Statewide Coalition: Supporting Underrepresented Populations in Precalculus through Organizational Redesign Toward Engineering Diversity (SC:SUPPORTED) Results from Year One

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Dr. Gallagher is an Assistant Professor of Engineering and Science Education at Clemson University, with joint appointments to Mathematical Sciences and Education & Human Development. Her research interests include student cognition in mathematics, development of teacher identity among graduate teaching assistants, curricular reform to foster diversity and inclusion in STEM fields, and development of mathematical knowledge for teaching.

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My name is Marketa Marcanikova in the bioengineering program at Clemson university where my research focuses on the measurement of kinematics of cervical vertebrae using motion analysis. I performed my undergraduate degree in chemistry at South Carolina State University which I believe made me to be a suitable candidate for working on the SC SUPPORTED and allowed me to understand the importance and the necessity of the equal opportunity for all students which will prepared them for the future professional career . I am currently working under the guidance of Dr. E. Gallagher in the research section of SC SUPPORTED team.

Sez Atamturktur Ph.D., Clemson University

Dr. Sez Atamturktur Russcher serves as the Assistant Vice President for Research Development and Provost's Distinguished Professor at Clemson University. Dr. Atamturktur Russcher is a professor of environmental engineering and earth sciences, professor of mechanical engineering, professor of industrial engineering, and professor of civil engineering. Her research, focused on uncertainty quantification in scientific computing, has been documented in over 100 peer-reviewed publications in some of the finest engineering science journals. Dr. Atamturktur Russcher's research has received funding from several federal agencies including the National Science Foundation, the U.S. Department of Energy, the Department of the Interior, Department of Transportation, the Department of Education, and the Los Alamos National Laboratory, as well as industry organizations and partners, such as the National Masonry Concrete Association and Nucor. She serves as the director of the National Science Foundation-funded Tigers ADVANCE project, which focuses on improving the status of women and minority faculty at Clemson. In addition, Dr. Atamturktur is the director of the National Science Foundation-funded National Research Traineeship project at Clemson, with funding for over 30 doctoral students and a goal of initiating a new degree program on scientific computing and data analytics. Dr. Atamturktur is also the director of a Department of Education-funded Graduate Assistantship in Areas of National Need project that provides funding for 10 doctoral students. Dr. Atamturktur is one of the four co-directors of Clemson's Center of Excellence in Next Generation Computing and Creativity. Prior to joining Clemson University, Dr. Atamturktur served as an LTV technical staff member at Los Alamos National Laboratory.

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Mr. Richard H. Roberts Jr, Florence Darlington Technical College

Mr. Roberts has extensive experience in all sectors of industry and education. He currently is the Managing Director for the South Carolina Advanced Technological Education Center at Florence Darlington Technical College, Florence S.C. As Managing Director, he manages day to day operations, grants writing and a large industry consortium, including an internship program for students in advanced technology programs. Prior to his current position at FDTC he served as Director of Job Placement and Career Services at the Community College of Allegheny County, Pittsburgh, Pa where he worked with industry and helped place students in internships, apprenticeships, and jobs across a multi-campus system serving 20,000 credit students. He also served Vice President of Family/Children's Services and Program Development for Lifesteps, Inc a large non-profit in the Western Pennsylvania area. He has served in various executive level management/supervisory positions within non-profit organizations, private industry and education including Penn State University and as a User Analyst/Subject Matter Expert for Lockheed Martin IMS. He has held the held appointed and elected positions of Legislative Affairs Chair for the Pennsylvania Association of Educational Program Personnel, Chairman, Zoning Hearing Board in his municipality from 2003-2007, Elected to the position of School Director in the South Butler County School District (Knoch H.S.) and held that position continually before completed his school board tenure in December 2015. Appointed and served on the Executive Board of the Pa. Midwestern Intermediate Unit #4 and recently held a seat on the West Jefferson Hills, Pa Chamber of Commerce executive board.

Mr. Roberts holds a Bachelor's degree in Police Administration from Eastern Kentucky University, and a Master's degree in the Administration of Justice from Shippensburg University. He has completed 18 post graduate credits toward his doctorate degree while attending Point Park University, Pittsburgh, Pa.

