Developing Highly Qualified Middle Grades Teachers With Expertise in STEM Disciplines via SUSTAINS

Dr. Melissa M. Bilec, University of Pittsburgh

Dr. Bilec is an assistant professor in the Swanson School of Engineering's Department of Civil and Environmental Engineering. Dr. Bilec's research program focuses on sustainable healthcare, the built environment, and life cycle assessment. She is interested in improving the overall environmental performance of buildings while connecting the occupants in a more thoughtful manner. She is the Principal Investigator in a multi-disciplinary and multi-institutional research project, NSF EFRI-Barriers, Understanding, Integration – Life cycle Development (BUILD). She has worked in the sustainable engineering arena since 2004. As the assistant director of education outreach in the Mascaro Center for Sustainable Innovation, Pitt's center for green design, she translates research to community outreach programs and develops sustainable engineering programs for K-12 education.

Prof. Daniel Mosse, University of Pittsburgh
Dr. Margaret S. Smith, University of Pittsburgh

Margaret Smith holds a joint appointment at the University of Pittsburgh as Professor of Mathematics Education in the School of Education and Senior Scientist at the Learning Research and Development Center. Her research focuses on what teachers learn from the professional education experiences in which they engage. Smith's current research is examining the extent to which beginning teachers learn to plan lessons that build on student's mathematical thinking and the experiences in which they engage that support that learning.

Prof. Jennifer L Cartier, University of Pittsburgh

Dr. Cartier joined the Department of Instruction and Learning in the School of Education at the University of Pittsburgh as a Science Education faculty member in 2001. She has been the Principal Investigator on two longitudinal NSF-funded research projects that investigate how elementary teachers develop the capacity to design and support student engagement in cognitively challenging science learning contexts. Dr. Cartier is currently studying how secondary science teachers develop pedagogical design capacity through participation in carefully scaffolded role-play scenarios and other approximations of pedagogical practice. Since January of 2012, Dr. Cartier has served as the Director of Teacher Education at the University of Pittsburgh, spearheading the design of innovative components of the secondary teacher preparation curriculum such as explicit training in relationship-building skills, adolescent social-emotional learning needs, and mindfulness practices that build teachers' capacity to engage in responsive teaching. With support from NSF's Noyce program, Dr. Cartier is currently collaborating with faculty across the University of Pittsburgh to design a middle grades teacher preparation program that focuses on sustainability.

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Abstract

Beginning in 2012, teacher educators throughout Pennsylvania launched programs to prepare teachers who specialize in middle grades (4-8). This new state-approved certification track will replace the current elementary track (K-6) and overlap with the existing secondary track (7-12). Camblin reminds us that "the middle grades, those enrolling 10- to 14-year-old students, have an important relationship to college access.[1] The middle grades are when students, families, and school personnel begin to address career aspirations, academic preparation, and college information." The Commonwealth's new emphasis on highly qualified middle grades teachers provides a unique opportunity to impact children at a crucial time in their formal education experience.[2]

In our project, we are aiming to (1) develop a program (SUSTAINS, STEM Undergraduate Students Teaching Adolescents Innovation and Sustainability) that will allow undergraduate STEM majors at the University of Pittsburgh (Pitt) to interact with young adolescents in formal and informal learning contexts and to engage with peers and faculty members around issues pertaining to K-12 education; (2) develop a state-approved, one-year Masters of Arts in Teaching (MAT) program to prepare middle grades (4-8) teachers who will specialize in mathematics and/or science; (3) integrate issues related to sustainability across the undergraduate and teacher preparation programs; and (4) expand our capacity for faculty in the Schools of Education, Arts & Sciences, and Engineering to collaborate on program and course design. We expect SUSTAINS will help address the need for middle grades math and science teachers by developing a program to attract college STEM majors into the teaching profession and by developing a rigorous middle grades teacher preparation program that reflects core commitments of effective middle grades educators. We will present some of our progress thus far related to SUSTAINS development.

Introduction

Beginning in 2012, teacher educators throughout Pennsylvania launched programs to prepare teachers who specialize in middle grades (4-8). The Commonwealth of Pennsylvania's new emphasis on highly qualified middle grades teachers provides a unique opportunity to impact children at a crucial time in their formal education experience, when they are developing a sense of their efficacy as learners, exploring career aspirations, and developing as adolescents along social, cognitive, physical, and emotional dimensions. This new state-approved certification track will replace the current elementary track (K-6) and overlap with the existing secondary track (7-12).

