REL Southwest Ask-A-REL Response

October 2017

Questions:

1. **What practices have been shown to be successful in influencing students' aspirations in STEM fields?**

2. **Are there STEM career awareness programs that have proven to be more effective than other programs in promoting STEM majors or employment in a STEM-related field for low income, Hispanic, and other minority students?**

Background:

"The term 'STEM education' refers to teaching and learning in the fields of science, technology, engineering, and mathematics. It typically includes educational activities across all grade levels— from pre-school to post-doctorate—in both formal (e.g., classrooms) and informal (e.g., afterschool programs) settings."[1] Hispanics remain underrepresented in the key fields of science, technology, engineering, and math.[2] "In Texas, which has a large Hispanic population, the state has launched a number of initiatives to increase Hispanic STEM achievement, but research is needed to assess the initiatives' impact. To address this critical need, the Texas Hispanic STEM Research Alliance is examining factors related to improving Hispanic student participation, achievement, and advancement in STEM courses and careers. Alliance work includes refining the research agenda and supporting the use of data and evidence to improve practice, policy, and student outcomes. In addition, the alliance is building the capacity of Texas educators, stakeholders, and policymakers to understand and apply data and research evidence."[3]

Response:

Following an established REL Southwest research protocol, we conducted a search for research reports as well as descriptive study articles on programs and practices that promote STEM awareness, majors, and/or careers. The sources included ERIC and other federally funded

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[1] Gonzalez, H. B. & Kuenzi, J. J. (2012). The Congressional Research Service (USA) has published a STEM primer. Congressional Research Service. CRS Report for Congress.

[2] Education Supports Racial and Ethnic Equality in STEM: Executive Summary (2011), U.S. Department of Commerce, Economics and Statistics Administration.

[3] Texas Hispanic STEM Research Alliance—http://relsouthwest.sedl.org/research-alliances/texas_hispanic_stem.html

databases and organizations, research institutions, academic research databases, and general Internet search engines (For details, please see the methods section at the end of this memo.)

We have not evaluated the quality of references and the resources provided in this response. We offer them only for your reference. Also, we searched the references in the response from the most commonly used resources of research, but they are not comprehensive and other relevant references and resources may exist.

Research References

Question 1: What practices have been shown to be successful in influencing students' aspirations in STEM fields?

Christensen, R. & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science, Environment and Health*, *3*(1), 1-13. https://eric.ed.gov/?id=EJ1125793

From the ERIC abstract: "Understanding middle school students' perceptions regarding STEM dispositions, and the role attitudes play in establishing STEM career aspirations, is imperative to preparing the STEM workforce of the future. Data were gathered from more than 800 middle school students participating in a hands-on, real world application curriculum to examine the relationship of the students' interest in STEM and their intentions to pursue a career in a STEM field. Among the middle school students who completed surveys for the MSOSW project, 46.6% expressed a desire to pursue a career in STEM at the time of the post test. Regarding alignment of positive interest in STEM with intent to purse a STEM career, middle school students who have stated that they plan to pursue a career in STEM, also show higher dispositions toward STEM and STEM career measures. Gender differences were also examined, resulting in the finding that middle school males generally have greater intent to pursue a career in STEM, and also show more positive interest in STEM areas. However, females appear to more positively react to the project activities presented in this study than males, so over the course of a project year females tend to "catch up." This is true regarding assessed STEM interest as well as stated intent to pursue a career in STEM. These findings provide additional contributions to the growing base of knowledge about the importance of middle school aspirations for STEM careers."

