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Preparing All Girls to Change the World through STEMM

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Abstract

According to research, women are significantly underrepresented in the areas of Science, Technology, Engineering and Mathematics (STEM). The goal of this proposed model is to increase the number of females entering into STEM careers by providing mentoring, parental support, collaboration with external stakeholders, and engagement in a STEM learning environment. The model will identify twenty female students at the elementary/middle level that have shown a keen interest in STEM/STEAM/STEMM. These female students and their parents will embark on an experience that will engage them in STEM related experiences and opportunities throughout high school. With k-12 support, the hope is that the students will pursue STEM college degree(s) and enter a STEM/STEAM/STEMM profession.

Keywords

Underrepresented, Science, Technology, Engineering and Mathematics, STEM, Model, Females, Gender, Mentoring, Parental Support, Elementary Students, Middle School Students

1. Introduction

According to the US Bureau of Labor Statistics in 2021, less than one percent of all mathematicians and only 17% of individuals employed in architecture and engineering occupations are female. According to CNBC, STEM related occupations have been the best paying and fastest growing careers for decades (Smith, 2022). Data from the U.S. Bureau of Labor Statistics also show that the average STEM worker earns $100,000 per year. In the United States, the national annual salary is $53,924. Hence, the average STEM worker earns nearly twice the national average (**Figure 1**).

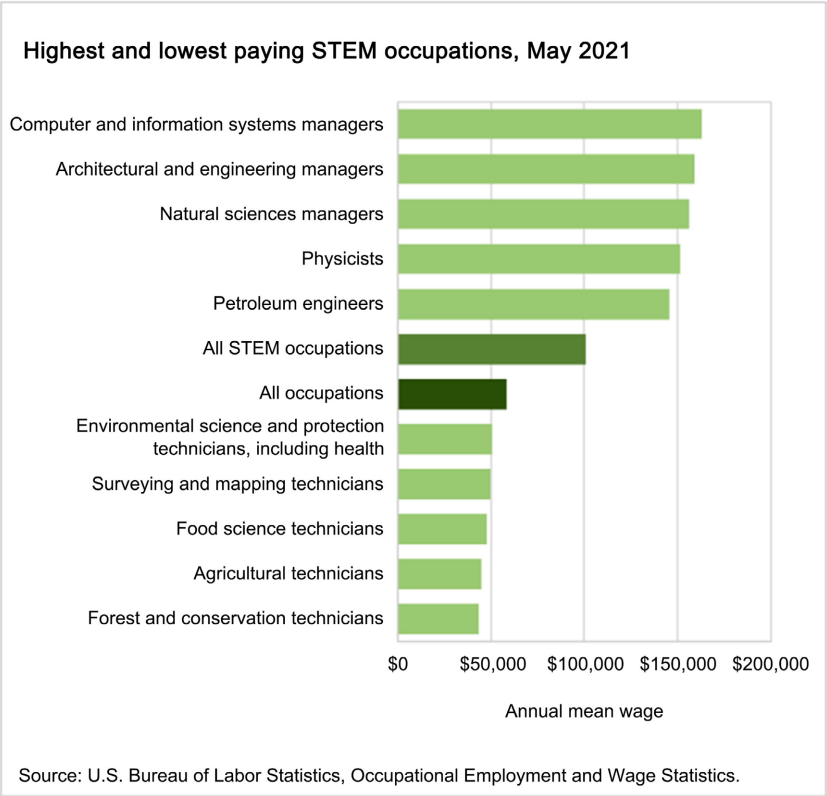

Figure 1. Highest and lowest paying STEM occupations.

2. Research Background

In March 2019, Edutopia identified three barriers that keep girls from pursuing STEM (Science, Technology, Engineering and Math) careers. They are:

1) Lack of a Math Identity: This implies that girls do not see themselves as STEM practitioners.

2) Race and Class Norms: Students from affluent families have access to the support and experiences that promote the pursuit of STEM careers. This may include access to Math and Science camps, trips to science centers or access to resources (e.g. Engineering software or graphing calculators). Stereotypical attitudes and lack of resources hinder girls from pursuing STEM careers.

3) Test Type: (Reardon et al., 2018), concluded that males perform better on multiple-choice items. Hence, when giving STEM related questions, students should be given the opportunity to express their understanding in words (writing).

To address these barriers, hands on STEM programs, female role models/mentors and providing information on STEM careers is suggested. In "5 Ways K–12 Educators Can Empower Girls to Consider STEM" Ramage focused on girls in general and did address the unique needs of students of color (Ramage, 2022). Due to limited access to resources, providing hands on STEM programs and female role models/mentors for traditionally underrepresented girls of color is challenging. Practitioners must use innovative ways to tap into exist-

ing resource banks. Without a change to the current status quo, girls and traditionally underrepresented groups will continue to face barriers to accessing STEM careers. Limited access to careers in STEM related fields directly affects the earning potential for students. This supports a cycle of lack (Limited Female STEM Professionals - Limited Role Models/Mentors - Limited new STEM Professionals). This issue is further compounded by a lack of K12 teachers in STEM fields.

