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Model for Enhancing Mathematics Teacher Preparation

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Abstract

Mathematics teacher preparation programs include an induction process into the educational community composed of coursework as well as on campus and field experiences. This article describes a unique mathematics teacher preparation program at Bowling Green State University called "Science and Math Education in ACTION". We share the aims of each year in ACTION as well as students' reactions to their experiences in and from the program.

Biography

Daniel J. Brahier – Daniel is a Professor of Mathematics Education at Bowling Green State University. He was a lead author of NCTM's *Principles to Actions* document and teaches middle school in addition to his responsibilities at the university. He has served as Director of the ACTION program since 2011.

Jonathan D. Bostic – Jonathan is an Assistant Professor of Mathematics Education at Bowling Green State University. His area of interest is supporting K-16 students' and teachers' mathematical proficiency by focusing on experiences in problem solving and modeling with mathematics. He has been an ACTION mentor since 2012.

A Model for Enhancing Mathematics Teacher Preparation

The preparation of a mathematics teacher is a multi-faceted endeavor. The process needs to include an appropriate mix of mathematics content, learning psychology, pedagogy (including pedagogical content knowledge), and field experiences. While there is no single method to prepare a teacher, these components are typically found in most teacher education programs in Ohio and around the country. In the summer of 2009, Bowling Green State University instituted a new program to enhance middle and high school teacher preparation in mathematics (and in science). Funding of student scholarships was secured through a grant from Choose Ohio First, administered by the Ohio Board of Regents, and the university provided cost sharing to establish the Science and Math Education in ACTION program (often referred to as simply "ACTION"). The goal was to accept approximately 25 students into a cohort each year, building the program to a maximum of about 100 students in four years.

This competitive scholarship program requires an application process that consists of submitting transcripts and ACT/SAT scores and securing a letter of recommendation, as well as answering several essay questions and participating in an online interview to most accurately select participants. At this time, two cohorts have graduated and the program has met its maximum number of accepted students. Thus, we feel it is important to share broadly the design and successes of the program in relation to preparing future Ohio mathematics and science teachers. The program's components may also speak to practicing teachers in terms of potential professional development experiences. The purpose of this manuscript is to outline the ACTION program, graduates' reflections, and share how the program supports undergraduates' preparation for the teaching profession.

An essential component of the ACTION program is teaching undergraduates how to conduct research in their own classrooms. This type of research is characterized as action research; research that studies a problem stemming from everyday lived experiences and seeks to understand and/or improve upon this problem (Johnson, 2012). Benefits of teachers doing action research are numerous, including the generation of knowledge that can be applied to one's own classroom and the promotion of reflection on practice (Hine, 2013). In addition, studies on the effects of having undergraduates conduct pure research in the biological, physical, and mathematical sciences indicates that students learn how to think like a scientist and gain research as well as communication skills (Seymour, Hunter, Laursen, & Deantoni, 2004). In general, a review of the literature indicates that the model of providing a combination of pure research in science and mathematics, internships in business and industry, and conducting action research in a classroom is unique to the ACTION program.

Program Description

The ACTION program engages teacher candidates in the same coursework – both in terms of mathematics courses and education experiences – as non-ACTION students but adds several research and internship dimensions to the process, as shown in Figure 1.

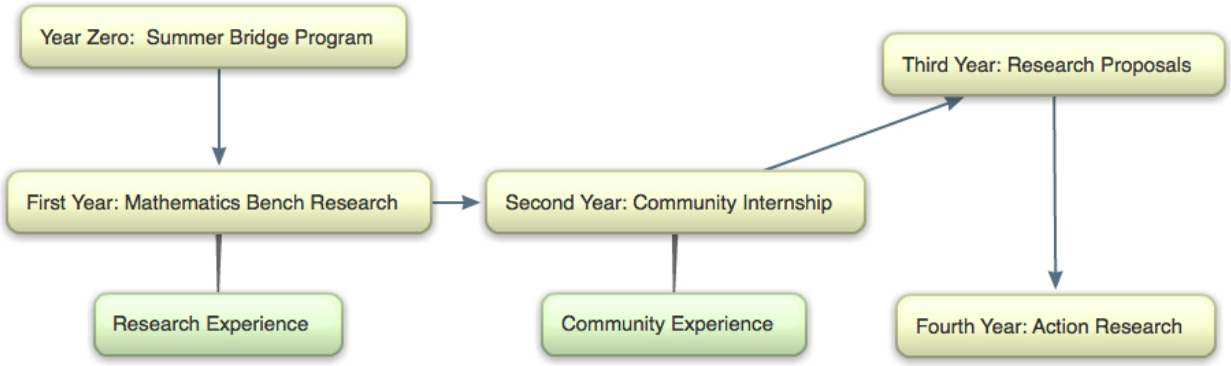

Figure 1. Components of the Science and Math Education in ACTION Program

We outline the components of the ACTION program year-by-year in the following sections.

