Examining Shared Strategies for Knowledge Construction in NGSS-Aligned Instructional Scaffold

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Abstract: In this study we examined a group of middle school students engaging in an NGSS-aligned lesson, using an instructional scaffold (Model-Evidence-Link Diagram) to support their argumentation and meaning making process. We chose to code inductively for emerging patterns in their discourse to identify moments of shared knowledge construction of complex Earth and Space science topics. Our results found that paraphrasing was a key strategy that students used to reach understanding together and to ensure group members reached consensus. These findings suggest that rephrasing concepts in familiar terms is essential to deriving meaning and being able to utilize new concepts for higher level reasoning and argumentation, and critical evaluation of scientific models.

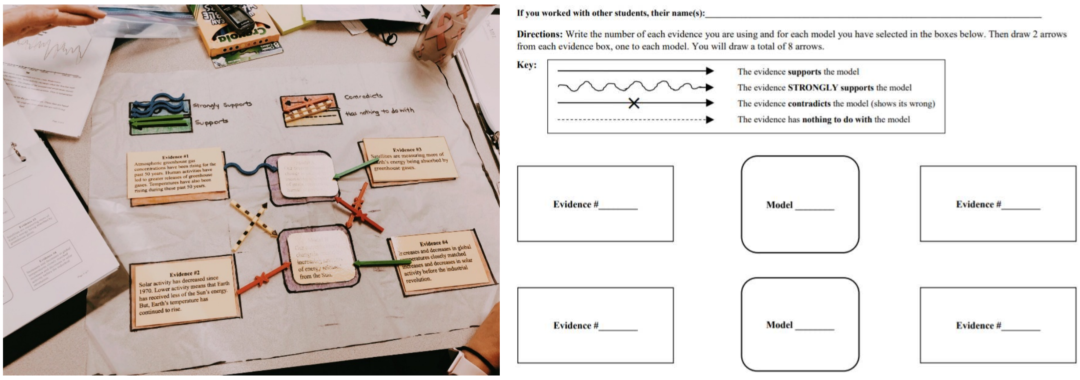
Keywords: Science, Argumentation, Knowledge Building, NGSS

Introduction

The Next Generation Science Standards (NGSS) vision is anchored in the philosophy that all individuals can learn complex science and become engaged STEM citizens (National Research Council, 2013). Instead of textbooks and resources, the standards themselves are written for teachers to use the process of science as a guide for exploration, which represents a significant departure from past documents and massive shift in instructional practice (Krajcik et al., 2014). As part of the recommendations made by the Framework committee, each standard within the document is a performance expectation (PE). These PE's are built upon three interrelated dimensions: (1) disciplinary core ideas (DCI's) that outline the specific content to be learned, (2) scientific and engineering practices (SEPs) that outline what students can do with that content knowledge, and (3) cross-cutting concepts (CCs) that unify science and engineering (NGSS lead states, 2013). In sum, these PE's demonstrate not just what students know but also what they can do with that knowledge.

To cultivate a student's ability to meet a PE all three dimensions, DCIs, SEPs, and CCs, must be intertwined for students to learn science. In the following study, we examined the use of a classroom instructional scaffold that supports students' construction of these connections through the use of Earth and Environmental topics that are aligned to the NGSS. The Model-Evidence Link (the pre-constructed MEL) diagram engages students' in the evaluation of four lines of evidence and two alternative explanations (scientific alternative and another alternative), potentially facilitating their growth in scientific understanding through scientific practices (Authors, 2018). Students read the evidence texts and then draw arrows from the lines of evidence that indicate that the select evidence either supports, strongly supports, contradicts, or has nothing to do with each model, thus, making such reasoning and evaluations explicit (see Figure 1a). Students then explain their decisions on the diagram which potentially facilitates deeper understanding about Earth and space science content, especially when students reflect on their judgments regarding competing alternative explanations about a phenomenon (Authors, 2016).

Also in this study, we used an extension of the MEL, called build-a-MEL (baMEL), where students constructed their own MEL diagram, picking four lines of evidence from a possible eight, and two alternative explanatory models, from three choices (see Figure 1b). By building and evaluating their own MEL diagrams, we hypothesized that students would actively engage in scientific dialogue to construct knowledge around Earth and space science topics, and be able to critically evaluate models on how scientifically plausible they are according to the evidence available. We chose to examine closely how students make meaning and construct knowledge through scientific argumentation and collaborative learning.



(a) (b)

Figure 1. Model Evidence Link diagram examples (a), MEL (b), baMEL.

Methods

In the present research, we conducted a qualitative case study of a single group of sixth grade students randomly selected from five observed classrooms to analyze the trajectory of participation across the implementation of one MEL and two baMELs. This case study was an inductive exploratory opportunity to examine how students navigated understanding novel information through shared discourse (Stake, 2005).

Data collection

We conducted four observations in each classroom; a pre-observation of any science lesson of the teacher's choice and one MEL and two baMEL implementations. During data collection we collected field notes as well as video and audio recorded each lesson, using one main camera for the duration of the lesson, audio recorders with each group, and a go-pro camera attached to the teacher, to capture as many interactions as possible.

Analysis

All the observations were transcribed, and we selected one of the five teachers to focus for the scope of this study. This teacher was identified through a sequentially random selection process and the decision to choose only one was logistical due to the large amount of data collected in each classroom. To analyze the transcripts, we used inductive open coding to examine which sort of dialogic patterns emerged in how students were reaching conceptual understanding of complex topics and reaching consensus in their groups (Strauss & Corbin, 1990). Open coding allows researchers to break down, categorize, classify, and interpret patterns in the phenomena being observed. We looked to see which types of strategies students were using to reach their conclusions. We traced dialogues in each group to identify moments of clarification, justification, and meaning making.