In 2022, school districts across the United States continued to experience a critical shortage of teachers. Earlier this year, the state of Illinois had over 2000 teaching positions that were vacant or filled with "less than qualified" staff. Last year, Tennessee reported more than 1000 unfilled vacancies and the Tennessee Department of Education issued 1354 emergency teaching credentials. These credentials allowed Tennessee educators to teach without a license. According to the Wall Street Journal, the demands of staffing shortages, COVID (safety) protocols, political battles over what can be taught and issues related to school violence have led to the mass exodus of teachers. According to the U.S. Bureau of Labor Statistics (Torpey, 2018), more than 270,000 primary and secondary education teachers are expected to leave the profession each year, on average, from 2016 to 2026.

Decades of data indicate that teachers have the greatest impact on student achievement. Opper suggests that a student's academic success is related to their teachers' on the job performance. Per Opper, this factor is two to three times more impactful than any school related factor. In this study, long-term teacher performance was examined. However, the impact of long-term student support was not addressed (Opper, 2019). Unfilled teacher vacancies hinder a school district's capacity to provide students with highly qualified teachers. This in turn negatively affects student achievement.

According to the U.S. Department of Education, preexisting teacher shortages in critical areas such as science, technology, engineering, and math (STEM) were further impacted by the COVID-19 pandemic. "These shortages impact educational opportunity for students, and research shows that educator shortages disproportionately impact students of color, students from low-income backgrounds, students with disabilities, and students from rural communities" (USDOE Fact-sheet, 2022).

In additional to providing students with the necessary requisite skill to achieve in STEM related careers, they also need the additional support that programming, mentoring and increased STEM identity initiatives supply.

Researchers have identified components of an effective K-12 STEM program. In "Pathways to effective K-12 STEM programs" an interdisciplinary approach in STEM to develop factual, procedural, conceptual, and meta-knowledge problem-solving, analytical, critical thinking, teamwork, and communication skills for students' and teachers' at a public university were examined.

The study did not examine long-term interventions or the impact of social/family support (Akerson et al., 2018, Kimmel et al., 2015).

3. STEM/STEAM/STEMM Model

Terms:

STEM (Science, Technology, Engineering, and Math)

STEAM (Science, Technology, Engineering, Art, and Math)

STEMM (Science, Technology, Engineering, Math, and Medicine)

The model presented can be used for any content discipline (for example, math, reading, science, etc.) but for the purpose of this model, it will focus on STEM.

The current model identifies components that may be effective in the recruitment, empowerment and retention of females in the field of STEM. The components of the current model include mentoring, parental support, collaboration with external stakeholders, and engagement in a STEM learning environment.

Target Population: female students in grades 4 - 6 who will be tracked from Elementary/middle School to College and then to career.

Component 1: STEM/STEAM/STEMM mentor/role models

Having a mentor/role model who shares similar personal and academic interests can empower an individual. The mentor/role model can share the importance of the four W's: What, When, Why and Where.

What inspired them to go into STEM? When did they become interested in STEM? Why STEM is important? Moreover, where they went to college and later obtained a job in the field of STEM?

Having a mentor/role model to share personal stories will allow the students to witness and be encouraged by the STEM journey of others.

Component 2: Parental Support

A Parents role is integral in supporting and sustaining a student's interest in the field of STEM. STEM is a field that is often male dominated. A Parent's encouragement is vitally important. It is also important for the parent to maintain a constant presence especially during the K-12 years.

Component 3: Collaboration with External stakeholders

K-12 schools, colleges and universities, STEM related industries, churches, and non-profit organizations are important external stakeholders. It is important to engage all stakeholders in the conversation and have them actively engaged with the students STEM journey. Shadowing experiences, internships, and similar types of engagement are crucial in keeping students interested in STEM.

Component 4: Engagement in STEM related environments

STEM learning could occur after school, on Saturdays, during traditional field trips, virtual field trips, when attending a STEM related movie and discussing its impact on the world, visiting a museum, participating in a STEM summer program, etc. Students will have the opportunity to participate in STEM activities that they view as fun and exciting.

4. Research Methodology

The goal of this proposed model is to increase the number of females entering into STEM careers by providing mentoring, parental support, collaboration with

external stakeholders, and engagement in a STEM learning environment.