In our project, we are aiming to (1) *develop a program* (SUSTAINS, STEM Undergraduate Students Teaching Adolescents Innovation and Sustainability) that will allow undergraduate STEM majors at the University of Pittsburgh (Pitt) to interact with young adolescents in formal

and informal learning contexts and to engage with peers and faculty members around issues pertaining to K-12 education; (2) *develop a state-approved, one-year Masters of Arts in Teaching (MAT) program* to prepare middle grades (4-8) teachers who will specialize in mathematics and/or science; (3*) integrate issues* related to sustainability across the undergraduate and teacher preparation programs; and (4) *expand our capacity for faculty* in the Schools of Education, Arts & Sciences, and Engineering to collaborate on program and course design. We expect SUSTAINS will help address the need for middle grades math and science teachers by developing a program to attract college STEM majors into the teaching profession and by developing a rigorous middle grades teacher preparation program that reflects core commitments of effective middle grades educators.

In high-poverty schools, the problem of finding effective and qualified math and science teachers is particularly acute. One study found that 50% of students in high-poverty schools had math and science teachers who were not certified to teach those subjects.[3] In the seminal 2010 report, *Gaining Ground in the Middle Grades: Why Some Schools Do Better*, researchers noted that, "the middle grades are where many students begin to lose ground in key subject areas such as mathematics . . . Indeed, success in key subjects in the middle grades is a strong predictor of success in high school and beyond."[4] In 2007, the results from the third Trends in International Mathematics and Science Study (TIMSS) showed that US students perform better in both mathematics and science at the fourth grade level than they do at the eighth grade level.[5] Our developing MAT program is focusing on preparing middle grades teachers with special expertise in mathematics and science, as these are areas in which students in this age group are often underserved.

Our aim is to help address the need for middle grades math and science teachers by developing a program to attract college STEM majors into the teaching profession. Core to this program are two elements –sustainability and building on existing, robust partnerships. Figure 1 illustrates our overall strategy and potential impacts from the SUSTAINS program.

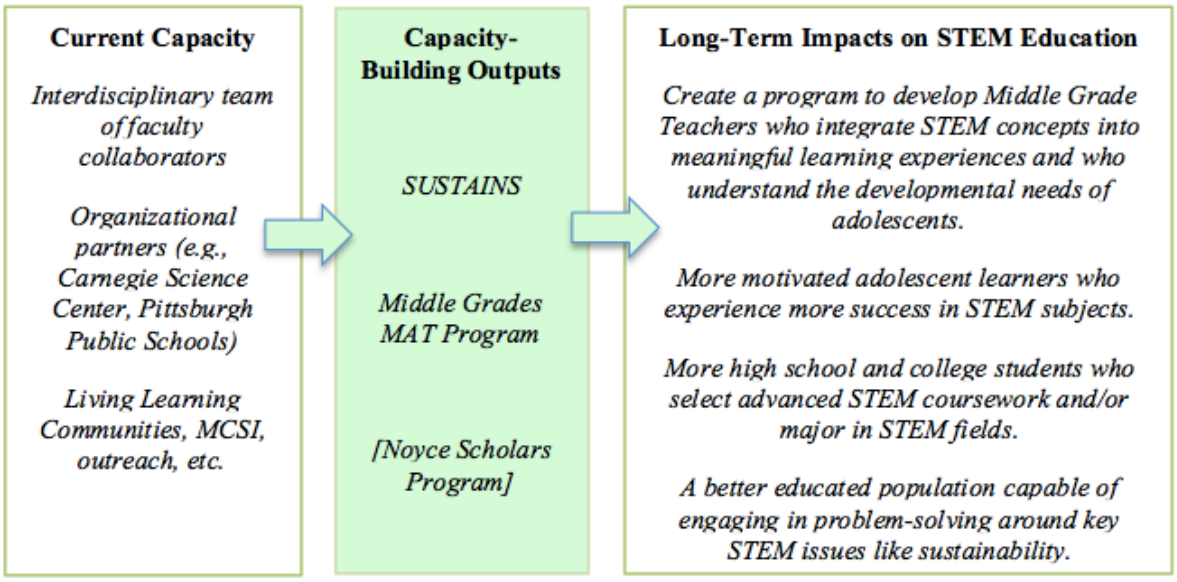

Figure 1: Theory of Action for SUSTAINS program

We have chosen to begin with a focus on sustainability because (1) many existing outreach opportunities within our partner institutions reflect a deep commitment to this issue; (2) it is an issue that engages middle grades students along many dimensions (emotional, social, physical, and cognitive); (3) we believe that a significant number of STEM undergraduates resonate with the need to help educate the general public (children and adults) about issues related to sustainability; and (4) it is a context within which project-based pedagogical practices can be employed (e.g., gardening projects provide a context where students can learn about biological principles, develop knowledge of statistics and probability, draw from and deepen their understanding of economics and local commerce, and engage in purposeful writing tasks). Thus, sustainability provides an umbrella context that can help to connect a STEM university student's experiences within SUSTAINS with his/her work during the post-baccalaureate Middle Grades MAT program.

Examples of SUSTAINS Program Outcomes

During the summer 2013, the Mascaro Center for Sustainable Innovation (MCSI) and the SUSTAINS project team, hosted a summer undergraduate to support and foster the activities and spirit of SUSTAINS. The undergraduate student worked to *consider and evaluate alternative pedagogical approaches and delivery methods* in engineering education and *develop two portable sustainability modules* to be delivered at middle schools.

