratio" were the same. Students didn't confirm if two notes were the same, but the recorded combined action on the Idea Wall suggests agreement. Both exemplars were from Group 2.

Table 2
Exemplar Science Discourse for 2-No Link (Merge identical notes)

Student	Transcript	SD-Codes
A	We have three different moisture notes	Narration
B	Okay, I might delete it. Can you delete it?	Procedural Inquiry
C	No, combine this moisture and this moisture?	Ideas Negotiation; Tool Engagement; Group goal
A	Yeah.	Ideas Taken-up; Group goal

Table 3
Exemplar science discourse for 3-Partial Link (Merge two notes with similar science ideas)

C	Carbon to nitrogen is the same thing as Green to Browns	Ideas Generation
A	Brown and greens are facts, but carbon and nitrogen are factors.	Ideas Negotiation
	So we are saying H2O and water are different things?	Ideas Negotiation
A	No, it's like saying that the amount of oxygen and hydrogen, like affects the amount of water.	Ideas Negotiation

Knowledge integration in an individual's compost design from Group 2

We noticed varying levels of individual's understanding among students indicating different levels of KI. Student B provided explanations for all four factors, integrating information from the Idea Wall with "4-*Full link*" (Carbon-Nitrogen Ratio, Particle Size & Turing) or "5-*Complex link*" (Moisture). For example, student B explained that "*it's good to have …40% to 55% moisture. If the compost is too wet, there will not be enough air flow. If it is too dry it's hard for the decomposers to live in.*" This explanation explicitly stated the ideal range of moisture and how moisture level influences decomposers that directly affect decomposition. Student B was also the only student who explained the factor turning by writing, "*turn or mix the compost every 1 to 7 days, anything more than 7 will make a slow decomposition.*" Student A explained three factors (all except *Turning)*, at the "3-*Partial Link*" level. Taking one of the implicit explanations (Particle Size) from Student A as an example, *"a medium particle size… would create the fastest decomposing compost system"*, student did not give ideal range of particle size and how it influences decomposition rate. Student C also explained three factors, with one at the "3-*Partial Link*" (Particle Size) level and the other two (Carbon-Nitrogen Ratio & Moisture) at the "2-*No link*" level. An example of the "no link" response can be seen in Student C's vague explanation that the Carbon-Nitrogen Ratio affects decomposition without providing any explanation about how, by writing that "*amount of carbon and nitrogen…it affects how fast we can compost.*" Student D included information about how Moisture impacts compost at a "*Partial Link*" level and Carbon-Nitrogen Ratio at a "*No link*" level.

We also observed that the converged group understanding was not always exhibited at the individual level.". For instance, Students A & C actively discussed whether "Green and Brown" and "Carbon and Nitrogen" represented the same concept and collectively decided to merge these terms into "Carbon and Nitrogen" on the Idea Wall. However, Student C employed the concept of "Carbon and Nitrogen" ("*amount of carbon and nitrogen…affects how fast we can compost*") to the final report while she initially thought "Green to Brown" is the same as "Carbon and Nitrogen" in the discussion. Student A wrote "*slightly more browns than greens would breast the fastest decomposing*" while he reasoned that these two concepts are different in the Ideal Wall session.

Discussion and conclusions

We explored interactions that provide insights into the essential aspects of collaborative learning (Damşa, 2014; Järvelä et al., 2015) when students collaborated in technology-enriched learning environment (Stahl, 2015). Our findings show that despite differed length of turns of talk being generated, both groups exhibited similar patterns of discussion, with identical percentages of productive interactions. It implies that merely urging students to speak more shouldn't be the primary goal to foster productive interactions, particularly in a learning environment using various technological tools. Offering activities that help students to successfully negotiate conflicts, build upon others' ideas, and align personal actions to achieve common goals is important for collaboration and learning.

Our study also explores KI during collaborative interactions using the Idea Wall. Notably, initial usage revealed a higher number of entries for creating notes and combining actions, but all at the low level of KI, indicating superficial technology use. This could be due to students' limited familiarity with the tools or scientific concepts early in the unit. Providing support in comprehending the tools, through activities that introduce students to their functions or even allowing them to practice using the tools before engaging in group collaboration, can undoubtedly enhance interactions and potentially foster stronger integration of knowledge at the group level.

While students did not score highly in KI on their combined notes in Idea Wall, some students 'final explanations scored much higher, indicating that they did benefit from the collaboration. However, our observations revealed an interesting nuance: traces of group science discourse were evident in the explanations of compost design for some individual students but not for others. This variance implies that group idea negotiations and collective decisions, intended to share meaning and knowledge, do not consistently translate into changes or manifestations in the individual understanding of students. This signifies the need for providing support for science understanding, whether through group-level activities or individual mastery of scientific concepts. As collaborative learning evolves, with a shift towards emphasizing group understanding over individual mastery from group work, it's vital to recognize how group-level learning outcomes affect KI knowledge across levels. This interconnectedness underscores the need to recognize the complex and multifaceted factors influencing collaborative learning, which do not neatly delineate the boundaries between individual and group learning.

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