2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34446

Understanding Self-efficacy and Persistence for STEM Education in Underrepresented Middle School Students

Dr. Rajani Muraleedharan, Saginaw Valley State University

Dr. Rajani Muraleedharan is an assistant professor of Electrical and Computer Engineering (ECE), and the faculty advisor for Society of Women Engineers (SWE) at Saginaw Valley State University (SVSU), Michigan. Dr. Muraleedharan obtained her Ph.D. at Syracuse University, New York. Before joining SVSU, She worked as an 3/4 Full-time ECE Assistant professor at Rowan University, New Jersey and as a postdoctoral research associate at the Wireless Communications and Networking Group (WCNG), University of Rochester, New York. She also was a research intern at Mitsubishi Electric Research Lab (MERL). Her research interest includes signal processing, computational intelligence, behavioral science, mobile-cloud computing, information and network security in heterogeneous sensor networks. Dr. Muraleedharan collaborates with researchers and mentors students on topics such as health and emotion recognition for autistic children, cybersecurity, unmanned aerial vehicles (UAV), physics education, environmental monitoring and green energy applications.

Currently Dr. Muraleedharan is mentoring research on 'Multirotor Swarm for Autonomous Exploration of Indoor Spaces' project funded by Michigan Space Grant Consortium. She is the author/co-author of 2 book chapters, 4 journal papers, 31 conference and symposium IEEE/ACM papers, and 3 of which has won the best paper award. In 2009, Dr. Muraleedharan was awarded the Outstanding Teaching Assistant award and also received her Certificate in University Teaching from the Future Professoriate program at Syracuse University. She is the reviewer of IEEE Transactions on Evolutionary Computation, Neurocomputing, and Systems and Cybernatics, Wiley Security and Communications networks. Dr. Muraleedharan has participated in many professional and service activities university wide. In summer 2015, she instructed Middle school Robotics and Beyond Camp, and in 2014 served as a judge for A.H. Nickless Innovation Award at SVSU. Dr. Muraleedharan strives to promote science, technology, engineering, and mathematics (STEM) education for young girls and aspire young women engineers by volunteering for MindTrekkers event, Delta College, Middle school girls camp, ISD Bay Arenac and Girls Scouts, Michigan yearly.

Dr. Muraleedharan is a member of Institute of Electrical and Electronics Engineers (IEEE), Association for Computing Machinery (ACM), Society of Photo-optical Instrumentation Engineering (SPIE), Women in Engineering (WIE), American Society of Engineering Education (ASEE) and SWE. She is the Students activities chair, IEEE Northeast Michigan Section since 2014. She is the member of Institutional Review Board Committee, reviewer of Consumers Energy Engineering Talent Scholarship, and member of C of IDEAS at SVSU.

Dr. Marie Cassar, Saginaw Valley State University

Associate Professor of Psychology

Work-in-Progress: Understanding Self-Efficacy and Persistence in STEM education for Underrepresented Middle School Students

Abstract

Growth in tech industries such as, communications, robotics and transportation, have highlighted the need for drawing an increasingly diverse population of students into STEM education early in their academic careers. While many middle schools have initiatives to increase students' awareness and preparation for STEM fields, students are nevertheless often intimidated by STEM coursework, choosing to delay or avoid courses critical for success. The proposed project assesses, using a pre-post intervention design, possible factors influencing the attitudes and perceptions of students from underrepresented groups about STEM curriculum and presents a multifaceted intervention designed to develop students' preparation and persistence in STEM fields. The intervention includes four activities: extracurricular peer-directed, hands-on educational experiences building students' collaborative interaction skills, technical knowledge, and curiosity about STEM; industry site visits and personal interactions with professionals working in STEM fields focused on motivating students to visualize themselves on STEM career pathways; family/mentor-focused STEM opportunities intended to broaden students' educational and emotional support networks; and an integrated STEM-curriculum for teachers to build upon key concepts.

Background and Introduction

In 2017, a National Science Foundation (NSF) study [1] projected the adult population of United States will be more than 50% minorities by 2060, which directly impacts the Science, technology, engineering and mathematic (STEM) workforce and measures to remove barriers in STEM education becomes critical. Many universities focus on efforts to recruit students for undergraduate education by supporting local STEM events and creating collaborating enrichment activities such as week-long STEM camp for high-school students to increase STEM program awareness. Educators in higher education are redesigning courses and providing transitional bridge programs to improve student retention in STEM programs. Although these unique educational initiatives increase STEM retention by a few % in terms of student population and program credits, it still does not minimize the barriers of STEM participation in underrepresented population.