DiBenedetto, C. A., Easterly, R. G., III & Myers, B. E. (2015). Can scientific reasoning scores predict the likelihood of SBAE students' intent to pursue a STEM career, a career in agriculture, or plan to attend college? *Journal of Agricultural Education*, *56*(1), 103-115. https://eric.ed.gov/?id=EJ1122828

From the ERIC abstract: "Demands placed on teachers and students continue to increase in order to develop the skills required of the 21st century workforce. There continues to be a need to utilize curriculum and instruction to inspire students to engage in STEM majors and careers. Improving instructional methods and providing opportunities for students to question and problem solve, through the use of inquiry-based instruction (IBI) can increase scientific reasoning abilities. This instructional approach may assist in improving, not only the academic achievement of students, but it may encourage students

to plan to attend college and develop potential career aspirations for agriculture and STEM. This research used the scientific reasoning scores from 663 students enrolled nationwide in school-based agricultural education programs (SBAE) to predict students' likelihood to indicate plans to pursue a career in agriculture, STEM or plan to attend college. The findings reveal scientific reasoning scores predict students' likelihood to indicate intention to pursue a STEM career and plan to pursue college. Implications from this research suggest SBAE instructors should continue their efforts to incorporate IBI into instruction in order to engage students to think critically and solve real world problems, while exposing students to the skills requisite for STEM major/career access."

Duran, M., Höft, M., Lawson, D. B., Medjahed, B. & Orady, E. A. (2014). Urban high school students' IT/STEM learning: Findings from a collaborative inquiry- and design-based afterschool program. *Journal of Science Education and Technology*, *v23*(1), 116-137. https://eric.ed.gov/?id=EJ1038289

From the ERIC abstract: "This exploratory study examines the impact of a collaborative inquiry- and design-based afterschool program on urban high school students' IT/STEM learning--using information technology (IT) within the context of science, technology, engineering, and mathematics (STEM). The study used a mixed methods design, involving 77 participants within two cohort groups, each participating in an eighteen-month intervention period. Data were collected from the pre- and post-surveys, analysis of the participants' IT/STEM projects, external evaluation reports, and follow-up interviews. Findings indicate that the program had a significant impact on students' technology and IT/STEM skills, frequency of technology use, and understanding of IT use in STEM-oriented fields. Some degree of impact on attitude changes toward IT/STEM and career aspirations in these fields was also in evidence. The study demonstrates that IT/STEM experiences supported through technology-enhanced, inquiry- and design-based collaborative learning strategies have significant impact on urban high school students' IT/STEM learning. Effect of afterschool programs on attitude changes and IT/STEM-related career aspirations of urban high school students are recommended areas of further investigation."

Grossman, J. M. & Porche, M. V. (2014). Perceived gender and racial/ethnic barriers to STEM success. *Urban Education*, *49*(6), 698-727. https://eric.ed.gov/?id=EJ1035210

From the ERIC abstract: "This mixed-methods study examined urban adolescents' perceptions of gender and racial/ethnic barriers to STEM (science, technology, engineering, and mathematics) success, and their meaning-making and coping regarding these experiences. The sample includes surveys from 1024 high school-aged students and interviews from 53 students. Logistic analysis showed that higher science aspirations significantly predicted perceived support for girls and women in science. Analysis of interviews showed themes of microaggressions, responses to microaggressions, and gender- and race-based support. Findings suggest participants vary in perceptions of barriers, yet are generally optimistic about overcoming such obstacles."

Means, B., Wang, H., Young, V., Peters, V. L. & Lynch, S. J. (2016). STEM-focused high schools as a strategy for enhancing readiness for postsecondary STEM programs. *Journal of Research in Science Teaching*, *53*(5), 709-736. https://eric.ed.gov/?id=EJ1096580

