Article

Volume 2 (2024), pp. 86-97
American Journal of STEM Education:
Issues and Perspectives
ISSN: 3065-1190

STEMM Simulation Program Inspires Underprivileged Middle School Students

Laura Daniel, PhD
Donamarie N-Wilfong, DNP, RN
The Simulation, Teaching, and Academic Research (STAR) Center
Allegheny Health Network, USA

ABSTRACT

"What do you want to be when you grow up?" While students are often asked this question at young ages, as they mature during the middle school years, the timing is right to revisit this question. Hence, to promote career exposure and exploration, a Science, Technology, Engineering, Mathematics, and Medicine (STEMM) on the Go (SOTG) program was created that brought simulations into underprivileged middle schools. Results showed significant increases in students' interest in mathematics and medicine. The SOTG program is an experiential initiative that introduces future generations to STEMM careers while cultivating lifelong skills in a fun and inclusive environment. These SOTG programs broaden the field of simulation education and provide crucial STEMM exposure to underserved populations.

Keywords: Middle school; simulation education, STEMM, underprivileged

INTRODUCTION

"**W**hat do you want to be when you grow up?" Nearly all students have been asked this ubiquitous question at some point in their lives. Many of the very young students will often answer with truly uninhibited answers such as, "President of the United States!" and "Astronaut!" However, as students mature their ambitions may change, particularly during their preteen years. As Kier, Blanchard, Osborne, and Albert (2013) have claimed, it is during the middle school years in which students develop their interests and recognize their academic strengths, which may affect their ambitions. For example, middle school is typically the time when students may first become separated into distinct mathematical tracks based on academic capability. This heightened awareness of skills and interests is poignant, and some students will even make the decision of whether to enter a STEMM career as early as the middle school years (Steingard, Wollmuth, Murtha, & Correa, 2023). Thus, the middle school years is an opportune time to revisit the question of "What do you want to be when you grow up?"

By contemplating this question in grades six through eight, Skamp (2007) purported it will allow students time to develop self-efficacy in their chosen fields. However, to answer this question, students need an understanding of what careers exist. In fact, some researchers have claimed a potential reason why students do not select a STEM career is simply due to ignorance (Boys & Girls Club of America, 2024). Hence to promote career exposure and exploration during the critical middle school years, a *Science, Technology, Engineering, Mathematics, and Medicine (STEMM) on the Go (SOTG)* program was created by a healthcare simulation center in conjunction with middle school faculty, to bring hands-on STEMM adventures into middle school classrooms. This article provides readers with a description of the collaborative simulation education program that came to fruition because of the partnership among simulation experts, healthcare network philanthropists, a psychometrician, middle school faculty, and middle school administration.

LITERATURE REVIEW

STEMM fields were chosen because STEMM jobs are some of the fastest growing and highest paying. According to the Bureau of Labor Statistics (2022), the number of careers in STEMM fields is expected to rise by roughly 12%. Furthermore, the National Science Foundation (2023) purported that workers in STEM fields earn higher wages on average, regardless of sex, race, ethnicity, or disability status. Equally important, the National Inventors Hall of Fame (2024) purported that STEM education builds a powerful skill set, applicable to many areas of life. The SOTG program introduced students to STEMM topics that standard school curricula may not typically cover.

The program's objective was to promote equity and inclusiveness in STEMM education by widening underprivileged students' exposure to STEMM professions and to stimulate interest in those careers. Moreover, the program aimed to simultaneously cultivate teamwork, communication, and problem solving. The program was designed to be a fully mobile program wherein the simulation center brings the activities directly to middle school classrooms. This format was a cost-effective and efficient method to reach the students without the expense of bussing and without requiring time for them to travel.

The SOTG program followed a hybrid simulation education model, with both virtual and hands-on modalities. This type of mixed teaching method was chosen to keep students engaged and to enhance their understanding. Furthermore, this program met the four themes that youth in underserved populations require of STEMM programs: equitable, relatable, relevant, and supportive (UScellular, 2024).

The SOTG program met the equitable standard by holding the program in the middle school classrooms rather than requiring students to pay for bussing to the simulation center. This design helped to ensure the program was accessible to all students regardless of schools' finances. The relatable standard was met by introducing students to true STEMM professionals. These guest speakers and faculty members helped to humanize the fields, helping to make STEMM careers feel personable and attainable. Furthermore, the STEMM role models provide students with tangible examples of career pathways (Restini, Weiler, Stransky, Voll, & Wisco, 2024).

