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This essay shows how the current SoTL project was used as a vehicle for undergraduate research to directly improve student learning and how it might be used to introduce a new paradigm in the training of secondary mathematics teachers. Using the language of David Lopatto's research into undergraduate research, I share how I have integrated an undergraduate student as a co-investigator of our SoTL project. The article shares the criterion I used for choosing the student, a brief overview of the SoTL project, the educational benefits for the student and possible future directions for incorporating undergraduate students.

Keywords

Learning outcomes, Undergraduate research, Statistics education

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A Model for Undergraduate Research in Statistics Education

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Abstract

This essay shows how the current SoTL project was used as a vehicle for undergraduate research to directly improve student learning and how it might be used to introduce a new paradigm in the training of secondary mathematics teachers. Using the language of David Lopatto's research into undergraduate research, I share how I have integrated an undergraduate student as a co-investigator of our SoTL project. The article shares the criterion I used for choosing the student, a brief overview of the SoTL project, the educational benefits for the student and possible future directions for incorporating undergraduate students.

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Introduction

Many undergraduate programs in mathematics offer a mathematics degree with secondary teaching licensure. Although students seeking these degrees plan to teach mathematics in the high school, capstone undergraduate research experiences for the major are focused on the core discipline of mathematics rather than education. This essay offers an in-depth look at creating and implementing a successful undergraduate research experience involving SoTL research. After describing the student and the project, the article focuses on the student's self-reported benefits and changes in her overall attitude towards educational research in mathematics and statistics. Finally, future directions and opportunities for expanding the scope of this experience are offered.

Choosing a Student

Having taught in the mathematics department for twelve years, I have seen a few students who shine brightly both as students and future educators. These exceptional students show more focus on the profession of teaching and already carry thoughtful reflection into early educational field experiences. Their insight and drive to understand student learning make them prime candidates to seek graduate studies in mathematics education. As mentioned earlier, most capstone experiences for a degree in mathematics with secondary licensure focus on doing mathematics. If an undergraduate experience will fit in their curriculum, I prefer to give exceptional students a taste of education research. Unfortunately, since the students are required to complete a research project in mathematics during their senior year, I have had to work with students on undergraduate research in education during their sophomore year. The difference in maturity from the sophomore to the senior year makes early research less than ideal.

In the spring of 2008, I identified an exceptional licensure student whom I'll call "Miranda". At the time, Miranda was a first-year student, but she'd already shown an interest in the statistics education project I was proposing.

The Project

This essay is focused on inclusion of an undergraduate as a co-investigator in a research project. As such, I feel strongly that a wide variety of projects can easily be modified into a strong undergraduate research experience.

The project I had proposed was simply to put individual first-year students from the general population through a short series of statistics problems to gauge their concepts of variation. I would create "telling tasks" or deep problems that get at the heart of variation and allow us to view student's reasoning. I would then videotape these sessions, code and analyze the responses, and look for overall patterns which reveal the core notions of spread and standard deviation. A basic, but solid little research project.

To modify this project, I consulted articles by David Lopatto of Grinnell College. In his 2003 piece, *The Essential Features of Undergraduate Research*, Lopatto surveyed faculty to find out the essential ingredients necessary for a solid undergraduate research project. Among the list of essentials, we see that students should read from the literature base, be involved in the creation of some aspect of the project, and have the opportunity for written and oral communication of findings.

I had already gotten a literature review for the project, so having Miranda read and discuss those pieces with me served us both quite well early in the project. While she wasn't able to have the broad reaching grounding in the literature provided by a graduate experience, combing through the background literature for this project gave her a solid footing to discuss her work with her other professors.

"Telling tasks" had to be created for the project and I could find no better way for Miranda to gain ownership of her undergraduate research experience than to be an integral part in the creation of these deep problems. I provided Miranda with a healthy supply of test questions from seasoned professors who tested concepts over rote calculation. Based loosely on these questions, she proposed the set of problems which would eventually become our telling tasks. It was quite easy to discuss the pros and cons of each task and revise them to make solid challenges and still maintain Miranda's ownership of the work.

