REL Appalachia Ask A REL Response

Math; Educator Effectiveness
June 2019

Question:

How does a STEM (science, technology, engineering, and mathematics) or STEAM (science, technology, engineering, art, and mathematics) approach to gifted programs affect students' math or science outcomes and their attitudes about math and science?

Response:

Thank you for your request to our REL Reference Desk regarding evidence-based information about a STEM or STEAM approach to gifted programs. Ask A REL is a collaborative reference desk service provided by the 10 Regional Educational Laboratories (RELs) that, by design, functions much in the same way as a technical reference library. Ask A REL provides references, referrals, and brief responses in the form of citations in response to questions about available education research.

Following an established REL Appalachia research protocol, we searched for peer-reviewed articles and other research reports on STEM or STEAM gifted programs. We focused on identifying resources that specifically addressed the effects of a STEM or STEAM approach to gifted programs in middle and high school on students' math or science outcomes and their attitudes about math and science. The sources included ERIC and other federally funded databases and organizations, research institutions, academic research databases, and general Internet search engines. For more details, please see the methods section at the end of this document.

The research team did not evaluate the quality of the resources provided in this response; we offer them only for your reference. Also, the search included the most commonly used research databases and search engines to produce the references presented here, but the references are not necessarily comprehensive, and other relevant references and resources may exist. References are listed in alphabetical order, not necessarily in order of relevance.

References

Gadanidis, G., Hughes, J., & Cordy, M. (2011). Mathematics for gifted students in an arts- and technology-rich setting. *Journal for the Education of the Gifted*, *34*(3), 397–433. Retrieved from

https://www.researchgate.net/publication/254113711_Mathematics_for_Gifted_Students_in_an_Arts_and_Technology-Rich_Setting

From the abstract: "In this paper we report on a study of a short-term mathematics program for grade 7–8 gifted students that integrated open-ended mathematics tasks with the arts (poetry and drama) and with technology. The program was offered partially online and partially in a classroom setting. The study sought to investigate (a) students' perceptions of their school-based mathematics experience, (b) students' perceptions of the program we offered, and (c) students' mathematical thinking while engaged in the activities of our program. The study provides insights into the design of challenging mathematics experiences for gifted students, the integration of the arts with mathematics, and the use of technology in mathematics teaching and learning."

Gubbins, E. J., Villanueva, M., Gilson, C. M., Foreman, J. L., Bruce-Davis, M. N., Vahidi, S.,…Tofel-Grehl, C. (2013). *Status of STEM high schools and implications for practice*. Storrs, CT: The National Research Center on the Gifted and Talented. Retrieved from https://nrcgt.uconn.edu/wp-content/uploads/sites/953/2015/04/STEM_eBook.pdf

From the introduction: "To learn more about current STEM high schools across the country, the United States Department of Education commissioned The National Research Center on the Gifted and Talented (NRC/GT) to design and implement a study of STEM high schools. The University of Connecticut and the University of Virginia collaborated to address the following project objectives: (1) To create a searchable matrix of STEM high schools throughout the country listing pertinent variables about the identification, curricular, instructional, and professional development variables. (2) To document the common and unique curricular and instructional strategies used in STEM high schools by conducting onsite observations, interviews, and focus groups of selected high schools. (3) To create and disseminate an online or mail surveys for high school administrators and teachers documenting the curricular and instructional strategies used in high schools throughout the country."

Ihrig, L. M., Lane, E., Mahatmya, D., & Assouline, S. G. (2018). STEM excellence and leadership program: Increasing the level of STEM challenge and engagement for high-achieving students in economically disadvantaged rural communities. *Journal for the Education of the Gifted*, *41*(1), 24–42. Abstract retrieved from https://eric.ed.gov/?id=EJ1169072

From the abstract: "High-achieving students in economically disadvantaged, rural schools lack access to advanced coursework necessary to pursue science, technology, engineering, and mathematics (STEM) educational and employment goals at the highest levels, contributing to the excellence gap. Out-of-school STEM programming offers one pathway to students' talent development. Using a concurrent triangulation mixed-methods research design, this study was conducted to evaluate the experiences of 78 high-achieving students and their 32 teachers, participating in an extracurricular, school-based, STEM talent development program for rural students from economically disadvantaged communities. Findings suggest that students and teachers expressed satisfaction with program participation and that they thought more creatively and critically about their work. Results

also showed that students' perceptions of the mathematics and science activities were significantly different, which informs ways to improve programming for future high-achieving, rural students. These findings expand the literature supporting the use of informal STEM education environments for underserved gifted populations to increase engagement in and access to challenging curricula."

