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Identification of misconceptions and troublesome concepts in Microbiology, with development and testing of targeted pedagogical activities

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Project Summary - Identification of misconceptions and troublesome concepts in Microbiology, with development and testing of targeted pedagogical activities

Studies in cognitive science have provided insight into how prior knowledge and misconceptions shape the learning process. Misconceptions have been demonstrated in a large proportion of science students (Coley & Tanner, 2012, 2015; Gregory & Ellis, 2007; Gregory, 2009). To effectively address student misconceptions about microbiology and other foundational science concepts, we wanted to identify key misconceptions, and prepare relevant learning activities to help unseat them. Concept inventories have been useful in identifying common misconceptions in several scientific disciplines (for examples, see Garvin-Doxas et al. 2007; Hestenes et al. 1992; Smith et al. 2008). Concept inventories use machine scorable (multiple choice and true/false) questions to measure student understanding of fundamental concepts in specific disciplines, focusing on those that are frequently subject to misconceptions. Guidelines published by Adams & Wieman (2010) are widely used for creating and validating these tools, and were followed in making the concept inventory in this project: the Introductory Microbiology Concept Inventory (IMCI).

This project involved identifying microbiology misconceptions, developing the IMCI, creating relevant educational resources, using them in class, and evaluating their effectiveness. We created a new interrupted case study, where the instructor prompt students to analyze part of the case study, share responses, and engage in class discussion prior to continuing onto the next portion of the case study (Herreid 2005b). A concept map activity was included to help students make visual connections between terms and concepts. We obtained measures of student learning (via selected IMCI questions administered pre-/post-activity) and student perceptions of this activity using an opinion survey based on work by Bonney 2015 and Herreid et al. 2014.

Microbiology misconceptions were identified through participant interviews involving "think-aloud" questions and getting participant feedback on the pilot concept inventory questions. The concept inventory was used in Fall 2016 with students in introductory microbiology classes, and showed learning gains across a number of concepts, but with some potentially unclear or confusing questions. We continued to refine and validate of the IMCI, again using participant interviews/feedback, and the updated IMCI was administered to introductory microbiology students in Fall 2018 . Based on Fall 2018 IMCI results, and aligning with selected American Society for Microbiology (ASM) Curriculum Guidelines (Merkel et al. 2012), an new class activity was constructed to address specific misconceptions that had been identified as problematic from the IMCI results. The activity included an interrupted problem-based case study that was constructed based on actual disease case reports from medical literature, and written to be engaging and emotive (based on recommendations in Bonney (2015) and Herreid (2005a, 2006). The case study was used in a Winter 2019 Medical Microbiology course. Pre-/post-case study administration using a subset of the IMCI showed significant increase in learning gains on relevant concepts but no gains were observed for microbiology questions that were not related to the case study. According to the opinion survey, students found the case study interesting, memorable, and helpful.

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