Program administrators aimed to secure STEMM professionals from diverse backgrounds to match the program's student population because "identity matters in STEMM" (Marshall, et al., 2024). These researchers claimed that the perception of students' belonging in STEMM fields affects their long-term persistence. Furthermore, some researchers cited a lack of access to relatable role models as a possible STEM deterrent for underserved students (Hernández-Matías, Díaz-Muñoz, & Guerrero-Medina, 2023). Therefore, by exposing underserved middle school students to diverse STEMM professionals, it was expected to increase their sense of relatability to STEMM professionals.

The relevant standard was met as the program faculty designed the activities to reflect today's modern society and cutting-edge technology to help keep the lessons pertinent to the young, tech-savvy preteen/teenaged students. Lastly, the supportive standard was met by having the same simulation specialist facilitate all the sessions throughout the year. By having a consistent mentor present, she was well suited to develop a nurturing rapport with each of the students. Furthermore, students were encouraged to share their thoughts, ideas, and feelings openly and regularly to help foster a supportive, psychologically safe environment.

Table 1
STEMM Sample Curriculum

Content	Activities	Outcomes
Science	Students review human anatomy through interactive sessions with high fidelity simulators. Students participate in a contamination and germ transmission glo germ activity.	The hands-on activities will nurture students' problem solving skills. The students will gain a first-hand perspective of science-related careers in the field of medicine.
Technology	Students participate in a simulated escape room with hands-on logic problems and technological puzzles.	Students' minds will be opened to technology beyond what they typically see in their lives. Students will likely gain a broader, deeper respect for technology and its role in education and healthcare. Students will think creatively, process information critically, communicate effectively, and work collaboratively. Students will feel a sense of accomplishment when they escape.
Engineering	Simulation specialists demonstrate 3D printing and moulage applications. Students participate in an "Astronaut Drop" engineering challenge.	Students will be exposed to the work needed to create high-fidelity mannequins and elements of realism in simulations. Students' creative thinking skills will be sharpened as they design and evaluate "astronaut landing pads."

Mathematics	Healthcare professionals teach students volumes, measurements, and conversions using tools from the real healthcare setting. Students participate in interactive simulated medication administration activities with intravenous (IV) pump therapy.	Students will gain respect for mathematics as they learn first-hand how mathematics is used in healthcare careers. Students' critical thinking skills will be cultivated.
Medicine	Students use stethoscopes and ultrasound technology to learn heart and lung anatomy and organ sound assessment.	Students will distinguish between normal and abnormal heart and lung sounds. Students will gain foundational skills applicable to a variety of healthcare careers.
Medicine	Students learn when and how to administer first aid.	Students will apply best practices of aid administration. Students will gain practical skills applicable to a variety of healthcare careers and even to their own lives.
Medicine	Students complete the career aspiration posttest, STEMM interest posttest, and an evaluation. Students learn basic CPR skills.	Students will resuscitate adults, children, and infants. Students will likely feel a sense of accomplishment in successful resuscitation of patients. Students will be presented with a certificate of completion.

The program met once a month, for eight months, where each session addressed one of the STEMM fields. This extended program length was chosen to best nurture the students' interest and motivation to pursue a STEMM career (STEM Next, 2024). Medicine was covered three times since this program was offered by a healthcare simulation center and since medicine was absent from middle school curricula. Because this was the students' first experience with simulation, the need for a psychologically safe learning environment was paramount. Prebriefing occurred during the first session with a comprehensive orientation and ice breaker games and activities. Table 1 lists sample content for the seven main sessions. These lessons were collaboratively designed and vetted by a panel of experts including simulation educators, simulation technicians, a psychometrician, a philanthropist, middle school counselors, science teachers, and principals. Each session was carefully constructed to be at a level conducive to the unique student population, designed to challenge students to think outside the box, think critically, and innovate through a variety of simulations and activities.

RESEARCH METHOD

This program took a holistic approach to ensure goals were met and populations were well served. Key performance indicators measured students' STEMM interest and student and school satisfaction. Students and administrators were both surveyed as Restini, Weiler, Stransky, Voll, and Wisco (2024) purported, program effectiveness needs to be measured for each stakeholder group. Student interest in STEMM fields was measured before and after the program through a 50-item STEMM interest scale, designed by the authors. STEMM interest was chosen as an outcome since Staus, Falk, Penuel, Dierking, Wyld, and Bailey (2020) purported that STEM interest is a primary determinant of persistence and ultimately college major choice. Moreover, STEMM programs often utilize interest as an outcome because researchers have documented positive relationships between interest and learning and professional aspirations (Hidi & Renninger, 2006; Renninger & Hidi, 2011). Other researchers have further claimed that student interest is a "powerful motivational process that energizes learning, guides academic and career trajectories, and is essential to academic success" (Harackiewicz, Smith, & Priniski, 2016). Likewise, the National Academies of Sciences, Engineering, and Medicine (2014) reported that student interest influences self-efficacy and the belief that one can succeed. The response options on the interest survey were 5-point Likert scales of agreement.