From the ERIC abstract: "The logic underlying inclusive STEM high schools (ISHSs) posits that requiring all students to take advanced college preparatory STEM courses while providing student-centered, reform-oriented instruction, ample student supports, and real-world STEM experiences and role models will prepare and inspire students admitted on the basis of STEM interest rather than prior achievement for postsecondary STEM. This study tests that logic model by comparing the high school experiences and achievement of students in ISHSs and comparison schools in North Carolina. After identifying ISHS and non-STEM comparison high schools serving students who were similar in terms of socioeconomic status and academic achievement prior to high school entry, we employed propensity-score weighting and HLM modeling to estimate the impact of attending an ISHS on a set of outcome measures obtained from student surveys and from the state's longitudinal student data system. Analyses of student survey data found that attending an ISHS raises the likelihood that a student will complete pre-calculus or calculus and chemistry in high school, leads to increased involvement in STEM extracurricular and out-of-class activities, and enhances interest in science careers and aspirations to earn a master's or higher degree. Analyses of student outcome data from state administrative records revealed a positive impact of inclusive STEM high school attendance on grade point average (GPA) but not on ACT scores."

Peterman, K., Kermish-Allen, R., Knezek, G., Christensen, R. & Tyler-Wood, T. (2016). Measuring student career interest within the context of technology-enhanced STEM projects: A cross-project comparison study based on the career interest questionnaire *Journal of Science Education and Technology*, *25*(6), 833-845. https://eric.ed.gov/?id=EJ1122250

From the ERIC abstract: "This article describes Energy for ME and Going Green! Middle Schoolers Out to Save the World, two Science, Technology, Engineering, and Mathematics (STEM) education programs with the common goal of improving students' attitudes about scientific careers. The authors represent two project teams, each with funding from the National Science Foundation's ITEST program. Using different approaches and technology, both projects challenged students to use electricity monitoring system data to create action plans for conserving energy in their homes and communities. The impact of each project on students' career interests was assessed via a multi-method evaluation that included the Career Interest Questionnaire (CIQ), a measure that was validated within the context of ITEST projects and has since become one of the instruments used most commonly across the ITEST community. This article explores the extent to which the CIQ can be used to document the effects of technology-enhanced STEM educational experiences on students' career attitudes and intentions in different environments. The results indicate that the CIQ, and the Intent subscale in particular, served as significant predictors of students' self-reported STEM career aspirations across project context. Results from each project also demonstrated content gains by students and demonstrated the impact of project participation and gender on student outcomes. The authors conclude that the CIQ is a useful tool for providing empirical evidence to

document the impact of technology-enhanced science education programs, particularly with regard to Intent to purse a STEM career. The need for additional cross-project comparison studies is also discussed."

Peterson, B., Bornemann, G., Lydon, C. & West, K. (2015). Rural students in Washington state: STEM as a strategy for building rigor, postsecondary aspirations, and relevant career opportunities. *Peabody Journal of Education*, *90*(2), 280-293. https://eric.ed.gov/?id=EJ1059569

From the ERIC abstract: "In rural settings, leaving for college can mean a young person's first step in leaving home forever (Sherman & Sage, 2011). That presents a serious challenge for college recruiters as they ask parents from Indian reservations or close-knit Hispanic or rural farming communities to allow their children to consider postsecondary opportunities. In this article, the authors discuss impediments to college-going that rural students face and shine a light on several efforts in central Washington State that help students connect to job opportunities in fast-growing, lucrative STEM (science, technology, engineering, and mathematics) careers in the region. Beyond inviting STEM professionals to job fairs, these efforts can expand opportunities for collaboration between STEM professionals and rural schools and teachers. Such opportunities might include enriching the K-12 curriculum with locally relevant problems of science, using local STEM professionals to collaborate on learning projects, and possibly engaging students to contribute to national databases and studies. These programs represent one way to highlight the real-world application of postsecondary education, encouraging students to pursue STEM college programs and careers."