With respect to pedagogical approaches and delivery methods in engineering education and in support of the aforementioned project objectives of 1, 3, and 4, the SUSTAINS' team supposition is that exposing engineering students to creative and inspiring learning environments, as opposed to traditional, lecture-style classrooms, may facilitate the interest in STEM education at multiple levels, from formal K-12 settings to informal adult learning. For example, in the course CEE1218, Design of the Environment, we implemented a 'flipped' class and created active, service-based learning projects in the arena of sustainable energy and the built environment in the course, CEE1218, Design of the Environment.

In summer 2013, we investigated the impact of these methods. The following data was collected: pre- and post- confidence/knowledge tests, final course reflection survey, and the College and University Classroom Environment Inventory (CUCEI). Conclusions on the students' perception of the flipped classroom teaching method and the course were developed from analyzing the aforementioned data. The students scored the class environment above average and on the CUCEI. One main finding from the final course reflection survey was that students frequently expressed that they learned various personal skills such as leadership, listening, and communication. Based on this data, we believe that the findings suggest that students were open to classes being taught in this way, and that there are benefits associated with the flipped classroom that are not available through traditional lecturing methods. Our next step is to evaluate the supposition that this method may foster consideration interest in STEM education at multiple levels and better evaluate any short-comings of flipped classroom.

In support of developing sustainability modules, two portable modules were developed in the areas of sustainable agriculture and green buildings/indoor environmental quality (IEQ). These two areas were selected to be coordinated with our partner schools (i.e., Falk School and SciTech) and anticipated hands-on activities. For the sustainable agriculture module, our plan was to pair this module with a local school garden project. The module focuses on food-miles with engineering, math, and sustainability interwoven into the activity. The primary aim of this module is for the students to consider, "where does our food come from?" Specifically, the students begin to evaluate issues such as food-miles, organic food, and meat versus non-meat options.

In contrast with the outdoor connection in the sustainable agriculture module, the second module on green buildings and indoor air quality was developed with the aim of connecting students with the indoor environment. The structure of the module is first a brief lecture on green buildings and IEQ, then an introduction on 'live' commercial IEQ measurement equipment (i.e., sensordrone, envirometer, P-sense). The students are divided into groups to carry out the following tasks: (1) develop a data collection plan based on the IEQ equipment, (2) collect data about the space using the IEQ equipment and data collection, and (3) report back, graph their results, analyze outcomes, and present findings to the group. The entire module was approximately two hours in length.

This module was piloted to a group of 23 high school students participating in the Crossroad Guidance, Success, and Preparation program (http://crossroadsfoundation.org/), which aims to guide and prepare scholars to achieve success. At Pitt, the Crossroads program integration is overseen by one co-author (D. Mosse) via his role in the SUSTAINS project and as the Department Chair of the Department of Computer Science. Two undergraduate students, two graduate students, and one faculty member (M. Bilec) delivered the IEQ module, see **Figure 2**. The module was successful and our aim is to repeat this module at our partner schools, along with developing an assessment tool to better understand the learning outcomes. This work was presented to an audience of ~40 people, primarily undergraduate STEM majors, on July 23, 2013 at the Mascaro Center for Sustainable Innovation's 10th annual Undergraduate Summer Research Symposium.

Figure 2: Engineering students teaching indoor environmental quality module to 23 high school students to support SUSTAINS program

Broader Considerations

The aforementioned activities represent a deeper-dive into some of our work. Some other activities include developing one new course, Designing a Research-Based Certification Program for Middle-School Grade Teachers, that was taught in Spring 2013. Four doctoral and four MEd students in mathematics or science education participated in the course, engaging in benchmarking and research-based program design. Local stakeholders (principals and teachers from local schools) attended one class meeting to provide feedback on initial design ideas.

Our partnerships with local schools have the potential to impact not only the dozens of undergraduate STEM students, but also hundreds of young adolescents in high-needs communities where the SUSTAINS and MAT participants will volunteer and teach. There is a general shortage of middle grades teachers with expertise in STEM areas, and students in high-needs schools are far more likely than their middle-class counterparts to have nonqualified STEM teachers.

One crucial role of an educator is to develop and support opportunities for students to learn about different quantitative methods for solving problems that have personal meaning. Environmental concerns such as global warming and energy security are increasingly represented in everyday media, and consequently, in the consciousness of adolescents. Additionally, youth are seeking careers that will enable them to impact issues that are meaningful to them. Thus, the next generation of educators will need to be prepared to engage young learners in studying, understanding, and contributing to the solutions for complex environmental challenges, in part by drawing connections between their personal decisions and sustainability.

SUSTAINS and our MAT program will prepare new teachers who can support adolescents as they make those crucial connections.

Acknowledgements

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