Miranda and I were accepted to the United States Conference on Teaching Statistics USCOTS 2009 in June to discuss both the preliminary findings as well as the unique opportunity this has provided for an undergraduate to be included in solid research. We have also been accepted for a talk for the National Council of Teachers of Mathematics (NCTM) in 2010 to share better developed results of this work.

Educational Benefits for the Student

The second piece by Lopatto, *Survey of Undergraduate Research Experiences (SURE): First Findings* (2004), shares a list of 20 possible benefits to be gained from an undergraduate research experience. If we use quotes from conversations with Miranda and written pieces, she can finally add her voice to the discussion and we can see the true impact of the experience on her education and future plans.

Lopatto's 20 benefits includes skills in writing and oral presentation which Miranda has readily acquired. Her self-confidence has also grown enormously as we have successfully carried out the research and been accepted for talks at the national level. I would like to focus, however, on a few benefits that will allow Miranda to talk about her own experience:

- Understanding of the research process and how [educators] work on real problems
- Clarification of a career path
- Becoming part of the learning community

Miranda is part of a teaching fellows program which requires she teach in the public schools for four years as repayment for a scholarship. As a result of the project, she has begun to think about how research on student learning will affect her classroom practices as she fulfills her teaching commitment. "If I think there is a problem with my class or a practice at my school, I think I could actually create my own project to get some answers and help me solve the problem. I could at least have some ammunition to talk with a tech[nology] coordinator or the principal." This shows me that Miranda has the self-confidence to try her hand at research from scratch and knows how the results might impact her own classroom.

Miranda had always envisioned herself as a career high school math teacher. "I love math, but this math education stuff is really exciting. I can see how you became addicted to it." Once she has finished the four years of school teaching required by her scholarship, Miranda is now considering graduate school which had never been part of her life goals. Since most graduate programs for mathematics educators require teaching experience, four years in the public schools of North Carolina will put her in a solid position to seek a graduate degree.

Not only does Miranda better understand the work required for research in mathematics education, she is getting practical experience which may also lead to co-authoring an article or two on the results of the statistics education project. She surprises me by being a little star-struck by the promise of getting to meet some of the author's of the articles in our literature review. "I can't believe that I'll get to actually see her talk about her work in person." and "You mean they might just sit down at the dinner table with us. Would I be able to ask them questions about their work or would that be bad?" I can remember similar comments I made as I was becoming part of the learning community.

Miranda has made significant gains in most of Lopatto's 20 benefits, which is more than enough for me to consider this project a success. All of these benefits show up as you talk with a mature young teacher who is excited by the promise of using solid practices to help her understand her classroom, her profession, and her contributions to the field.

Future Directions

The demand for this opportunity has increased as we are getting better students who are shining earlier and earlier. Our department is also considering changing our degree requirements to allow students seeking licensure to complete a capstone education research experience. I hope this is in response to the successes I've had with one-on-one undergraduate research experiences like Miranda's. If demand continues to increase or the new curriculum changes allow for more education researchers, I must make plans to increase the capacity of this type of experience. With numbers up to approximately 4 students, I could see continuing with the current model. I think new research could support this many while still giving them ownership of the material. But, as numbers increase past

5, one option is to consider replication rather than new research projects for groups of students.

I have not seen strong instances of replication in education research and I feel that this might be a viable solution to a problem of increasing numbers. The faculty advisor could identify a project with a strong literature review, well-defined data collection processes, and well-written conclusions. A group of student researchers can gain many of Lopatto's benefits by working through the project with new participants. The ownership of these new results should be enough to satisfy the young researchers. The strong structure aids the professor's workload and makes this an appealing idea capable of handling large numbers of student undergraduate researchers.

Conclusions

Student's undergraduate research experiences are widely seen as a "good thing". Understanding Miranda, the project, and the benefits she received solidify that this is a host of "good things" for undergraduate mathematics majors seeking teaching licensure. I am most proud of having students like Miranda better understand the research process, get clarification of their possible career paths, and become part of the learning community. Perhaps this success can spur others to modify projects to include undergraduates as co-investigators. If the project must support multiple undergraduates, please consider taking a solid completed research project and allowing the small groups to replicate the findings. Finally, if you are considering embarking on such a journey for the first time, know that it is quite satisfying and well worth the time and energy to walk a while with these new members of the community.

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