Uncovering Students' Ecological Knowledge Resources

Lana M. Minshew, University of North Carolina at Chapel Hill, minshew@live.unc.edu
Kelly J. Barber-Lester, University of North Carolina at Chapel Hill, kelba@live.unc.edu
Sharon Derry, University of North Carolina at Chapel Hill, derry@email.unc.edu
Janice L. Anderson, University of North Carolina at Chapel Hill, anderjl@email.unc.edu

Abstract: This paper reports a cognitive resource analysis of middle school students' understanding of energy flow and matter cycling in ecosystems. We discuss students' resources that we uncovered through our analyses, highlighting how those that emerged through analysis of the second cohort of students extend our previous work. Five major topic areas of cognitive resources were identified in one cohort and confirmed in a second.

Keywords: knowledge in pieces, design-based research, science, misconceptions, resources

Introduction

This project focused on the scientific domain of ecosystems, with a special interest in how students understand and think about the flow of energy and cycling of matter. We emphasized the role of prior knowledge in learning and accepted scientific inaccuracies as characteristic of students' initial phases of learning (Smith et al., 1994). Our Knowledge in Pieces (KiP) framework, representing a class of learning theories (Hammer, Elby, Scherr & Redish, 2005; diSessa, 1988; Clark & Linn, 2003), takes a fragmented approach to describing student knowledge. Students' possess knowledge fragments that some call phenomenological primitives (diSessa, 1988), resources (Hammer et al., 2005) or simply ideas (Clark & Linn, 2003).

In previous work, we explored how a KiP framework can be used to examine students' understandings in this domain (Minshew, Barber-Lester, Derry, & Anderson, 2017). In contrast to misconceptions literature, which suggests that learning is a process of replacing misconceptions with expert knowledge (Smith et al., 1994), a KiP perspective allows for the reorganization of resources. In other words, resources are not necessarily extinguished but reorganized when students learn scientific concepts. In this study, we extended a previous analysis (Minshew et al., 2017) to a second cohort of students. The research question was: 1) What resources related to flow of energy and cycling of matter in ecosystems do students in Cohort Two bring with them to the classroom and how do those resources compare to those exhibited by the students in Cohort One?

Research design

Participants were sixth graders (n = 208) at a rural STEM-focused middle school in the southeastern United States. Data was collected over two academic years, 2015-2016 (Cohort One) and 2016-2017 (Cohort Two). Our initial analysis (Minshew et al., 2017) based on data from Cohort One was extended by this analysis of data from Cohort Two. Each year a representative sample of 12 students were interviewed before engaging in the Compost Unit. In interviews students explained models they constructed representing their understandings about energy and matter in ecosystems. Interviews were analyzed qualitatively through successive steps of coding, creation of data matrices and summaries.

Results

Our analysis of Cohort Two students' interview data revealed that they had resources in the same major topic areas (*food chains, decomposers, waste, energy*, and *matter)* initially found in Cohort One, providing confirmatory evidence for resources identified in our initial analysis. Analysis of data from Cohort Two also revealed five specific resources that were not initially noted in our analysis of Cohort One. Table 1 provides an overview of both discovered and confirmed resources. Resources in Table 1 are organized by major topic area; columns on the right side indicate in which cohorts a resource was discovered (•), confirmed (⦿) or absent (blank).

Conclusions and implications

Our study focused on the knowledge that students brought with them concerning energy flow and matter cycling in ecosystems. Analysis of students' interviews from a model-based assessment task uncovered resources in five major topic areas. These had been previously identified in Cohort One and confirmed by this analysis in Cohort Two. Students in Cohort Two expressed additional specific resources in the topic areas of *energy* and *matter*

 © ISLS

which were not initially identified in Cohort One. However, a post-hoc analysis revealed that some of these were present in Cohort One.

The use of a KiP framework to examine student understanding is novel in the science domain of energy and matter in ecosystem. This resource-oriented view of student understanding pushes both researchers and educators to focus on the wealth of experiences that students bring with them to the science classroom. These resources are potentially powerful and important assets to be engaged in the pursuit of advancing scientific understanding.

Table 1: Identified resources related to flow of energy and cycling of matter for both Cohorts One & Two

Topic Area	Resource	Cohort 1	Cohort 2
Food Chains	There is a relationship between sun/sunlight and producers	•	⊙
	Animals eat other animals	•	⊙
	Animals eat plants	•	⊙
	Decomposers are a part of the food chain	•	⊙
Decomposers	Bacteria, worms, and mushrooms are decomposers	•	⊙
	Decomposers break things down	•	⊙
Waste	Animals and humans generate waste	•	⊙
	Some waste can be broken down and is connected to soil	•	⊙
Energy	The sun is central to energy	•	⊙
	Rain and clouds are connected to energy	•	⊙
	Organisms need energy	•	⊙
	Plants need energy to make their own food/perform photosynthesis		•
	Animals eat to get energy	⊙	•
	Electricity is connected to energy	•	
	Decomposers get energy from breaking down dead organisms or organic waste	⊙	•
	Energy flows through an ecosystem	⊙	•
Matter	Everything is matter/matter takes up space	•	⊙
	Matter exists in different states	•	⊙
	There is organic and inorganic matter	⊙	•

References

Clark, D., and Linn, M. (2003). Designing for Knowledge Integration: The Impact of Instructional Time. *The Journal of the Learning Sciences. 12(4),* 451-493.

diSessa, A. A. (1988). Knowledge in pieces. In G. Forman & P. B. Pufall (Eds.) *Constructivism in the Computer Age (pp. 49-70).* Hillsdale, NJ: Lawrence Erlbaum Associates.

Hammer, D., Elby, A., Scherr, R. E., & Redish, E. F. (2005). Resources, framing, and transfer. In J. P. Mestre (Ed.) *Transfer of Learning from a Modern Multidisciplinary Perspective (89-119).* Greenwich, CT: Information Age Publishing.

Minshew, L. M., Barber-Lester, K. J., Derry, S. J., & Anderson, J. L. (2017). Leveraging students' knowledge to adapt science curricular to local context. *Educational Technology & Society, 20(4),* 205-218.

Smith, J. P., diSessa, A. A. & Roschelle, J. (1994). Misconceptions reconceived: A constructivist analysis of knowledge in transition. Journal of the Learning Sciences, 3(2), 115-163. Doi: 10.1207/s15327809jls0302_1

Acknowledgements

This is based upon work supported by the National Science foundation under Grant No. DRL1418044. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of National Science Foundation.