Integrated Math/Biology Lessons for Approaches to College Mathematics

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We report on our analysis of student reasoning during the first iteration of a design experiment (Cobb et al., 2003) in which we implemented a lesson that integrates mathematics and biology content through graph interpretation activities. Montclair State University (MSU) has seen an increase in the number of first-year STEM majors who fail college Precalculus, contributing to lower retention and graduation rates. In response, the MSU math department developed a course called Approaches to College Mathematics (ACM) to prepare these students for Precalculus. Research shows that integrating graphing with other STEM content can lead to improved learning across the integrated content areas (e.g., Basu & Panorkou, 2019; Gültepe, 2016; Panorkou et al., 2022). We conjectured that activities we designed for ACM with an integrated STEM context might support students in reasoning emergently about graphs and their covariational meanings. Moore and Thompson (2015) define emergent (in contrast to static) shape thinking as reasoning about a graph as a meaningful trace of the relationship between two covarying quantities. Therefore, we explored the following research question: What kinds of reasoning do ACM students engage in as they work with the integrated lesson we designed?

The lesson consisted of a whole-group graph comparison task, an in-depth analysis of graphs in student pairs, and a concluding presentation by students to showcase their learning. Our analysis was based upon multiple data sources: student handouts, group digital posters, and instructor (second author) field notes. Two researchers, neither of whom were the instructor, independently coded the student data, employing a qualitative coding process that began with deductive analysis and then moved into inductive analysis (Hammersley, 2004; Patton, 2015). After discussion and comparison of codes, there was 100% intercoder agreement.

We noted three major categories to classify students' static versus emergent thinking, as well as integrated versus unintegrated reasoning: unintegrated (biology only) with no shape thinking, unintegrated (math only) with static shape thinking, and integrated thinking (both biology and math) with emergent shape thinking. We found that these students engaged in reasoning about integrated math and biology content only when they were engaging in emergent shape thinking. When their shape thinking was static, their reasoning was unintegrated. We argue that this shows the potential for lessons with an integrated design to foster deeper mathematical understanding in ACM students. At the same time, we noted that students struggled with details of mathematical terminology and notation, such as the origin, domain and range, scale, and the labeling of points. We also noted a significant amount of interval-point confusion, a long-known graphing difficulty (Leinhardt et al., 1990). These difficulties are typical of the struggles ACM students face and may be exacerbated by the differences between graphs that appear in biology and math texts.

Our poster will include the research design, graphs and interpretation tasks, students' written responses, and a discussion of how we make sense of their integrated reasoning through a static-emergent shape thinking framework. Student data will be showcased, organized according to major themes from our findings.

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