

Examination of shifts in content understanding and imagined trajectories for underrepresented high school students serving as mentors for Science Explorers

ISTEM Faculty Grant

Victoria Hand, Ph.D.
School of Education

Summary

The proposed grant will support a research study that investigates a mentoring opportunity for high school students from underrepresented backgrounds who excel in mathematics and science. The **STEMsation** mentoring program represents a collaboration between the School of Education, the CU-Teach program, Science Explorers, and several STEM-focused high schools in Colorado. The program will train underrepresented high school students as mentors for the Science Explorers workshop in their district. We hypothesize that participation in **STEMsation** will provide the mentors with: (1) a deeper and more connected understanding of STEM domains; (2) an ability to distinguish between higher- and lower-level scientific and mathematical reasoning, and (3) an opportunity to reflect on and potentially overcome negative stereotypes and structural barriers faced by underrepresented groups of individuals in STEM fields.

Introduction

In A&S at CU-Boulder, African American students make up less than 2% of the overall total; Latinos only 7.4%; while white students comprise over 77.7%. The percentage breakdown in Engineering is similar. These stark statistics remind us that the gap between those individuals who have access to the most lucrative, rewarding and cutting-edge professions in society, and individuals who do not, is largely intractable. Factors often cited for the persistent lack of participation of underrepresented students in STEM undergraduate education are lack of interest (NRC, 2006), poor preparation (NRC, 2006), or lack of access to quality math and science courses/teachers (Darling-Hammond & Sykes, 2003) in secondary education. Recent research indicates that the broader structural processes that influence these factors may be the most concerning (Eisenhart, 2011) since high school students often lack insight into how these structures mediate their opportunities to pursue university-based STEM education (Martin, 2006). This proposal seeks to investigate how participation of underrepresented high school students in a university-organized STEM mentoring program shapes their preparation for and perceptions of pursuit of a STEM career.

The gap between groups of students in STEM education has been a major focus of educational research for the last twenty years (Lubienski, 2008). Findings from this body of work indicate that underrepresented students face a number of structural challenges to tackle before they can advance into a STEM career (Oakes & Lipton, 2007). For example, they are often tracked into low-level math and science courses as early as

elementary school, which limits their opportunity to take the courses required for college entrance (Oakes & Lipton, 2007). They do not necessarily find math and science classrooms to be inviting places, since they find it difficult to negotiate what it looks like to be a STEM learner from within their existing racial and cultural frameworks (Fordham & Ogbu, 1986; Hand, 2010). Finally, and key to this proposal, they don't recognize how what they think about themselves in relation to STEM is being shaped by these largely *invisible* structures (Bourdieu & Passeron, 1977). In other words, students from underrepresented backgrounds may come to believe that they are not "cut out" to pursue a degree in math or science due to internal factors (such as aptitude or interest), instead of seeing how the system itself is creating roadblocks for their successful navigation of a trajectory of STEM learning (DiME, 2007).

This proposal targets this trajectory by investigating how an opportunity for underrepresented high school students to engage in a STEM mentoring program shapes not only their understanding of STEM content, but also their explanations for what it takes to be successful in STEM courses. The **STEMsation** mentoring program brings underrepresented high school students who excel in math and science in two high schools in Colorado to serve as mentors for Science Explorers. The mentoring program is funded in part by grants through the University of Colorado Diversity and Excellence Grants and WISE (Women Investing in the School of Education). Skyline High School in Longmont, which recently opened a STEM institute for their students, is one of the schools that will send students to the mentoring program.

STEMsation is comprised of two parts. The first part is an all-day training program for high school students on campus to develop mentoring skills around the Science Explorers curriculum. The mentoring program will be adapted from the CU-Teach curriculum and the AVID tutoring model, where mentors are trained to: (1) identify the key mathematical or science concepts that emerge in students' activities, (2) support students in shifting from low- to high-level reasoning around these concepts, and (3) help students in thinking systematically about the results of their experiments. We hypothesize that by drawing out core scientific and mathematical ideas, and linking these ideas to inquiry-based reasoning, students will be more likely to grasp the importance of learning with understanding (Bransford, Brown, & Cocking, 1999). The campus training will also involve lunch with SOE and A&S faculty and students, and a campus tour.

The second part of the program involves students in mentoring for Science Explorers. The SE workshops will take place within the districts from which the high school students come. Mentor students will arrive at the school site, mentor the middle school students through the various activities, and then reflect on their experiences with the program organizers.

Our first hypothesis about student participation in the mentoring program is that they will develop deeper, more connected understandings of STEM content, both within and

across STEM disciplines. Research indicates that students who engage in sense-making about subject-matter, and engage in identifying core ideas that cut across facts and procedures are more likely to develop adaptive and robust expertise of the content area (Bransford et al., 1999). The nature of the Science Explorers curriculum—based around hands-on scientific investigations—provides an opportunity for mentors to engage the middle school students in high level conversations about key concepts and phenomenon under study. Furthermore, its interdisciplinary nature enables mentors to draw links between what students often perceive as disparate bodies of knowledge.

We also hypothesize that through the mentoring experience, students will reflect back onto their experiences as middle school students in math and science classes and *imagine* a possible future for the present middle schoolers. Research indicates that this type of reflection, or what researchers call prolepsis (Cole, 1996), spur individuals to exercise forms of agency in the present that they otherwise may not towards construction of a possible future. Cole (1996) describes an example of prolepsis when parents experience the birth of their first child. The event brings forth memories of their own childhood, together with imaginings about what their new child may someday become, and the parents are motivated to help the child realize this vision.

In the case of this mentoring program, as the mentors work with underrepresented middle school students who show interest in math and science, they too may come to recognize material and ideological structures that hindered the success of underrepresented students in their school, and begin to imagine most robust trajectories for the middle schoolers, and for themselves, into STEM careers.