STEM education and enrichment are currently national priorities set by the U.S. government through initiatives such as 'Change the Equation' and 'Educate to Innovate'. It is a top priority for researchers, policymakers, educators, and youth developmental experts who agree that investing in our youth to succeed in STEM will produce positive results for our country's future. To meet the needs of the future STEM workforce, it is critical that we close the gender gap and increase students' interest in STEM education and careers, particularly females and underrepresented populations.

STEM Needs in Great Lakes Bay Region

The need to build a STEM workforce of tomorrow and attract new opportunities and business in Great Lakes Bay led to launching a comprehensive STEM education strategy and training in the Great Lakes Bay Region (GLBR) by GLBR Alliance (GLBRA) in May 2014 to serve early-

childhood, K-12, community college, university, out-of-school time providers (museums, zoos, Boys and Girls Clubs, etc.,), Businesses and adult learners in Arenac, Bay Clare, Gladwin, Gratiot, Isabella, Midland and Saginaw counties of Michigan. Two organizations, Accenture and Innovate+Educate conducted research and gathered data that includes demographics, enrollment figures, test scores for local students, inventories of existing STEM programming, economic data, employment projects and many other facts [8]. The key data showed 36% of Michigan high school students entering college require math remediation, 13% higher than the national average. The key findings were (1) strong math, science and literacy skills are the core competencies required for a strong STEM workforce, (2) student at or below the poverty level have lower math achievement, and (3) school administrators and teachers are not always aligned on the STEM agenda. The recommendations of this study were (1) to improve 5^{th}-8^{th} grade math achievement, (2) increase in-classroom, research-based K-12 STEM-aligned programming with evidence of increasing interest in science, and (3) to increase the number of out-of-classroom experiential STEM learning opportunities.

In 2015, 70 stakeholders participated in the GLBR STEM Funders Network STEM Ecosystem STEM Asset Survey. The survey identified current regional STEM programming, created a resource map, needs and gaps. 80% of respondents indicated that youth need more support from community and business partners for mentoring opportunities; 88% indicated the need for more family STEM experiences, and 70% indicated that youth need more support from higher education for mentoring, academic coaching, and family STEM experiences.

Literature Review

In [2] an inquiry-centered after-school program was designed to enhance middle school students' engagement using 21^{st} century engineering design-based experiences. The results show evidence of *mentors* and their role in shaping engineering awareness and opportunities to students. A national report on college freshmen major/career interests shows that on average, 20% of women intend to major in a STEM field, compared to 50% of men. Four consecutive years of data show that these numbers increase for men over time (from 45% to 56%), but do not increase for women (Girl Scout Research Institute, 2012). A study conducted by Junior Achievement in 2018 provides more alarming data: high school girls' interest in STEM remained at 11% after participating in STEM programs. Career "influencers" are also changing. *Parents' influence* in career choices increased from 19% to 28% over a two-year period, while social media declined from 15% to 8%. The study found that *other key influencers were teachers, courses, volunteering and extra-curricular activities*. In [7] fashion fundamentals were incorporated in STEM as an effort to increase curiosity in girls, but quantitative data does not show increase in girls' knowledge of math, but their mindsets indicated a perception of growth. On the other hand, many researchers [3] have aided in developing STEM *training* experiences for *K-12 educators* so students may understand the value of STEM in their lives.

Pilot-Program Description

The pilot program is funded by The Nexteer Steering the Future Fund and focusses on the underrepresented population who are at or below the poverty level and have lower mathematics score in Michigan Student Test of Educational Progress (M-STEP). The research study is based on the GLBRA recommendations such as 1) increase the engagement of families/parents in STEM

with educators and business leaders and 2) increase diversity. The program focusses on concepts such as mentoring, 21st century STEM activity, training educators and education and career influencers to evaluate short- and long-term impact of the 2-day STEM exploration camp. The program aims to provide afterschool collaborative and engaging environment through inquiry-based and experience learning through interactions with hands-on activities, mentoring and panel discussion with experts in the STEM field.