Robinson, A., Dailey, D., Hughes, G., & Cotabish, A. (2014). The effect of a science-focused STEM intervention on gifted elementary students' science knowledge and skills. *Journal of Advanced Academics*, *25*(3), 189–213. Abstract retrieved from https://eric.ed.gov/?id=EJ1039758

From the abstract: "To develop Science, Technology, Engineering, and Mathematics (STEM) talents, both researchers and policy developers recommend that educators begin early. In this randomized study, we document the efficacy of teacher professional development and a rich problem-based inquiry curriculum to develop the science talent of elementary students. The intervention, STEM Starters, a federally funded Jacob K. Javits project, provided sustained and embedded professional development to classroom teachers and to pull-out gifted program teachers to support the implementation of a problem-based curriculum in their classrooms. During the intervention, randomly assigned teachers participated in 120 hr of professional development that focused on science content, inquiry-based instruction, technological applications, and differentiated instruction within problem-based curriculum units. Statistically significant gains in science process skills, science concepts, and science content knowledge were found among gifted students in the treatment group when compared with gifted students in the comparison group."

Subotnik, R. F., Tai, R. H., Rickoff, R., & Almarode, J. (2010). Specialized public high schools of science, mathematics, and technology and the STEM pipeline: What do we know now and what will we know in 5 years? *Roeper Review*, *32*, 7–16. Retrieved from https://eric.ed.gov/?id=EJ882061

From the abstract: "Specialized public high schools of science, mathematics, and technology are commonly viewed as the 'crown jewel' of their respective school districts and, many times, of their respective states. These schools are intended to coalesce the most academically talented, science-focused students in each district or state and typically draw excellent teachers as well. As the nation considers policies to address Science, Technology, Engineering, and Mathematics (STEM) education issues, options for additional functions are likely to arise. Currently no existing studies provide a comprehensive analysis of the contribution these schools make over and above regular high schools to the STEM pipeline. This article presents the extant literature on variables that have been shown to predict participation in STEM careers on the part of adolescents in and out of specialized high schools. The literature review is followed by a description of a recently embarked 3-year National Science Foundation (NSF)-sponsored study designed to answer the following questions: Are specialized STEM high-school graduates more likely to remain in the STEM pipeline than students with similar achievement and interests who attended regular public high schools? Which educational/instructional practices used by specialized STEM high

schools are associated with higher STEM pipeline retention rates in college and higher rates of entrance into STEM-related professions?"

Wilson, H. E., & Zoellner, B. (2016). Effectiveness of a constructivist-based science camp for gifted secondary students. *Journal of Research in Education, 26*(1), 76–108. Retrieved from https://eric.ed.gov/?id=EJ1118479

From the abstract: "Constructivist-based pedagogy is particularly applicable to gifted secondary students in the sciences due to the increased background knowledge of the population and the nature of the study of science. This research was an investigation of the effectiveness of a residential constructivist-based summer learning experience in aquatic biology and biomedicine for gifted secondary students. Both quantitative and qualitative approaches were used to analyze the data. Quantitative analyses showed that the program significantly increased both scientific knowledge and conceptual understanding of science among participants. There was no change in academic self-concept of the participants. Qualitative results supported these findings and demonstrated the importance of social relationships for program effectiveness. These results have implications for researchers in constructivist theory, science, and gifted education."

Additional Ask A REL Responses to Consult

Ask A REL Midwest at American Institutes for Research. (2018). *What research exists on the implementation of STEM programs in middle school? What does the research say about the components of effective STEM programs in middle school, such as curriculum materials?* Retrieved from https://ies.ed.gov/ncee/edlabs/regions/midwest/askarel/2018/middle-school-STEM.aspx

Ask A REL Southwest at American Institutes for Research. (2018). *What is the effect of an arts-integrated education on student learning of preK mathematics?* Retrieved from https://ies.ed.gov/ncee/edlabs/regions/southwest/ask-a-rel/effects-arts-integrated-education-prek-math.aspx

Additional Organizations to Consult

National Association for Gifted Children: https://www.nagc.org/

From the website: "NAGC's mission is to support those who enhance the growth and development of gifted and talented children through education, advocacy, community building, and research. We aim to help parents and families, K–12 education professionals including support service personnel, and members of the research and higher education community who work to help gifted and talented children as they strive to achieve their personal best and contribute to their communities."