Authors worded items positively to reduce the cognitive demands (Johnson & Morgan, 2016). Cognitive load theory is the interplay of working memory characteristics and instructional systems, materials (de Jong, 2010). This theory postulates that content can be presented in such a way that increases intellectual performance (Kirschner, 2002). Wording items in a positive direction is more intuitive and does not require students to interpret what the response options mean in the context of a negative qualifier in the stem. Authors evaluated the items for simplicity and potential ambiguities. As part of this evaluation, the authors reviewed the tool's reading demands as operationally defined as the word count per item and the tool's overall reading level. None of the previous STEMM interest surveys located by the authors have done this type of granular analysis. However, this verbiage analysis is crucial to purporting the applicability of the scale to young middle school students and ensures the survey is "easy to understand," as was recommended by Tyler-Wood, Enezek, and Christensen (2010).

The average number of words in each item (7.6) was well below Peterson's (2000) recommended cutoff of 20 words per item. Similarly, the number of commas in each item (≤ 2) was below Peterson's (2000) recommendation of three or fewer. Furthermore, these commas were not used in the more complicated fashion of joining separate clauses or forming compound sentences, but instead were used in a lighter way, in a list series. The Fletch-Kincaid reading level of the STEMM interest scale was 6.6, meaning that is appropriate for sixth graders in the sixth month of school, below the current grade level of all program participants. These innovative adaptations of this scale were meaningful ways to promote the best survey taking experiences for 7th and 8th graders.

Student and school satisfaction was measured via anonymous and confidential, customized 13-item blended evaluations, designed by the authors that possessed similar formatting as the interest scales. They assessed multiple levels of Kirkpatrick's new world model (2016) to measure student engagement and satisfaction and their confidence toward STEMM careers. The student evaluation had an average of 7.7 words per sentence and a 4.1 Fletch-Kincaid reading level, meaning it is written at the level of fourth graders in the first month of school, well below the participants' grade level. The administrators' evaluation measures their satisfaction with the program. It was expected that both student and administrator average satisfaction scores would be equal to or greater than 4.0 on a 5-point scale.

This program also asked all simulation and middle school administrators, and faculty members involved with the program to complete an anonymous strengths, weaknesses, opportunities, and threats (SWOT) analysis. The SWOT required leadership to think critically and provided them with a safe outlet to communicate concerns, accolades, and/or ideas. All responses were recorded electronically and without any identifiers. Responses were aggregated and presented to the team for discussion and consideration.

Participants

The SOTG program was held at two middle schools, within the metropolitan limits of a major city, with 43 students. The first school was a public charter school that served students from over 15 school districts. This school was selected for participation due to its working relationship with the SOTG program's healthcare institution. This school offered the program to seventh (n = 16) and eighth grade (n = 13) students. The second school had a personnel connection to the first school. This public school restricted the program to seventh graders and had 14 enrolled students. The entire student populations at both schools receive free or reduced cost lunches. The program was offered to the schools and students at no cost.

RESULTS

Student interest in science and technology was steady before and after the program, while engineering, mathematics, and medicine experienced increased interest. Average interest scores were analyzed using Wilcoxon Signed Rank tests. The average interest in math and medicine was significantly higher after the program, $Z = -2.70$, $p < .05$ and $Z = -2.47$, $p < .05$, respectively. A quarter more students (25%) also planned to further their education after the program. More students also reported they planned to enter a STEMM field after the program, by 4%.

The average student satisfaction score was 4.06, which was above the program's student satisfaction goal of 4.0. Most students (88%) would recommend this program to others. Over four-fifths of the students (82%) reported they liked the sessions, viewed them as fun, and that they learned something new during the sessions. The program's objectives of exposing underprivileged students to STEMM careers and to inspire them to further their education and pursue those careers, was achieved. Over three-quarters (76%) of the students reported they knew more about careers after the program. Likewise, almost 60% of the students reported more interest in careers in STEMM fields after the program. The students most frequently reported that the field trip to the simulation center was the best part. Therefore, it is recommended that future programs incorporate at least one field trip to the simulation center, so students can gain a deeper appreciation for the field.