The following problems will be addressed:

1) What are the factors that contribute to an underrepresentation of females in STEM professions?

2) What are the factors that contribute to an underrepresentation of females of color in STEM professions?

3) What is the impact of long-term mentoring and support on increasing the number of females in STEM fields?

4) What is the impact of long-term parental support on increasing the number of females in STEM fields?

This STEM model will use a longitudinal design to discover the effect that various components have on the likelihood of female participants pursuing STEM careers after graduating from college.

4.1. Participants

Twenty female participants will be recruited from local elementary/middle schools in grades four through six.

4.2. Instruments

Students will be administered the "About the Student Attitudes toward STEM Survey (S-STEM)". The Upper Elementary (4-5th) and Middle/High School (6-12th) S-STEM Surveys are intended to measure changes in students' confidence and efficacy in STEM subjects, 21st century learning skills, and interest in STEM careers (*About the Student Attitudes toward STEM Survey (S-STEM) - Friday Institute for Educational Innovation*, n.d.). Yearly, parents will be administered the "STEAM4U questionnaire for PARENTS Structure (n.d.)." The parent survey will assess:

- Parents' self-efficacy in STEM and its variation from their participation in the activity/initiative.
- Family self-efficacy in STEM and its variation from their participation in the activity/initiative.
- Parents' perception of the variation of their student's self-efficacy in STEM.
- Other variables related with self-efficacy and STEM awareness and their variation and
- The extent in which the challenge has been implemented (STEAM4U Questionnaire for PARENTS Structure, n.d.).

The surveys are available to help program coordinators make decisions about possible improvements to their program. A mixed method design will include having all participants complete traditional yearly surveys, interviews and questionnaires. The survey will collect information from a wide range of relevant areas including race, grade level, school type, etc.

4.3. Procedure

- Submit research study to local schoolboard IRB for approval.

- Contact school principals and arrange a virtual or face-to-face meeting to discuss the project.
- Receive approval from the principals.
- Teachers from the identified grade levels will receive a letter explaining the project and will nominate 3 to 4 female students to participate in the STEM project.
- After receiving the list of the nominated students, the students and parents will receive an invitation to an information session to discuss the project.
- After the information session, an electronic interview invite will be sent to each prospective female student and parent to sign up for an interview.
- The interview team will interview each participant and rate them based upon STEM interest.
- After the interviews, twenty female students will be notified. Other students will be added to a waiting list.
- Each participant and parent and/or guardian will sign a consent form to participate in the program.
- After all documentation is received from each participant and parent, each participant, parent, principal and teacher will receive a confirmation letter of participation.
- The STEM female cohort will begin the program.
- If a student leaves the program, a student from the waiting list will be added. Every effort will be made to keep the cohort at 20 students.
- For students who leave the program, an exit interview will be given to determine why they left. Data will be used to inform ongoing program effectiveness.
- When students enter college/university, they will enter the program's college/university STEM Network. Monthly support will be provided with mentoring, university STEM support, collaboration with external stakeholders, and engagement in a STEM learning environment.
- When students graduate from college/university, they will enter the program's Graduate STEM Network. For five (5) years, monthly support will be provided with mentoring, STEM support and collaboration with external stakeholders.
- If a graduate leaves the STEM profession, an exit interview will be given to determine why they left. Data will be used to inform ongoing program effectiveness.

4.4. Intellectual Merit

The goal of this model is to increase the number of girls entering into STEM fields. This model can potentially advance knowledge in the fields of Education, STEM, Equity, Diversity and Inclusion, Counseling and Public Policy. In addition, it potentially influences colleges/universities, school districts and state/federal entities. It also has implications for program developers due to the impact that the research has on college and career impact and readiness. This model can be re-

searched and replicated for other content areas.

4.5. Broader Impacts

The broader impacts of this model include changes in programming and counseling practices. Additional impacts include, increased student interest in STEM; retention and progress of students in STEM; broadening and strengthening faculty research efforts to leverage additional funding and collaborations to increase efforts regarding STEM.

Overall, the potential of the proposed activity to benefit society and contribute to the achievement of specific desired societal outcomes include:

- Increased student interest in STEM;
- Increased participation of students in STEM related fields;
- Improved professional development;
- Development of a diverse, globally competitive STEM related workforce;
- Use of STEM Educator best practices to inform public policy;
- Decreased gender disparities in STEM.

5. Conclusion

Research has identified the benefits of mentoring, parental support, collaboration with external stakeholders, and engagement in a STEM learning environment. As STEM related careers continue to expand globally, it is important that innovative and creative approaches be utilized to encourage females to enter STEM fields. This model utilizes researched best practices with ongoing K12 support. Additionally, support is provided throughout the students K16 experience and beyond.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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