Sahin, A., Gulacar, O. & Stuessy, C. (2015). High school students' perceptions of the effects of international science Olympiad on their STEM career aspirations and twenty-first century skill development. *Research in Science Education*, *45*(6), 785-805. https://eric.ed.gov/?id=EJ1088142

From the ERIC abstract: "Social cognitive theory guided the design of a survey to investigate high school students' perceptions of factors affecting their career contemplations and beliefs regarding the influence of their participation in the international Science Olympiad on their subject interests and twenty-first century skills. In addition, gender differences in students' choice of competition category were studied. Mixed methods analysis of survey returns from 172 Olympiad participants from 31 countries showed that students' career aspirations were affected most by their teachers, personal interests, and parents, respectively. Students also indicated that they believed that their participation in the Olympiad reinforced their plan to choose a science, technology, engineering, and mathematics (STEM) major at college and assisted them in developing and improving their twenty-first century skills. Furthermore, female students' responses indicated that their project choices were less likely to be in the engineering category and more likely to be in the environment or energy categories. Findings are discussed in the light of increasing the awareness of the role and importance of Science Olympiads in STEM career choice and finding ways to attract more female students into engineering careers."

Sax, L. J., Kanny, M. A., Riggers-Piehl, T. A., Whang, H. & Paulson, L. N. (2015). "But I'm Not Good at Math": The Changing Salience of Mathematical Self-Concept in Shaping Women's and Men's STEM Aspirations. *Research in Higher Education*, 56(8), 813-842. https://eric.ed.gov/?id=EJ1081229

From the ERIC abstract: "Math self-concept (MSC) is considered an important predictor of the pursuit of science, technology, engineering and math (STEM) fields. Women's underrepresentation in the STEM fields is often attributed to their consistently lower ratings on MSC relative to men. Research in this area typically considers STEM in the aggregate and does not account for variations in MSC that may exist between STEM fields. Further, existing research has not explored whether MSC is an equally important predictor of STEM pursuit for women and men. This paper uses a national sample of male and female entering college students over the past four decades to address how MSC varies across STEM majors over time, and to assess the changing salience of MSC as a predictor of STEM major selection in five fields: biological sciences, computer science, engineering, math/statistics, and physical sciences. Results reveal a pervasive gender gap in MSC in nearly all fields, but also a great deal of variation in MSC among the STEM fields. In addition, the salience of MSC in predicting STEM major selection has generally become weaker over time for women (but not for men). Ultimately, this suggests that women's lower math confidence has become a less powerful explanation for their underrepresentation in STEM fields."

VanMeter-Adams, A., Frankenfeld, C. L., Bases, J., Espina, V. & Liotta, L. A. (2014). Students who demonstrate strong talent and interest in STEM are initially attracted to STEM through extracurricular experiences. *CBE - Life Sciences Education*, *13*(4), p687-697. https://eric.ed.gov/?id=EJ1047232

From the ERIC abstract: "What early experiences attract students to pursue an education and career in science, technology, engineering, and mathematics (STEM)? Does hands-on research influence them to persevere and complete a major course of academic study in STEM? We evaluated survey responses from 149 high school and undergraduate students who gained hands-on research experience in the 2007-2013 Aspiring Scientists Summer Internship Programs (ASSIP) at George Mason University. Participants demonstrated their strong interest in STEM by volunteering to participate in ASSIP and completing 300 h of summer research. The survey queried extracurricular experiences, classroom factors, and hands-on projects that first cultivated students' interest in the STEM fields, and separately evaluated experiences that sustained their interest in pursuing a STEM degree. The majority of students (65.5%, $p < 0.0001$) reported extracurricular encounters, such as the influence of a relative or family member and childhood experiences, as the most significant factors that initially ignited their interest in STEM, while hands-on lab work was stated as sustaining their interest in STEM (92.6%). Based on these findings collected from a cohort of students who demonstrated a strong talent and interest in STEM, community-based programs that create awareness about STEM for both children and their family members may be key components for igniting long-term academic interest in STEM."

