Examining student conceptions of the nitrogen cycle
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Nitrogen is arguably one of the most important elements on Earth, but education about this element presents distinct challenges. As an essential component in living cells, fertilizers that sustain food production, and the atmosphere, nitrogen provides an opportunity to learn key concepts in ecology and environmental science. These concepts fit in a broader group of core concepts and skills in biology such as systems thinking, transformations of matter, and quantitative reasoning. Despite its importance for life on Earth and its connection to important concepts within biology, the nitrogen cycle often receives cursory attention in biology courses. It is thus likely that undergraduates obtain degrees in biology with little knowledge of the nitrogen cycle. The objectives of this study were threefold:

1. Describe the conceptual understanding, knowledge application, and misconceptions of the nitrogen cycle among undergraduate biology students
2. Determine differences in nitrogen cycle knowledge among introductory, intermediate, and advanced students
3. Examine results in the context of current teaching practices and future improved instructional strategies

These objectives were achieved through a mixed methods explanatory design that assessed student knowledge about various aspects of the nitrogen cycle. Written surveys were administered to introductory (100-level), intermediate (300-level), and advanced (400-level) students (n=222) in biological science courses at Michigan State University. Interviews were conducted with a small subset of participants from each course (n=7) that were selected based on demographic characteristics and course level. Interviewees were asked to discuss concepts related to the nitrogen cycle, their own attitudes about learning about the nitrogen cycle, draw a diagram of the nitrogen cycle, and interpret a textbook diagram of the nitrogen cycle.

Performance on the written survey was significantly higher among intermediate and advanced students than introductory students (ANOVA, p < 0.001), but performance did not differ among intermediate and advanced students. Statements of misconceptions related to nitrogen cycling processes decreased with course progression, from 27% among introductory students to 3% and 8% in intermediate and advanced students, respectively. Despite a general improvement in nitrogen cycle knowledge from introductory to advanced students, difficulty in describing mechanisms and analyzing transdisciplinary topics persisted among all groups, particularly for chemical transformations and microscopic processes. Our results indicate that limited instruction on the nitrogen cycle and lack of integration with other course concepts are likely to hinder students’ ability to apply this knowledge in new contexts. To address this deficit, we suggest that undergraduate biology courses (1) focus on function over memorization and (2) emphasize transdisciplinary aspects when teaching the nitrogen cycle.