Ikhalfani Solan, South Carolina State University

Ikhalfani Solan is a Professor of Mathematics at South Carolina State University. He received his B.Sc in Mathematics and Physics from the University of the West Indies, Jamaica and his Ph.D. in Mathematics from the University of South Carolina. At South Carolina State University he teaches several mathematics courses to engineering students. He is also very interested in the effects of small learning communities on learner motivation, commitment and strategies. Email: Isolan@scsu.edu

Dr. Ronald W. Welch, The Citadel

Ron Welch (P.E.) received his B.S. degree in Engineering Mechanics from the United States Military Academy in 1982. He received his M.S. and Ph.D. degrees in Civil Engineering from the University of Illinois, Champaign-Urbana in 1990 and 1999, respectively. He became the Dean of Engineering at The Citadel on 1 July 2011. Prior to his current position, he was the Department Head of Civil Engineering at The University of Texas at Tyler from Jan 2007 to June 2011 as well as served in the Corps of Engineers for over 24 years including eleven years on the faculty at the United States Military Academy.

Dr. Anand K. Gramopadhye, Clemson University

Dr. Anand K. Gramopadhye's research focuses on solving human-machine systems design problems and modeling human performance in technologically complex systems such as health care, aviation and manufacturing. He has more than 200 publications in these areas, and his research has been funded by NIH, NASA, NSF, FAA, DOE, and private companies. Currently, he and his students at the Advanced Technology Systems Laboratory are pursuing cutting-edge research on the role of visualization and virtual reality in aviation maintenance, hybrid inspection and job-aiding, technology to support STEM education and, more practically, to address information technology and process design issues related to delivering quality health care. As the Dean of Engineering, Computing and Applied Sciences at Clemson University, he has been involved in the initiation of programmatic initiatives that have resulted in significant growth in engineering and computing situating it in the forefront both nationally and internationally. For his success, he has been recognized by the NAE through the Frontiers in Engineering Program, and he has received the College's Collaboration Award and the McQueen Quattlebaum Award, which recognizes faculty for their outstanding research. In addition, Dr. Gramopadhye serves as Editor-in-Chief of the International Journal of Industrial Ergonomics and on the editorial board for several other journals.

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Abstract

National data indicate that initial mathematics course placement in college is a strong predictor of persistence to degree in engineering[1, 2, 3, 4], with students placed in calculus persisting at nearly twice the rate of those placed below calculus [3]. Within the state of South Carolina, approximately 95% of engineering-intending students who initially place below calculus are from in-state. The "Statewide Coalition: Supporting Underrepresented Populations in Precalculus through Organizational Redesign Toward Engineering Diversity (SC:SUPPORTED)," a Design and Development Launch Pilot funded under the National Science Foundation INCLUDES program, is a coalition of secondary districts and post-secondary institutions throughout South Carolina, joining together to address the systemic issue of mathematical preparation for engineering-intending students.

First year results include an analysis of system-wide data to identify prevalent educational pathways within the state, and the mathematical milestones along those pathways taken by engineering-intending students. Using individual data for all 21,656 first-year students in engineering-related fields enrolled in a public post-secondary institution in the state, we identified specific pathways with high rates of placement in or above calculus, pathways with balanced rates of placement in/below calculus, pathways with high rates of placement below calculus, and 'missing' pathways, defined as those which produce disproportionately few engineering-intending students [5]. For example, rates of placement in or above calculus among engineering majors ranged from below 17% in eight counties of origin to nearly 100% in four counties of origin.

First-year results also included analysis of qualitative data from focus groups conducted at key points along each pathway category to identify factors that do not readily appear in institutional data (*e.g.*, impact of guidance counselor recommendations in selection of last high school math course taken). Broad themes emerging from the focus groups provided additional insight into potential interventions at multiple points along educational pathways. Focus group data are contributing to the development of a survey to be administered in Year 2 to all post-secondary engineering majors statewide, with the goal of creating structural equation models of the factors leading to placement at or below the calculus level upon entry into an engineering major. These models will then allow us to design targeted interventions at points of maximal potential impact.