Wyss, V. L., Heulskamp, D. & Siebert, C. J. (2012). Increasing middle school student interest in STEM careers with videos of scientists. *International Journal of Environmental and Science Education, 7*(4), 501-522. https://eric.ed.gov/?id=EJ997137

From the ERIC abstract: Students are making choices in middle school that will impact their desire and ability to pursue STEM careers. Providing middle school students with accurate information about STEM (Science, Technology, Engineering, Mathematics) careers enables them to make more knowledgeable choices about courses of study and career paths. Practical ways of helping students understand the nature of science careers are limited. This study investigates using video interviews of STEM professionals as a method for better informing students about STEM career possibilities. ANCOVA analysis was used to compare treatment and comparison student interest in pursuing STEM careers before and after viewing video interviews with STEM professionals. Evidence for implementing video interviews as a way to interest middle school students in pursuing STEM careers exists. No gender differential in interest in STEM was detected. (Contains 5 tables.)

Question 2: Are there STEM career awareness programs that have proven to be more effective than other programs in promoting STEM majors or employment in a STEM-related field for low income, Hispanic, and other minority students?

Carpi, A., Ronan, D. M., Falconer, H.M. & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, *54*(2), 169-194. https://eric.ed.gov/?id=EJ1126228

From the ERIC abstract: "In this study, Social Cognitive Career Theory (SCCT) is used to explore changes in the career intentions of students in an undergraduate research experience (URE) program at a large public minority-serving college. Our URE model addresses the challenges of establishing an undergraduate research program within an urban, commuter, underfunded, Minority-Serving Institution (MSI). However, our model reaches beyond a focus on retention and remediation toward scholarly contributions and shifted career aspirations. From a student's first days at the College to beyond their graduation, we have encouraged them to explore their own potential as scientists in a coordinated, sequential, and self-reflective process. As a result, while the program's graduates have traditionally pursued entry-level STEM jobs, graduates participating in mentored research are increasingly focused on professional and academic STEM career tracks involving post-graduate study. In addition to providing an increasingly expected experience and building students' skills, participation in undergraduate research is seen to have a transformative effect on career ambitions for many students at MSIs. While undergraduate research is often thought of in context of majority-serving institutions, we propose that it serves as a powerful equalizer at MSIs. Building on the institutional characteristics that drive diversity, our students produce scholarly work and pursue graduate degrees, in order to address the long-standing under-representation of minorities in the sciences."

Charleston, L. J. (2012). A qualitative investigation of African Americans' decision to pursue computing science degrees: Implications for cultivating career choice and aspiration. *Journal of Diversity in Higher Education*, 5(4), 222-243. https://eric.ed.gov/?id=EJ989320

From the ERIC abstract: "According to Pearson (2002), minority groups are not well represented in science, technology, engineering, and mathematics (STEM) occupations. Among these underrepresented groups are African Americans. To ensure the economic vitality of the STEM workforce in the United States, it is imperative to broaden participation in STEM-related fields and computing sciences in particular (J. F. L. Jackson, Charleston, George, & Gilbert, in press; Moore, 2006; Pearson, 2002). Using the method of grounded theory, the author illuminates the experiences of African American computing aspirants at various levels of academic status (bachelor's, master's, and PhD levels). In doing so, this study identifies the key factors that contribute to study participants' successful pursuit of computing science degrees, thereby pointing toward implications for cultivating occupational choice and career aspirations. Study results include a heuristic model for broadening computing participation. (Contains 1 figure.)"

Falco, L. D. (2017). The School Counselor and STEM Career Development. *Journal of Career Development*, *44*(4), 359-374 https://eric.ed.gov/?id=EJ1148044

From the ERIC abstract: "There is an increasing concern that the demand for science, technology, engineering, and math (STEM) workers in the United States will exceed the supply. In the United States, very few students, and underrepresented students in particular, are pursuing STEM educational and occupational goals that underscores the need for school counselors to understand how to maximize opportunities for student success in STEM. Understanding the factors that influence students' academic and career choices early on is necessary in order to provide effective interventions and responsive services that will have a positive impact on students' future STEM career outcomes. Using social-cognitive career theory as a framework, this article synthesizes pertinent research on student STEM engagement, so that school counselors will be better able to support STEM career development for all students, especially those from historically underrepresented groups. Implications for school counseling practice are discussed."

