Investigating the Nature of Evidence 6th Grade Students Use When Constructing Scientific Explanations in Biodiversity

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Abstract: This paper investigates the nature of evidence that six grade students use when constructing scientific explanations in biodiversity situations. We employ a coding scheme that specifically targets the coherence of students' arguments and the way students use inscriptions when completing tasks. We found out that students use inscriptions differently depending on the nature of the inscription and that oftentimes, students' explanations have logical coherent reasoning regardless of scientifically accepted answers.

Introduction

Toulmin (1958) characterizes scientific arguments by a claim that is backed up by data that warrants the claim, and reasoning that explains how data or evidence supports the claim. This pattern has been widely used in the literature as a way to teach students how to construct scientific explanations. In their recent article, Songer and Gotwals (2009) describe a learning progression of ideas in classification, ecology and biodiversity and how those ideas can progress over three grades – 4th, 5th and 6th. Parallel with this content progression is the progression in inquiry skills, which is manifested with a four level progression describing increasingly sophisticated explanations, with each level also containing elements of scaffolding to guide students in their development. Moreover, Gotwals & Songer (in press) discuss the trajectories students follow in order to reason about biodiversity issues and categorize several kinds of reasoning that they call "middle knowledges" which are elicited by using assessment items based on writing scientific explanations. They found that even when students are scaffolded in formulating scientific explanations, there still existed "messy middle" knowledge, where students may understand content in certain types of situations, but not others. Also, even when students understood the science content in the tasks, constructing sound scientific explanations was often still difficult. Sandoval (2003) found that when learning about natural selection, students often failed to cite sufficient evidence to support their claim because they failed to recognize the importance of being explicit with evidence. He also found out that sometimes students' explanations were "coherent"; that is logical, even though they were not the "correct" scientific answer. Moreover, in later work, Sandoval and Millwood (2005) recognized that students often treated inscriptions in different ways when they considered them as evidence. For example, some students would consider the mere presence of a representation enough to consider it as evidence, and many times failed to explicitly explain how a certain representation provided evidence for the claim. This work investigates the difficulty that students have when they structure scientific explanations in ecology, and investigates the kinds of evidence that students use to back up their claim, specifically looking for coherence in the explanation. The work can also help to inform the literature about the pathways that students take as they learn to formulate more sophisticated scientific explanations in ecology. We address the following research questions:

a- How coherent are the students' claims in relation to evidence regardless of scientific correctness?
b- How do students use inscriptions as data or evidence to support their claims?

Method and Data Analysis

This work examines 6th grade students' written responses to assessment items who have participated in an inquiry-based biodiversity curriculum. The curriculum and assessment items were administered in six sections of 6th grade classrooms for a total of 170 students. The test contained 9 items which included questions about biodiversity with some multiple choice and food web questions in addition to complex scientific questions that required students to provide claim, evidence and reasoning for their answers. Originally, we coded the items using a rubric that focused mainly on scientific correctness, with codes from 0 to 4, with 4 being the highest code for correct scientific claim backed up by correct evidence and reasoning. For our current purpose, we recoded all of the selected questions based on whether there was a logical explanation with a claim backed by a logical evidence and/or logical reasoning. For example, even if the student did not give the scientifically correct answer, we still look at the logic of the explanation. Therefore in response to a question about destiny of large fish if all small fish in a pond, the student who answered: "All of the large fish in the pond will have to adapt to something else or they will die" has a logical claim even if this claim is not what the "correct" answer is. In order to further probe how students use inscriptions, we choose to examine item 9 that has two bar graphs of organisms in different habitats where students need to interpret the graphs in order to make a claim about which habitat likely has more food and shelter. Our new rubric distinguishes between the different ways students use the graph as evidence: those who don't use the graph as evidence, those who just mention that the evidence is in the graph, those who observe the higher bars in one graph and mention that their evidence is the graph with higher bars, and finally those who are able to interpret the bar graphs and mention how that supports their original claim.

Findings and Implications

The results indicate that even when students don't have the "right" answer, many are still reasoning logically about the questions and could either provide a logical claim or a logical claim backed up by logical reasoning and/or logical evidence. Due to space limitations we illustrate our point with examples from two questions. In item 2, which asks what happens to algae in a pond if fertilizers were added; the majority of answers which were scientifically incorrect had logical reasoning. A representative answer for this category is:

> *The algae would decrease because the river would dry up. By things you put in river it would affect the soil and soil will increase and dry up the river (DTF08550111)*

Note that the logic of the student above is based on an idea that the fertilizer affects the soil and the reasoning and evidence are based on common sense logic. It is probably safe to say that the student does not understand what a fertilizer does to the soil, but even with that, the student was able to make logical guesses that if it made the soil increase, then that is harmful for the algae thinking that it might take over the algae and make it decrease.

With regard to how students used inscriptions in item 9 with bar graphs comparing organisms found in two habitats, we found that the majority of students' responses somehow referenced the graph as evidence; however, many students were not explicit in comparing the numbers of different organisms between habitats. For example a common answer is represented by:

> *Habitat B, because you just look at it, if you look at the charts one is higher than the others (DTF08550303)*

The answer above is probably a necessary step in reasoning about the graph but it is insufficient to explain why one had more shelter than the other; that is, it does not explicitly specify what those bars are and how that is related to food and shelter. Moreover, we found out that while many students used some type of evidence from the graphs to answer the question, no student included scientific reasoning linking the evidence to the claim; they often just reiterated the evidence from graphs for the reasoning. An interesting dichotomy in our results was how very few students were able to mention correct evidence for item 2 (what would happen to algae with the addition of fertilizer) while many students referenced some evidence in item 9 (comparing organisms across habitats), but very few students were able to mention correct reasoning. One possible explanation for this result is that the evidence for question 2 did not originate from the representation; rather, the student had to know that fertilizers make algae grow. In contrast, in item 9 almost all students used the graph as evidence (even when they did not use that graph correctly), but were not able to mention correct reasoning because it somehow required relating it to the concept of biodiversity, something that was not explicitly evident in the question.

The different types of evidence used in the assessment items originated either from inscriptions (like bar graphs, or biological diagrams), individual experiences, knowledge of scientific phenomena, or what students learnt in the classroom. Many of students' responses were logically plausible even if they were not scientifically accurate. These findings compliment and add to the types of "messy middles" that Gotwals & Songer (in press) mention. Better understanding what types of messy middles students have helps to inform how educators can support students in moving from where they are to more sophisticated scientific reasoning, both in terms in content and reasoning.

References

Gotwals, A., & Songer, N. (in press). Reasoning up and down a food chain: Using and assessment framework to investigate students' middle knowledge. *Science Education.*

Sandoval, W. (2003). Conceptual and Epistemic aspects of students conceptual Explanations. *The Journal of Learning Sciences, 12*(1), 5-51.

Sandoval, W., & Millwood, K. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition and Instruction, 23*(1), 23-55.

Songer, N., Kelcey, B., & Gotwals, A. (2009). How and when does complex reasoning occur? Empirically driven development of a learning progressing focused on complex reasoning and biodiversity.*Journal of Research in Science Teaching 46, 610-631.*

Toulmin, S. (1958). *The Uses of Argument.* Cambridge, England: Cambridge University Press.