Introduction

The iSTEM funding that I was provided allowed me to continue work I had started previously as part of the Daphne project, which is funded in part through Knowles Science Teaching Foundation, with fellow project members: Erin Furtak (PI), Deborah Morrison, and Shealyn Malone. The focus of this project was to support high school biology teachers in creating, implementing, and analyzing formative assessments to develop students’ understanding of natural selection. This write-up briefly describes the work that was done in formulating, developing, and analyzing the data we collected.

Process

The majority of our data was collected during the 2008-09 school year from a single science department in a Denver area high school where six biology teachers participated in professional development organized around natural selection and formative assessments that helped to develop their understanding and teaching of this content. The six teachers and the research team participated in monthly meetings in the 2008-2009 and 2009-2010 school years for the purpose of establishing a professional learning community (PLC) organized around the teaching of natural selection. In the first PLC meeting, the group discussed the basics of the project and their current approaches to teaching natural selection. In subsequent meetings the participants identified students’ ideas related to natural selection and began mapping them into a map of student ideas in the domain. Participants explored strategies for addressing different naive conceptions and designed formative assessment activities for eliciting student ideas within the natural selection unit based on the map of student ideas. Teachers and researchers co-created formative assessments and then teachers implemented these in their classrooms, with teachers determining appropriate places in their regular instruction to locate each assessment.

Project Activities

The bulk of the summer of 2009 was spent organizing, making decisions about how to analyze, and analyzing data related to the pre-posttest for this project.

- Analyzing student responses to three open-ended assessments and pre-posttest,
- Revising pre-posttest to align to map of student ideas,
- Conducting and analyzing think-alouds of students taking the pre-posttest,
- Construction of a final revised pre-posttest, and
- Dissemination of the pre-posttest to colleagues in the EBIO department.

We will describe the outcomes of each of these activities below.
Project Outcomes

Analyzing student responses to three open-ended assessments and pre-posttest.

We separated students' common misunderstandings within the formative assessments into two separate constructs: misconceptions related to the origin of new traits and variation within a population, and selective force, or the consequences of those traits within a population in terms of differential survival and reproduction. With respect to origin of traits, we differentiated students' misunderstandings regarding how organisms are able to change themselves in response to a perceived need (anthropomorphic), how the environment causes changes in organisms (environmentally-induced changes), or how organisms differentially mate with organisms that have characteristics that could be advantageous in a future environment (eugenic). A more sophisticated misunderstanding involved students adopting genetic terms to describe more traditional misconceptions, such as an environment causes an organism to mutate in response to environmental changes, as compared to a correct understanding, which involved students identifying random changes in genes and recombination of genes as the source of new variation. With respect to selective force, students often described that species change over time without specifically describing how organisms that are better adapted to the environment are more likely to survive and reproduce, a complete understanding of this construct.

Revising pre-posttest to align to map of student ideas.

To better understand the ways in which the items on the pre-posttest were mapping onto the student ideas we uncovered in the open-ended responses, we created an item map for the multiple-choice items on which we categorized every multiple-choice distractor according to the categories on the map of student ideas. This helped us to see the number of ideas for which we had several items, and those ideas for which we would need to revise or generate more items. Based on this analysis, we rewrote several items, searched the literature to identify additional items, and added several additional items to the pre-posttest.

Conducting and analyzing think-alouds of students taking the pre-posttest.

We next conducted a cognitive analysis in which we asked undergraduate students (both biology majors and nonmajors) to talk aloud while taking the revised test. This helped us to see if the students were interpreting the items in the way we intended, and bringing the knowledge we wanted them to bring to bear on the items. We transcribed the talk-alouds and then aggregated this information by item. Then we compared data across students to determine which items would need revision.

Construction of a final revised pre-posttest.

Based on the results of the think-alouds we again revised the test for clarity. The final version of the revised pre-posttest was used in the 2009-2010 data collection.
for the Daphne project, informed a research paper presented at the American Educational Research Association Annual Meeting, and served as the basis for a CAREER proposal to the REESE program at the National Science Foundation that was recommended for funding in May 2010.

Dissemination of the pre-posttest to colleagues in the EBIO department.

We solicited the participation of colleagues across campus to use the revised multiple-choice items as formative assessment tools in their introductory biology courses. After speaking with multiple faculty members, we were surprised to learn that no professors in the EBIO department felt they could spare the time during class to administer the items, or to use them as clicker questions. We were able to collaborate with one instructor who asked students to respond to the questions online as a course assignment. We tried to download this information to an Excel spreadsheet to inform our research project, but the data was in a third-party system and, although we tried, there was no way to download the data in any form in which it would be interpretable.