Findings

There were three types of dialogue patterns that emerged from the group work, that provided a clear picture of the types of meaning making that students were engaging in to construct knowledge together. These patterns were particularly centered on deepening students understanding of the cross cutting concepts. From an initial round of open coding the broader themes of enacting the MEL activities were: (a) paraphrasing for group understanding, (b) paraphrasing for knowledge construction, and (c) paraphrasing to engage in debate. These themes illustrate how the act of paraphrasing evidence statements from the MEL activated meaning making of the broader connections between the evidence and the models.

From the onset of the observations it was apparent that all three group members were utilizing paraphrasing to create novel sentences. These paraphrasing moments represented students reflecting connections between their prior knowledge and the new information within the evidence statements (Wittrock & Alesandrini, 1990). As students continued to engage in dialogue, their paraphrasing became more novel and their comfort with the new content more evident. Particularly salient was how the students use of paraphrasing supported them to make meaning of the cross cutting concepts when engaging in debate about which models were or were not supported by evidence (see Table 1).

Table 1: Paraphrasing supporting meaning making of cross cutting concepts

Paraphrase for:	Discourse Excerpts

	(*__paraphrase__* support underlined and italicized)
Group Understanding	S2: Yeah its saying, that *__glaciers will add to the availability__* … will, *__will help the availability of freshwater,… in many parts__*.. uhhh *__but it saying glacial ice mass…__* no but the second sentence…that, that contradicts model A, it *__says glacial ice mass is decreasing__*. That *__means that the um… the freshwater is decreasing__*. It says, it says *__glacial ice mass is decreasing worldwide__*. That *__means the glaciers… not there aren't enough glaciers. Or… enough__* S3: That means more freshwater and less glaciers. S2: No but this the glaciers are a source of freshwater…
Knowledge Construction	S2: *__Glaciers are a source of freshwater__* right? And then it says *__glacial ice mass, which means the mass of the glaciers is decreasing, that means like there's less glaciers right__*? S3: Yea S2: So if you think about *__glaciers are a source, so less glaciers less sources of freshwater, less sources of freshwater less freshwater itself. Right__*? Don't you think that would…. S3: Ok so that's kinda saying… *__there is less water…. as more glaciers melt__* S2: Ok *__less sources of water__* S3: *__As glaciers melt__* S2: Yes…. So it supports the model C… it doesn't strongly support it. It doesn't ummmm,,,,strongly support it…
Debate	S3: So…. We are saying like…. S2: *__So these glaciers they collect more snow and ice…. in the summer the glaciers melt… the melted ice flows into rives that provide water for crops and farm animals__* S3: So *__it is saying that it provides water that they aren't losing water__* S2: Yea and *__as average temperatures across Asia increase. um the temperature… it allows the glacier to melt earlier…. And so it can't collect so much ice and snow.__* And it can't…. so it doesn't supply S3: So it helps model A… *__because it is saying there is more water because the glaciers are melting__*….. S2: No No No… it is saying there is less S3: No there is more water S1: No… he's right because when it melts it turns into water and its S2: No No No so what this is saying…. Model…. 6…. This is saying *__that glaciers are a source of water… and because the temperatures are increasing the glaciers melt earlier so they don't get a chance to collect as much snow and ice. Which means there is less water flowing into rivers__*. (PAUSE) So it supports model C…..

	S3: I think so… yea S1: Yeah…

Engagement in dialogue through paraphrasing enabled students to initially feel confident in their ability to employ a new evidence statement. They would begin their dialogue using a majority of the language presented in the statement and paraphrase very infrequently. In this phase the paraphrase served as a way to shallowly comprehend the broader ideas in the evidence text. As the group discussion continued the use of paraphrasing became more frequent and expanded to incorporate more novel language not present in the text. During these hybrid paraphrase moments students were drawing from their prior experiences, the evidence texts, and their peers to construct new knowledge about the broader scientific idea being discussed (Wittrock & Alesandrini, 1990). All of which coalesced into students creating unique paraphrases that included their own point of view and enabled the group to engage in authentic debate with each other.

With each new evidence statement, the group organically followed a similar path of moving from using paraphrases that nearly mirrored the written text, to more novel interpretations of the information, and then to debate. This gradual transition also followed the level of interaction between group members, with true argumentation occurring when independent thoughts were able to be produced by group members. During argumentation students' use of novel paraphrases tended to center upon the cross cutting concepts as a way to connect different evidence statements to each other or to a model. As can be seen in Table 1, as students' progress into deeper levels of paraphrasing they are deepening their understanding of two cross cutting concepts: *cause and effect* and *stability and change.* This example demonstrates that the MEL activity helped scaffold students' ability to employ paraphrase until they were able to reason beyond the text of the evidence statements.

Although paraphrasing has been identified as a strategy that good readers use it has not received as much attention as many of the other comprehension strategies, such as visualization, using prior knowledge, or questioning, particularly in the context of STEM learning (Kletzien, 2009). Broadly the act of paraphrasing while using the MEL scaffolds enabled students to grasp the complex language of science which then enabled them to make deeper connections within and between the evidence statements. These findings suggest that rephrasing concepts in familiar terms is essential to deriving meaning and being able to utilize new concepts for higher level reasoning, argumentation, and critical evaluation.

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