Introduction

In keeping with the guidelines for the NSF INCLUDES program, we report our Year 1 results in terms of Vision, Partnerships, Goals and Metrics, Leadership and Communication, and Sustainability.

Vision

The vision of SC:SUPPORTED is to improve persistence among engineering-intending students by addressing initial mathematics course placement and initial mathematics course outcomes, particularly among students from minoritized populations, low SES backgrounds, and rural areas. The launch pilot focuses on elucidating the pathways that lead students into college math courses below calculus and on testing interventions at points of maximal theoretical impact. Although the data we collect is specific to South Carolina, the framework for the study (Figure 1) is grounded in engineering identity theory and draws on national research on engineering identity and engineering pathways [1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14]. Each critical decision point is affected by a range of inputs that are not unique to South Carolina; collecting representative data to understand the relative impact of those input variables within the nearly closed system in South Carolina will provide insight that translates to the larger national context.

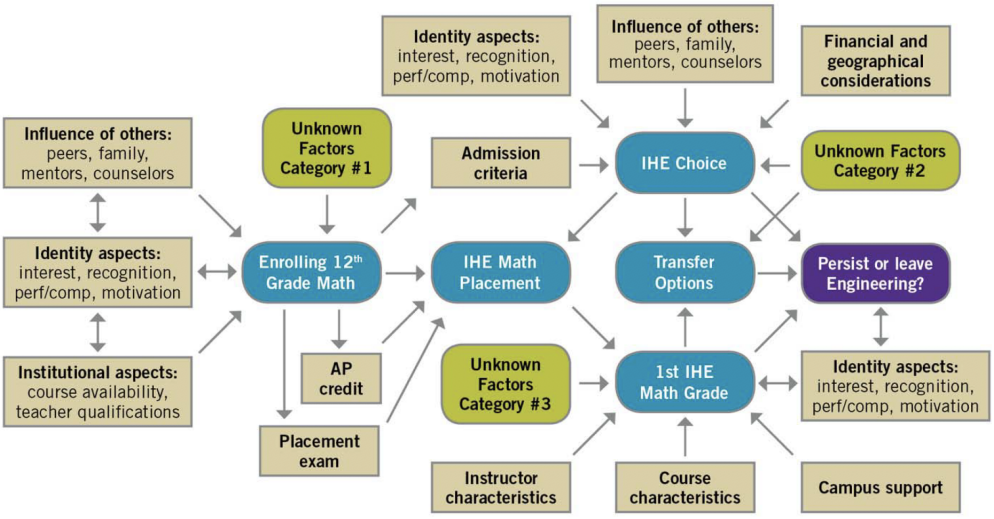

Figure 1 Theoretical framework for factors for retention in engineering based on previous published work. We anticipate unknown, state-specific factors as indicated.

The focus of the project in Year One was to identify precollegiate factors affecting initial mathematics placement. Year Two activities will include deeper dialogues regarding alignment of post-secondary efforts to support students placed below calculus.

Partnerships

Recent studies suggest most students take complex, indirect paths to an engineering degree by earning credits from and moving between a diverse set of institutions. In fact, only a small percentage of students follow the traditional path of graduating from a four-year engineering program within four years after high school [15].

Accordingly, the SC:SUPPORTED Launch Pilot includes a clearly-defined, diverse set of institutions:

1. All state-supported, four-year post-secondary institutions with ABET-accredited engineering programs in the state;
2. All state-supported technical (two-year) colleges in the state;
3. The 118 high schools in 43 districts statewide with 70% or higher poverty rate [16]. These 43 districts are located in proximity to the I-95 corridor with a high percentage of underrepresented minorities and historically low rates of post-secondary degree completion.

Goals and Metrics

The project is proceeding in six phases, with Phases 1 – 3 occurring in Year One and Phases 4, 5, and 6 occurring in Year Two. At the time of submission, we have completed Phases 1 and 2, with Phase 3 underway.