Year Zero: Summer Bridge Program

Prior to their first year of college, students participate in a residential, four-week, Summer Bridge Program to introduce them to the professors and content areas they will be studying for the next four years. Students engage in workshops, mini-courses, and laboratory experiences with a variety of instructors, most of which are university science, mathematics, science education, and mathematics education professors. Students investigate environmental issues by collecting data on air and water quality; they examine several methods of fingerprinting in a forensics lab; they explore bioinformatics problems involving connections between mathematics and the biological sciences. Additionally, team-building activities and social events on and off campus encourage students to bond with one another to form a supportive cohort of future educators. Finally, students read several carefully selected chapters of books such as Malcolm Gladwell's *Outliers* and Carol Dweck's *Mindsets* and write summaries and reflections on the content. The intent is to fully prepare the students for the college experience over the course of a four-week period in July by helping them transition from high school to university coursework.

Year One: Small Group Bench Research Projects

In the first year of college, undergraduates work in small groups (ordinarily 4-6 students per team) with a faculty member from one of the sciences or mathematics, conducting original research on a topic of the professor's choice. Undergraduates are generally surprised by this experience when conducting research alongside a university faculty member (i.e., bench research). They have reported being used to high school lab experiences in which the results of the experiments are already known and/or the investigation lacks an authentic feel of seeking to understand the world. Similarly, they are familiar with solving mathematics problems that have solutions presented in the back of the book. In research conducted at college and university campuses, there are no cookbook-style lab experiences or known solutions to the research questions and complex problems. Thus, students experience bench research in the ACTION program as they hypothesize, collect and analyze data, and draw conclusions from the results. For example, students have worked in teams to explore the meaning of "randomness" and to investigate linear algebra by examining the popular game *Angry Birds* and the mathematics that underlies the trajectories of objects released from a slingshot. By the end of the academic year, students create and present posters and/or PowerPoint slides at an on-campus Research Symposium. Faculty, university administrators, and parents attend sessions to hear about groups' projects and results. Over the past several years, many research groups have also presented their results at the annual conference of the Ohio Council of Teachers of Mathematics (OCTM). This initial research project creates a baseline set of experiences for students' second year as novice mathematics and science researchers.

Year Two: Community-Based Internships

Undergraduates are placed in a community setting in their second year for an internship. Placements include local businesses and agencies where science and mathematics are used on the job every day. We have found that local businesses and agencies are excited to host university students. Furthermore, they are also anxious to collaborate with K-12 mathematics and science teachers in ways that can help make mathematics and science seem connected to their students' everyday lives, which might include guest speakers, after school club sponsorships, and field trips.

The internships are designed to help students answer the question, "Why would anyone ever need to know this?" For example, one student was placed in a factory that produces Slim Jim beef snacks. She worked with a statistician whose job was to test the length and weight of products coming off the line – to ensure that the readings were within the allowable tolerances deemed to balance customer satisfaction and profit. Another team of students worked with a local city planning office to determine the feasibility of placing kiosks in parking lots for payment of parking fees thus replacing the current parking meters. These students collected data on the cost and usage of meters versus kiosks and designed a city map with recommendations for where to strategically place the kiosks for convenience of drivers. At the end of the internship, students write a final report for the business leader, submit a reflection paper that includes lesson plan ideas from the learning experience, and engage peers in a hands-on presentation to share their experiences. For the past two years, students from these ACTION internships have also shared their stories at the annual OCTM conference, distributing handouts for teachers that include classroom-ready

activities developed from their fieldwork. After engaging in pure mathematics (or science) research for a year and then interning in the community for another year, students are developmentally ready to think about what it means for a teacher to be a researcher in his/her own classroom.

Year Three: Writing a Research Proposal

ACTION students are taught how to conduct action research in the third year. The action research is intended to be conducted the following year during their student teaching experience as a way to explore a topic of interest, collect data on it, and draw a logical conclusion aiming to improve their instruction. This third year experience includes a yearlong course that meets monthly in which they research a topic and write a proposal for a classroom study, much like a professional learning community or lesson study in K-12 school environments. The course instruction focuses on the meaning of action research and how a teacher might act as a researcher in his/her own classroom. Students analyze research studies published in a variety of settings and learn to critique the content in terms of research design and validity of the conclusions drawn by the authors. They select a topic of interest and work individually with a faculty mentor to determine a problem. Next, they explore this area through a review of practitioner and research-based literature and write a research proposal describing work they intend to conduct during their student teaching experience. This proposal includes an introduction, literature review, and method section. Students have selected a variety of topics over the years including the use of games in the mathematics classroom and the effects of manipulative use on high school students' mathematical thinking. Faculty mentors assess their students' proposals and give feedback to them so they prepare for implementation the following year.