The average administrator satisfaction score was 4.75, which was above the program's administrator satisfaction goal of 4.0. Both participating middle school administrators reported the hands-on experiences were the best part. Both school administrators reported the content, and the activities went beyond traditional middle school lessons, exciting students in the process. One administrator summed up the school's positive experience by writing, "The STEMM on the Go program provided students with hands-on experience that they would not have gained in a traditional classroom setting. The hands-on aspects…allowed the students the opportunity to explore and experience all aspect[s] of the medical field. This type of experience helped to broaden their career choices." Likewise, another school administrator wrote a similar comment, "The program is organized and run[s] well. Communication is clear and monthly meetings are timely, on task, and support the program's initiatives. We greatly appreciate the opportunity to partner with the [SOTG] program. We feel this program gives our students expos[ure] and experience that will impact their future. Thank you!" Both schools expressed interest in continuing the program in future years.

At the conclusion of the program, eight administrators were invited to complete an anonymous, electronic SWOT from the two middle schools and the simulation center. Seven people submitted a SWOT, resulting in an 88% response rate. Respondents wrote ten opportunities, nine strengths, seven weaknesses, and five threats. The strengths that were written by more than one program administrator included: a strong and synergistic healthcare/school partnership, the mobile format allowed for increased efficiency, cost savings, and a condensed curriculum, the medical topics were empowering and novel, the overall content was engaging and unique, and the experiences were hands-on and enhanced the school's curriculum.

There was only one weakness, which was also identified as a threat, that was written by more than one administrator, which was the program's reliance on grants. Without a consistent source of funding, the program lacked sustainability. More than one administrator thought the program had expansion and advertising opportunities. Future programs could include additional grade levels, larger class sizes, and/or more schools. Advertising opportunities could include periodical advertisements, social media posts, and/or community flyers.

DISCUSSION AND CONCLUSIONS

While most simulation centers serve adult learners, this SOTG program extends their educational footprint to much younger audiences. Great care was taken to ensure the content and materials were at levels conducive to the students' cognitive abilities and that the simulations were fun, engaging, and relevant to the young members of generations Z and Alpha. Overall, the program inspired students to further their education and to consider STEMM careers. Over three-quarters of students (76%) reported the program inspired them to work hard at their career dreams and 91% believed they could reach their career goals. Not only did this program inspire students' future aspirations, but it also affected their current schooling. Most students (69%) reported more confidence in their science and math skills after finishing the program. This newfound confidence paves the way for the students to have the self-confidence needed to do their best and reach their full potential.

IMPLICATIONS

The SOTG program is an experiential program that introduces future working generations to STEMM careers, inspires them to further their education, while cultivating teamwork, communication, and problem solving in an inclusive environment. These results are restricted to underprivileged student populations and future replications of the program could include heterogeneous populations to generalize the findings across all middle school students. For example, future programs could extend the target audience to religious or private schools and/or diverse public schools. It would also be worthwhile to follow-up with program alumni in their senior year of high school to again ask them the question, "What do you want to be when you grow up?"

REFERENCES

Boys & Girls Club of America. (2024). *Bridging the exposure gap: Inspiring gen Z to pursue a STEM degree*. https://www.bgca.org/news-stories/2024/September/gen-z-stem-degree/

Bureau of Labor Statistics. (2022). *Employment in STEM occupations.* Employment Projections. https://www.bls.gov/emp/tables/stem-employment.htm

Bureau of Labor Statistics. (2022). *Healthcare occupations*. https://www.bls.gov/ooh/healthcare/home.htm

Carrillo, L.A., Valdes, R.A., Desjarlais, E.B., Medic, V., & Kim, J.E. (2024). Eyes on the future: Inspiring Latino middle school youth to pursue careers in STEM through early interactive science programming. *Wisconsin Medical Journal, 123*(1), 34-38.

Chichian, G. (2024). *Nonprofit spotlight: Why STEM education matters*. Catchafire. https://blog.catchafire.org/nonprofit-provides-stem-education

de Jong, T. (2010). Cognitive load theory, educational research, and instructional design: some food for thought. *Instructional Science, 38*, 105–134. doi.org/10.1007/s11251-009-9110-0

Harackiewicz, J.M., Smith, J.L., & Priniski, S.J., (2016). Interest matters: The importance of promoting interest in education. *Policy Insights from the Behavioral and Brain Sciences, 3*(2), 220 – 227.

Hernández-Matías, L., Díaz-Muñoz, G., & Guerrero-Medina, G. (2023). Seeds of success: Empowering Latina STEM girl ambassadors through role models, leadership, and STEM-related experiences. *Journal of STEM Outreach, 6*(2), 1-14. doi: 10.15698/jstem/v6i2.03

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111–127. doi.org/10.1207/s15326985ep4102_4

Johnson, R.L. & Morgan, G.B. (2016). *Survey scales*. Guilford Press.