The Xplore STEM camp includes 6th -8th grade student participants from two low-poverty schools where more than 65% of students are eligible for Free-Reduced Price Lunch (FRPL). The proposed camp is funded by the Nexteer Steering the Future Fund, administered by the Saginaw Community Foundation (SCF) with a timeline of April 2021-December 2021. Nexteer Automotive is a worldwide leader in developing innovative automotive steering and driveline products, and one of the key players in the GLBRA STEM Talent Pipeline. The Nexteer employees selected as mentors for the camp are committed to supporting local communities and advocate for STEM education by participating in many outreach programs conducted at the University and part of the Electrical and Computer Engineering Advisory Board (ECEAB). STEM@SVSU at Saginaw Valley State University was founded in 2014 with support of The Dow Chemical Company to serve a coordinated network of opportunities to link K-12, university and regional employers. STEM@SVSU will help in organizing meeting with school counselors to seek program interest, participation and discuss alternatives if the pandemic will force any school closure.

Xplore STEM Camp

There are 20-student and 1 teacher per school, and therefore a total of 40 students and 2 teachers participate in the virtual afterschool Xplore STEM camp. Due to the increased number of confirmed cases of the coronavirus (COVID-19) in Michigan, large gatherings are restricted and participants (students, staff, and volunteers) from different schools are unable to meet at a single location. Hence, the afterschool enrichment program includes two schools, who will be virtually attending the sessions via zoom. The teacher from each school will facilitate interactions during the online sessions conducted by the program director from the university. All Institutional Review Board (IRB) approved paperwork is shared with the schools, and the consenting students will complete an online pre-intervention, post-intervention survey and submit a 500-words self-reflection essay about their camp experience.

Virtual camps can be stressful and not valuable if not conducted in a seamless manner. Hence, a teacher professional development session is held prior to the camp to ensure students' who have network or software issue can have in-person support and guided activity is shared in case there is network connectivity issues. During this session, a background of the grade-level STEM concepts taught in the school will be assessed, which will be helpful in designing the depth of STEM activity. The focused activities should use kits that are cost-effective and should not require additional screens to operate (electronic devices such as phone, tablet and laptops) from the student participant as it is could add financial stress to the participating family. Each student participant will be given a kit to ensure social distancing while encouraging peer-learning environment through in-person activity. Also, if any student participant is unable to be in-person at their school due to COVID related symptoms, the student can then participate in the online platform and additional support will be provided to encourage student engagement.

On Day 1, students engage in activities focused to teach physics, sensor and programming concepts such as motors, torque, speed, optical sensors, variables, control statements, and functions with and without screens. Students are then handed the kits at the end of session with guided instructions to prepare for a self-driving car challenge. The curriculum designed for the Xplore STEM camp focusses on the 'science behind a self-driving car' using screen-free with color coded markers. Upon completion of the Day1 activity, students will be given an activity to experience at home, so they may engage and educate family members, building an emotional support network. Students will be asked to share their family-based interactions in a 'self-reflective' assessment aimed at empowering student achievement.

On Day2, volunteers from industry and the institution's ECEAB are invited to facilitate as role-models and motivational speakers, sharing their life-experiences such as, the roadblocks faced in achieving a STEM education and career. The self-driving car challenge will be conducted, and the winner of the bracket challenge from both schools will be invited to participate in the SVSU Go-Baby-Go program, where can experience the impact an engineer makes by engaging with community to modify toy-cars for children with disability.

A guided lessons and research findings of the pilot study will be shared with teachers, so they may opt to teach STEM-based curriculum for non-participants and future 6^{th}-8^{th} graders. The kits will remain at the school to make a larger impact through curriculum or afterschool programs. The measurable outcomes will be presented to support NSF's 10 Big Ideas, National, State, and Regional education and workforce development policy.

Research Design & Hypothesis

The project utilizes a one-group, pre-test, post-test design. Students will complete surveys before and after participating in the STEM-focused intervention. The surveys and intervention are designed for online participation to accommodate pandemic-related limitations of in-person school activities. A comparison of the pre-post intervention survey responses will allow for assessing whether the STEM-focused interventions resulted in positively influencing the students' attitudes toward STEM-related academic coursework and careers, their feelings of self-efficacy, and their beliefs about ability.

Pre-Post Intervention Survey

A self-report survey containing ***30 items*** was constructed to serve as the pre and post intervention survey. The commercially available SurveyMonkey software was used to create and administer the pre-post intervention survey. The revised STEM Survey-Middle and High School Students [5] will assess students' attitudes about STEM-related academic course work, STEM-related careers, personal interests and professional contacts, growth mindset and self-efficacy. The survey is part of a set of STEM outreach measurement resources available for educational purposes from The Friday Institute for Educational Innovation at North Carolina State University College of Education.