Year Four: Conducting Action Research

In their final year, ACTION students have monthly class sessions in the fall semester to closely examine appropriate qualitative and quantitative research methods for their action research. During this time, students also work individually with faculty advisors to learn about qualitative analysis approaches such as thematic analysis (Hatch, 2002) and survey analysis, as well as quantitative approaches including t-tests and chi-square analyses. The work in this course is similar to what most teachers experience in a graduate research methods class, as teacher candidates are challenged beyond the ordinary boundaries of an undergraduate education. Students finalize their proposals and then, during student teaching, conduct their action research studies, analyze their data, and write up the results in a final capstone paper.

Faculty advisors assess final capstone research papers. The intent of this paper is to use the contents to generate publications and presentations as well as to lay the groundwork for future study when new teacher begins his/her career. At a culminating senior year event, each ACTION student develops a PowerPoint and presents his/her research to an audience of peers, faculty members, and parents. This four-year experience leads to high quality action research, evaluated by practitioners and researchers at the university. Furthermore, ACTION graduates are able to transfer these ideas in ways that help them secure mathematics and science teaching jobs in Ohio. Some ACTION alumni have shared the results of their work at the OCTM annual meeting following graduation. The third- and fourth-year process mirrors an important facet of teachers' professional work: explore an issue in the classroom and seek to understand it and/or to solve the problem.

Pre-Service Teacher Reactions

Immediately following their final ACTION research presentation as seniors, ACTION students are involved in individual exit interviews. One of the interview questions asks them to reflect on what they considered to be the most significant experiences of the four-year program. A theme emerges from their comments indicating that ACTION graduates recognize the power of action research and how they can implement it as first-year teachers. The following student comments represent common shared experiences.

"I think the [action] research project really helped me a lot because I can actually show my future employers that I've done research, [that] I can do this, and if something is going wrong in my classroom, I can relate back to the action research and say, 'What should I do? How am I going to solve this problem?' Then hopefully I can come up with a solution." (Bethany, Middle Childhood Math and Science Education Major)

"When I'm going to be a teacher, I know that [opportunities for research are] what I can look for. Where are the problems with my students? What can I see will [that] help with that? Is it doing board work? Is it doing exit tickets more often? Is it different ways that I am teaching the material? So basically, in teaching I can have a bunch of little mini experiments … not experiments, but little mini research projects. I mean, I do that every day now, but seeing what worked and what didn't work with this lesson, and how can I change it for the next year? I think that research project helped me see that I need to reflect each day to see, 'How can I help my students even more?' There are some teachers that [say], 'This is what I've done every year, and I do the same thing all the time,' whereas me, I [think], 'That lesson did not go well. I liked the material, but how could I have explained it so that the students understood it better? What can I add to it to kind of connect it more?' So I think the research helped with that, but also with the [Ohio Department of Education] – the data driven things that are coming down now because I know now, "Okay, this is how I analyze a pre-test and a post-test to see if students have learned. This is how I can see if achievement is being met. This is how I can reflect on that and see what I can do different." (Tim, AYA Science Education Major)

"I think that the action research is probably what is going to help me most because I had no idea what action research was … it can be helpful on a daily basis … I can do action research everyday, every week…in my classroom. It kind of helped me learn to reflect more on my own teaching and especially with the topic that I chose. I feel like that helped me out as well and I'm definitely going to continue the research project part of it in my first classroom." (Sarah, AYA Mathematics Major)

Components of the ACTION program have clearly been a highlight of students' college experiences. They learned to recognize the value of real-world applications of mathematics, as well as the role of research in the life of a teacher.

Conclusion

As the process of preparing mathematics teachers for the future continues to be researched and improved, it is essential that educators consider the value of each of the components of the ACTION program to enhance the undergraduate experience. We learn from this description of ACTION that undergraduate students learn to be teacher researchers and they aim to employ this skill as novice Ohio mathematics and science teachers. Moreover, the engagement of community members in bringing mathematical topics to life in the classroom, as well as the use of action research to improve classroom-teaching practices, suggest professional development opportunities for in-service teachers as well. If a goal of educators is to improve K-12 students' performance in schools then teachers must address the question "When will we ever have to use this in the real world?" and to systematically determine ways to improve their practice, both of which are key elements found in the ACTION program.

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