Kier, M.W., Blanchard, M.R., Osborne, J.W., & Albert, J.L. (2013). The development of the STEM career interest survey (STEM-CIS). *Research in Science Education*. doi: 10.1007/s11165-013-9389-3

Kirkpatrick, J, Kirkpatrick, WK. (2016). *Kirkpatrick's four levels of training evaluation*. ADT Press.

Kirschner, P.A. (2002). Cognitive load theory: implications of cognitive load theory on the design of learning. *Learning and Instruction, 12*(1), 1-10.

doi.org/10.1016/S0959-4752(01)00014-7
Marshall, A.G., Neikirk, K., Stephens, D., Garza-Lopez, E., Vue, Z., Beasley, H.K., Doe, Y.J., Campbell, D., Fears, L., Alghanem, A., Spencer, E.C., Scudese, E., Owens, B., Vang, C., Morton, D.J., Conley, Z., & Hinton, Jr., A. (2024). A workshop to showcase the diversity of scientists to middle school students. *Advances in Physiology Education, 48(*2), 186-192. doi: 10.1152/advan.00117.2023
National Academy of Engineering and National Research Council. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. The National Academies Press. doi.org/10.17226/18612
National Inventors Hall of Fame. (2023, November 1). *What is the value of STEM education?* https://www.invent.org/blog/trends-stem/value-stem-education
National Science Foundation. (2023, January 30). *STEM median wage and salary earnings.* https://ncses.nsf.gov/pubs/nsf23315/report/stem-median-wage-and-salary
Peterson, R.A. (2000). *Constructing effective questionnaires*. Sage Publications.
Renninger, K. A., & Hidi, S. (2011). Revisiting the conceptualization, measurement, and generation of interest. *Educational Psychologist, 46*(3), 168-184. doi.org/10.1080/00461520.2011.587723
Restini, C.B.A., Weiler, T., Porter-Stransky, K.A., Voll, P.J., & Wisco, J.J. (2024). Empowering the future: Improving community wellbeing and health literacy through outreach and service-learning. *Frontiers in Public Health, 12*. doi: 10.3389/fpubh.2024.1441778
Skamp, K.R. (2007). Conceptual learning in the primary and middle school years: The interplay of head, heart, and hands-on science. *Teaching Science, 53*(4), 18-22.
Staus, N.L., Falk, J.H., Penuel, W., Dierking, L., Wyld, J., & Bailey, D. (2020). Interested, disinterested, or neutral: Exploring STEM interest profiles and pathways in a low-income urban community. *EURASIA Journal of Mathematics, Science and Technology Education, 16*(6). doi.org/10.29333/ejmste/7927
Steingard, C.H., Wollmuth, E.M., Murtha, A.N. & Correa, A. (2023). Write a researcher: A pen pal outreach program for middle and high school students. *Journal of Microbiology & Biology Education, 24*(2), e00240-22. doi:10.1128/jmbe.00240-22
STEM Next. (2024, March 24). 2024 Summer STEM challenge: Creating STEM journeys with purpose. https://stemnext.org/2024-summer-stem-challenge-creating-stem-journeys-with- purpose/
Tyler-Wood, T., Knezek, G., & Christensen, R. (2010). Instruments for assessing interest in STEM content and careers. *Journal of Technology and Teacher Education, 18*(2), 341-363.

University of Pittsburgh. (2023). Pitt pre-college STEM programs. https://be-stem.pitt.edu/pitt-precollege-stem-programs/

UScellular. (2024, September 17). UScellular drives creation of unique research-based STEM program to tackle declining interest among youth. https://newsroom.uscellular.com/uscellular-drives-creation-of-unique-research-based-stem-program-to-tackle-declining-interest-among-youth/

Laura Daniel, PhD, is the Director of Research at the Simulation, Teaching, and Academic Research (STAR) Center at Allegheny Health Network. Her major research interests lie in the areas of assessment, psychometrics, psychology in education, and research methodology. Email: laura.daniel@ahn.org

Donamarie N-Wilfong, DNP, RN, is the Vice President of Simulation Education at the Simulation, Teaching, and Academic Research (STAR) Center at Allegheny Health Network. Her major research interest is simulation education. Email: donamarie.wilfong@ahn.org

Acknowledgment Section

The authors did not use OpenAI's ChatGPT or any other AI tools in the drafting, editing, or refining of this manuscript. All content was generated, reviewed, and refined solely by the authors.