The items assessing attitudes about STEM-related academic courses ask students to rate agreement, using a 5-point Likert scale, with statements related to math courses (3 items), and science courses (3 items). Students are also asked to indicate agreement with statements assessing

interest in activities related to engineering and technology (3 items), feelings of confidence when working independently, online learning, when working in teams, and when challenged (5 items). Finally, seven items from the Student Attitudes Toward STEM Survey ask students about future academic plans and personal contacts with individuals working in STEM-related careers.

The pre-post intervention survey also includes the six items comprising the Revised Implicit Theories of Intelligence (Self-Theory) Scale [4]. These items assess the degree to which students report the belief in a growth mindset for intelligence. The items ask students to indicate agreement with statements about the malleability of a person's intelligence level, indicative of a growth mindset, using a 6-point Likert scale. The final three items on the pre-post intervention survey are from the Motivated Strategies for Learning Questionnaire [6]. These items assess students' self-efficacy for learning and performance. Students respond to each statement using a 7-point Likert scale with the anchor labels of "1 = not at all true of me" to "7 = very true of me." The Revised Implicit Theories of Intelligence (Self-Theory) Scale and the Motivated Strategies for Learning Questionnaire are available to use for educational purposes.

Survey Questionnaire & Results

All the students' responses to the pre and post intervention surveys will be anonymous to comply with IRB only de-identified information will be stored. To allow for matching the pre and post survey responses, each student will create a unique identifier that is recorded with his/her responses. The survey ratings provided by each student will be grouped by survey subsection. Average ratings by subsection for each student will be calculated for the pre- and post-surveys. The overall pre-post change in ratings will also be calculated. Table 1 shows the survey subsections for the planned data analysis. The mean ratings for each of the subsections will be analyzed using a repeated measures t-Test procedure.

Table 1

Mean pre-post intervention survey ratings by subsection

Survey Subsection	Pre-	Post-	Change
Math Coursework			
Science Coursework			
Engineering and Technology Interest			
21st Century Learning			
Future Careers			
Growth Mindset			
Self-efficacy for Learning and Performance			

Self-reflective assessment: The self-reflective assessment involves asking students to answer the following question.

"Describe how your abilities were challenged when you were working on the project this week. What new things did you learn? Explain how you learned new things. Did you develop and revise your strategies for overcoming difficulties? Explain how you kept working on the project even when things were not working."

Conclusion

The Xplore STEM Camp aims to promote critical and analytical thinking, communication skills, creativity, STEM career awareness and exploration, and assess the impact of family support networks.

References

[1] National Science Foundation, National Center for Science and Engineering Statistics. 2017. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017. Special Report NSF 17-310. Arlington, VA.

[2] Blanchard S, Judy J, Muller C, Crawford RH, Petrosino AJ, White CK, Lin FA, Wood KL. "Beyond Blackboards: Engaging Underserved Middle School Students in Engineering", J Precoll Eng Educ Res. 2015;5(1):2

[3] Thomas SW., Campbell SW., Subramanyam MD., Ellerbrock CR., "Contemporary STEM Issues: Engineering Training of Pre-Service Teachers for Middle School STEM Curriculum Development (Evaluation)", 2019 ASEE Annual Conference & Exposition.

[4] De Castella, K., & Byrne, D. (2015). My intelligence may be more malleable than yours: The Revised Implicit Theories of Intelligence (Self-Theory) Scale is a better predictor of achievement, motivation, and student disengagement. European Journal of Psychology of Education, 30, 245–267. Retrieved from the National Mentoring Resource Center (NMRC), Measurement Guidance Toolkit Website.

[5] Friday Institute for Educational Innovation (2012). Student Attitudes toward STEM Survey- Middle and High School Students, Raleigh, NC.

[6] Pintrich, P.R., Smith, D.A.F., García, T., & McKeachie, W.J. (1991). A manual for the use of the motivated strategies questionnaire (MSLQ). Ann Arbor, MI: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.

[7] Ogle, Jennifer & Hyllegard, Karen & Rambo-Hernandez, Karen & Park, Juyeon. (2017). Building Middle School Girls' Self-Efficacy, Knowledge, and Interest in Math and Science Through the Integration of Fashion and STEM. Journal of Family & Consumer Sciences. 109. 33-40.

[8] STEM Impact Initiative, Nov 2014: https://www.stempipeline.com/wp-content/uploads/2018/06/502952_STEM_Findings_Book_v3.pdf