Thus, our research questions are as follows:

1. What type of mathematical and scientific knowing do the mentors come to prioritize as a result of participation in the mentoring program?
2. How well can they shift from lower to higher-level reasoning around STEM content?
3. What types of explanations do they provide for the challenges that students from underrepresented backgrounds face in pursuing STEM careers?
4. How do they link these explanations to particular strategies they (and others) can take to overcome these challenges?

Study Design and Methodology

The study of the STEMsation mentoring program will be conducted by myself and two graduate researchers. The design of the study is aligned with qualitative research methods (Miles & Huberman, 1994) for several reasons. Firstly, the research aims to capture the quality of mentors' knowing in STEM content and their dispositions towards STEM careers. Secondly, understanding whether and how prolepsis occurred for the students will require in-depth and carefully conducted interviews that build on rapport between the researcher and participant. Thirdly, we plan to utilize and adapt well-

researched interview protocols in the field to gauge students' developing understandings and dispositions towards math, science and educational opportunity. Lastly, the research team will serve as participant-observers, participating both in the training programs, and in the data collection.

Data to be collected in the fall semester of 2011 will include: (1) baseline interviews about students' perspectives and experiences in science and mathematics, (2) observation notes of mentoring trainings and activities, (3) interviews with the teachers of the mentors about mentors' participation in school; (4) exit interviews and think aloud problem solving activities capturing shifts in mentors' knowing and perspectives in STEM domains. If possible, we will follow-up with a third set of interviews in May of 2013 to gather longitudinal data on mentors trajectories in school. This follow-up data collection is strongly supported by coordinators of the STEM Institute at Skyline High School, who are interested in learning about the types of experiences that best inspire their underrepresented students towards STEM careers. Data collected on the Science Explorers workshops will be useful for the program coordinators in assessing the effectiveness of this program.

Data will be coded using the constant comparison method (Miles & Huberman, 1994) in order to develop a set of coding protocols. Upon protocol development, researchers will independently code a subset of the data and any discrepancies that emerge will be reconciled by the team. A subset will again be coded independently by researchers to establish inter-rater reliability. Once coded, we will identify themes in the data around the four research questions. (See Table below for a summary of data collection and analysis.)

Research Questions	Data Source	Data Analysis
What type of mathematical and scientific knowing do the mentors come to prioritize as a result of participation in the mentoring program?	-baseline interviews -teacher interviews -exit interviews	-big ideas vs. facts and procedures -understanding vs. memorizing -connections across ideas
How well can they shift from lower- to higher-level reasoning around STEM content?	-Observation notes of trainings and workshops -think alouds	-grasping main concept -invoking students' sense-making -guiding inquiry
What types of explanations do they provide for the challenges that students from underrepresented backgrounds face in pursuing STEM careers?	-baseline interviews -exit interviews	-success/failure in STEM courses - stereotypes/discrimination -perspectives on college entrance
How do they link these explanations to particular strategies they (and others) can (will) take to overcome these challenges?	-exit interviews -(follow-up interviews)	-STEM-based activities in high school -resources employed -vision of pathway

Benchmarks for Success

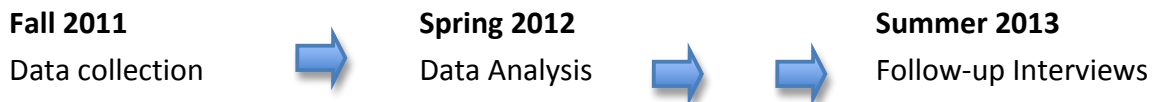
We divide section into two parts: (1) success of the program, and (2) success of the study.

Mentoring Program: We expect the mentoring program to result in the following outcomes: (1) mentors will learn to seek out big ideas in STEM content and to engage in high-level reasoning around STEM activities, (2) mentors will come to see STEM fields as a viable option for further study and for a college major, (3) mentors will increase their awareness of the CU-Boulder STEM undergraduate program, (4) Students will develop narratives and strategies for overcoming structural and ideological obstacles for sustained participation in STEM fields; (5) mentors will develop a plan for pursuing a STEM degree.

Research Study: We expect the study to lead to the following insights: (1) aspects of the program that support mentors in facilitating high level scientific and mathematical reasoning among students, (2) nature of the experience of prolepsis, and how it spurs development of imagined trajectories and of particular forms of agency.

Budget and Timeframe

I am requesting funds to hire one graduate researcher for the spring semester of 2012 (\$6,500) to perform data analysis, and one month summer salary for a graduate researcher to conduct and analyze follow-up interviews in May of 2013 (\$2,000). We will use the remaining funds to provide stipends to the Science Explorers staff for assisting us in training the high school mentors (\$1,500).



STEMsation Research Study Timeline

Contributions to CU STEM education and to educational research

We expect this program and associated research study to contribute both to CU and to neighboring high schools, and to the field of educational research. Firstly, the study represents an important and promising collaboration between the School of Education (and in particular CU-Teach), Science Explorers and STEM-focused high schools with significant populations of underrepresented students. CU-Teach is committed to inviting more students from diverse backgrounds to pursue degrees in STEM and a secondary school teaching license. This program is aimed at strengthening this pipeline. The mentoring program is particularly appealing to high schools with a STEM-focus, such as Skyline, who are attempted to develop groundbreaking programs with limited resources. We expect the collaboration with the high schools to build CU presence. Finally, the phenomenon of prolepsis of great interest to the research community at present, since studies indicate that having an understanding of the structural challenges that shape opportunity is particularly important to the forms of agency that underrepresented individuals exercise towards pursuit of STEM degrees.

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