Phase 1 (Pathways Analysis): analyze existing enrollment and placement data for statewide trends; identify strategic locations for focus groups.

Phase 2 (Focus Groups): Collect focus group data to identify underlying causes of anomalies in statewide enrollment and placement patterns.

Phase 3 (Survey Development): Use focus group data to add state-specific question blocks to existing validated survey instruments.

Phase 4 (Survey Deployment): Deploy survey to all students in engineering-related fields statewide with a target 30% response rate.

Phase 5 (Structural Equation Models): Combine survey data and existing geospatial markers for urbanization, diversity, and socio-economic levels to create a series of structural equation models (SEM) quantifying the relative significance of factors influencing initial college math course placement.

Phase 6 (Interventions): Use SEM results to create targeted interventions at points of maximum efficiency, with greatest potential of impact tied to sustainable cost.

Summary of results to date Using individual data for all 21,656 first-year students in engineering-related fields enrolled in a public post-secondary institution in the state, we identified specific pathways with high rates of placement in or above calculus, pathways with balanced rates of placement in/below calculus, and pathways with high rates of placement below calculus. Similarly, we identified pathways resulting in high rates of selection of engineering as a major from among the engineering-related fields in our population of interest, mid-range rates of

engineering selection, and low rates of engineering selection. Details on the data collection, analysis, and results are explored in greater detail elsewhere [5].

There is a wide discrepancy in county-level mathematics placement and major selection among the population of interest. For example, rates of placement in or above calculus among engineering majors ranged from below 17% in eight counties of origin to nearly 100% in four counties of origin. Among students entering engineering-related fields, the rates of those choosing engineering specifically were as high as 75% in some counties and as low as 10% in others.

These striking differences allowed us to identify locations to conduct a series of focus groups to explore factors contributing to mathematics placement, major selection, and preparation for college. The focus group data are allowing us to identify factors that do not readily appear in institutional data (*e.g.*, impact of guidance counselor recommendations and community leaders on selection of last high school math course taken). The broad themes that are emerging from the focus groups are driving the development of additional items to be added to previously validated survey items [17] for distribution to all post-secondary students in engineering-related fields statewide. They are also providing insight into potential interventions at multiple points along educational pathways.

Leadership and Communication

Project leadership includes a multi-institutional leadership team with representatives from each of the four-year campuses, the technical college system, and the coordinator of mathematics and science outreach to the public schools. The external advisory board includes engineering education experts from Purdue, Virginia Tech, and Research Triangle Park Educational Research. Each campus has a local technical lead to coordinate project activities, and each phase of the project includes a multi-institutional implementation team.

Sustainability and Scale

During Year One of the project, we are taking careful steps to ensure reliability and validity of the data in order to set the stage for sustainability of project interventions, as well as for scaling those interventions. We mention here some of the steps taken; this is not an exhaustive list but is intended to give the reader a sense of the care being taken with data collection and handling.

Process reliability. In order to ensure equivalence of existing quantitative data, we have used variables and formats required by state reporting guidelines where possible, and existing course articulation agreements for alignment of math placement information. Qualitative data from focus groups have been collected by the same two researchers in each setting, with a core set of consistent prompts.

Descriptive validity. We have recorded each focus group session with two independent audio recording devices, then had the audio files transcribed verbatim through a secure third party

service. Each audio file was verified against the recordings prior to analysis. Written artifacts generated in the focus group were labeled and photographed before analysis.

Evaluative validity. Each member of the qualitative analysis team submitted written responses and reflections to bracketing prompts to identify and mitigate researcher bias prior to analysis. Researchers are maintaining memos and log trails during the analysis process to identify any passages eliciting a strong emotional reaction that might indicate researcher bias.

Interpretive validity. Each focus group transcript was coded independently by at least three members of the qualitative research team, then initial codes were compared and discrepancies discussed until the team reached consensus. Passages on which agreement could not be reached were marked for further review and potential member-checking.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. EEC-1744497. Any opinions, findings, conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We also wish to acknowledge the assistance of the Institutional Research Officers at each campus in gathering the data used in this analysis.

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