

Reforming Undergraduate Biology Teaching Through Formative Assessment: Distractor-Driven Multiple Choice Items as Instructional Tools

Erin Marie Furtak
School of Education

Project Summary

The proposed RA position for Sarah Roberts, doctoral candidate in the School of Education, would support the development, validation, and enactment of a set of biology formative assessment multiple choice items. The project represents a new direction for research, will support a new, interdisciplinary collaboration between researchers in the School of Education and Molecular, Cellular and Developmental biology, and will improve the quality of science instruction for the university.

Project Description

Science education research has established that students have everyday ideas about scientific phenomena that survive years of science lessons, as well as misunderstandings based on what they learn in school. Part of the reason that these so-called alternative conceptions are so persistent is that teachers ignore or do not recognize them, or simply tell students that they are incorrect, rather than helping them to adapt their naive ideas into more scientific ones (Smith, DiSessa, & Roschelle, 1993).

Formative assessment, a process for determining what students know and then modifying instruction to meet students' needs, is an instructional approach that has been shown to increase student learning (e.g. Black & William, 1998; National Research Council, 2001). Despite its effectiveness, it remains a complex instructional approach that can be difficult to implement because students' ideas are hard to make explicit, and teachers do not have the proper strategies for finding them. Once revealed, students' ideas are often phrased in unclear or unscientific terms, and teachers often lack clear strategies for how to address and provoke students to change their thinking (Furtak et al., 2008).

Multiple-choice questions developed to reveal students' prior ideas matched with concrete strategies for adapting student thinking are potential formative assessment tools for addressing this problem. Multiple choice questions for formative assessment are based upon research into student thinking, so that the incorrect responses (known as distractors) reflect common explanations and (often implicit) assumptions. These "wrong answers" reveal what students are thinking, are diagnostic rather than evaluative, and are therefore ideally suited to making explicit students' ideas.

A number of such Distractor-Driven Multiple-Choice Questions (DDMC's) have been developed to assess students' understanding as parts of larger 'conceptual inventories' in the domains of astronomy (Sadler, 1998), force and motion (Hestenes, Wells, & Swackhamer, 1992), Chemistry (Odom & Barrow, 1995), and Biology (Anderson, Fisher, & Norman, 2002; Garvin-Doxas & Klymkowsky, 2008). Unfortunately, these instruments are more often used to produce scores indicating students' competence in a conceptual domain, rather than being used as resources for instruction to determine what students think and what they have yet to learn.

DDMC's can be easy-to-use formative assessment tools, since they are developed with specific concepts in mind and encourage students to reveal their actual thinking on a topic. The proposed research will take place in two phases: DDMC development and validation, and enactment of the items in introductory MCDB courses. Each phase of the research is described below.

Development and Validation, Summer 2009. The first phase of the project will begin with the development of a pool of approximately 25 items based on our prior research, a review of the literature, and revision of existing conceptual inventory items. Each item will be accompanied by research-based information about student thinking and suggestions for instruction matched with each of the distractors. The second phase of the project will entail validation of the items to ensure that each employs students' everyday language and truly taps the cognitive processes intended during item development (Li, Ruiz-Primo, & Shavelson, 2006). Our approach to validation will be threefold: first, we will ask students to perform think-alouds when responding to the items so that we can ensure that each item gets at the thinking processes it was intended to measure. Second, a panel of biology instructors and students will review each item, critiquing the wording, suggesting improvements, and further refining instructional strategies accompanying each distractor. Based on this two-phase process, items will be extensively revised and, when necessary, replaced.

Piloting, August 2009. Once the item validation process has been completed and intervention strategies outlined, instructors of MCDB introductory-level biology courses at will be invited to use the items and the accompanying strategies in their fall lecture classes. These enactments will be observed and will be accompanied by interviews of the teachers, instructors, and selected students to better understand how this kind of item can serve as a formative assessment tool at the postsecondary level.

Departmental Support

Sarah Roberts will meet weekly with Profs. Furtak and Klymkowsky through the summer to develop and validate the multiple-choice items, will observe courses in which the multiple-choice items are used as formative assessment tools, and will interview instructors and students. At the completion of the project, Sarah Roberts will write a manuscript based on the results of the study for dissemination of the items to the university-level molecular biology teaching audience. Exact matching funds for the RA position will not be provided since this research is currently not funded by any ongoing research project in the School of Education or MCDB.

Incorporation of GRA into PhD Student's Degree Program

Sarah Roberts is in the process of writing a dissertation in curriculum and instruction. A former mathematics and science teacher, Sarah is developing as an educational researcher who works at multiple levels, and exploring student learning, working with teachers in professional development settings. The proposed research will allow Sarah to build upon these experiences and another audience to her repertoire: university instructors of introductory science courses. She will apply for academic positions during the 2009-2010 school year, and participating in an

research project in which she becomes familiar with an additional literature base and is a co-author on new research papers will increase her marketability.

References

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