Rodgers, K., Blunt, S. & Trible, L. (2014). A real PLUSS: An intrusive advising program for underprepared STEM students. *NACADA Journal*, *34*(1), 35-42. https://eric.ed.gov/?id=EJ1044322

From the ERIC abstract: "Increasing numbers of underprepared students are admitted to colleges and universities with aspirations of earning a degree in a science, technology, engineering, or mathematics (STEM) discipline. Transitioning to college is difficult for all students, but can be especially challenging for the underprepared STEM student. Many of these students are capable of completing STEM degrees if given additional support during their first-year advising sessions as well as opportunities to strengthen their foundational knowledge prior to enrolling in major-level course work. Pathways Leading to Undergraduate Success in the Sciences (PLUSS) is an intrusive advising program the University of Southern Indiana designed to provide at-risk undergraduate

STEM majors with increased academic support. The PLUSS program is associated with increased retention rates."

Additional Organizations to Consult

The U.S. Department of Education—https://www.ed.gov/

Office of Innovation and Improvement: Science, Technology, Engineering and Math (STEM)—https://innovation.ed.gov/what-we-do/stem/

Hispanic-Serving Institutions - Science, Technology, Engineering, or Mathematics and Articulation Programs—
https://www2.ed.gov/programs/hsistem/index.html

From the program description: "The purpose of the Hispanic-Serving Institutions - Science, Technology, Engineering, or Mathematics (HSI STEM) and Articulation Programs is to: (1) increase the number of Hispanic and other low-income students attaining degrees in the fields of science, technology, engineering, or mathematics; and (2) to develop model transfer and articulation agreements between two-year and four-year institutions in such fields."

Minority Science and Engineering Improvement Program—
https://www2.ed.gov/programs/iduesmsi/index.html

From the program description: "This program assists predominantly minority institutions in effecting long-range improvement in science and engineering education programs and increasing the flow of underrepresented ethnic minorities, particularly minority women, into science and engineering careers."

Resources for STEM Education, April 17, 2017—
https://innovation.ed.gov/files/2017/04/Resources_for_STEM_Education.pdf

Science, Technology, Engineering and Math: Education for Global Leadership—
https://www.ed.gov/Stem

Methods

Keywords and Search Strings

The following keywords and search strings were used to search the reference databases and other sources:

STEM aspiration

STEM careers

Databases and Resources

We searched ERIC for relevant resources. ERIC is a free online library of over 1.6 million citations of education research sponsored by the Institute of Education Sciences. Additionally, we searched Google Scholar and PsychInfo.

Reference Search and Selection Criteria

When we were searching and reviewing resources, we considered the following criteria:

Date of the publication: References and resources published for last 15 years, from 2001 to present, were include in the search and review.

Search Priorities of Reference Sources: Search priority is given to study reports, briefs, and other documents that are published and/or reviewed by IES and other federal or federally funded organizations, academic databases, including ERIC, EBSCO databases, JSTOR database, PsychInfo, PsychArticle, and Google Scholar.

Methodology: Following methodological priorities/considerations were given in the review and selection of the references: (a) study types – randomized control trials, quasi experiments, surveys, descriptive data analyses, literature reviews, policy briefs, etc., generally in this order (b) target population, samples (representativeness of the target population, sample size, volunteered or randomly selected, etc.), study duration, etc. (c) limitations, generalizability of the findings and conclusions, etc.

This memorandum is one in a series of quick-turnaround responses to specific questions posed by stakeholders in the Southwest Region (Arkansas, Louisiana, New Mexico, Oklahoma, and Texas), which is served by the Regional Educational Laboratory (REL) Southwest at SEDL. This memorandum was prepared by REL Southwest under a contract with the U.S. Department of Education's Institute of Education Sciences (IES), Contract ED-IES-12-C-0012, administered by SEDL. Its content does not necessarily reflect the views or policies of IES or the U.S. Department of Education nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.