- Gifted children and STEM: https://www.nagc.org/resources-publications/resources/timely-topics/stem-meeting-critical-demand-excellence/gifted
- Pros and cons of STEM initiatives for gifted learners: http://www.nagc.org/pros-and-cons-stem-initiatives-gifted-learners

- Key reports in gifted education: https://www.nagc.org/resources-publications/resources/key-reports-gifted-education

National Center for Research on Gifted Education: https://ncrge.uconn.edu/

From the website: "Recent studies of gifted and talented programs indicate that the extent and quality of services available to gifted students varies from state to state, district to district, and even from school to school within school districts. Overall, the field knows little about how gifted and talented programs are implemented in schools, how long students participate and at what level of intensity, and whether these programs are effective in improving students' academic outcomes. In addition, students of particular racial and ethnic backgrounds (i.e., African American, Hispanic or Latino, and Native American), students from lower income families, and students from small-town or rural communities are disproportionally underrepresented in gifted and talented programs. These students are less likely to be identified as gifted and talented in early elementary school, and those who are identified are less likely to have access to or persist in programs or activities for gifted and talented students as they progress through the K–12 system. With funding authorized through the Jacob K. Javits Gifted and Talented Students Education Act, the Institute of Education Sciences, U.S. Department of Education (PR/Award #R305C140018) launched the National Center for Research on Gifted Education at the University of Connecticut to address these issues."

National Research Center on the Gifted and Talented (1990–2013): https://nrcgt.uconn.edu/

From the website: "The National Research Center on Gifted and Talented (NRC/GT) successfully competed for a series of federally funded grants (1990–2013) under the Jacob K. Javits Gifted and Talented Education Act. Our final studies focused on What Works in Gifted Education with the mathematics study at the University of Connecticut and the reading/language arts study at the University of Virginia. The respective research teams developed model-based curricula in mathematics for grade 3 students in general education classrooms and reading/language arts curricula for grade 3 students in gifted and talented programs reflecting the following curricular/instructional models: (a) Differentiation of Instruction Model (Carol Ann Tomlinson); (b) Depth and Complexity Model (Sandra N. Kaplan), and (c) Schoolwide Enrichment Model (Joseph S. Renzulli and Sally M. Reis). Multiple cohorts of students and their teachers participated in the two curricular studies and initial quantitative and qualitative results were shared with study participants and conference participants. We completed three additional projects: (a) explored the theory of the malleability of intelligence related to research by Dr. Carol Dweck, Stanford University, and others; (b) summarized the curricular and instructional practices in STEM high schools; and (c) analyzed the status of gifted education programming and services across the nation."

- Research-based resources by subject: https://nrcgt.uconn.edu/research-based_resources/#bysubject

Methods

Keywords and Search Strings

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

- ("gifted program" OR "gifted and talented" OR gifted OR GT OR enrich*) AND (STEAM OR STEM OR math* OR science OR art)
- ("gifted program" OR "gifted and talented" OR gifted OR GT OR enrich*) AND (STEAM OR STEM OR math* OR science OR art) AND (outcome* OR achievement OR attitude*)

Databases and Resources

We searched ERIC, a free online library of more than 1.6 million citations of education research sponsored by the Institute of Education Sciences (IES), for relevant resources. Additionally, we searched the academic database ProQuest, Google Scholar, and the commercial search engine Google.

Reference Search and Selection Criteria

In reviewing resources, Reference Desk Researchers consider—among other things—these four factors:

- Date of the publication: Searches cover information available within the last 10 years, except in the case of nationally known seminal resources.
- Reference sources: IES, nationally funded, and certain other vetted sources known for strict attention to research protocols receive highest priority. Applicable resources must be publicly available online and in English.
- Methodology: The following methodological priorities/considerations guide the review and selection of the references: (a) study types—randomized controlled 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), study duration, etc.; (c) limitations, generalizability of the findings and conclusions, etc.
- Existing knowledge base: Vetted resources (e.g., peer-reviewed research journals) are the primary focus, but the research base is occasionally slim or nonexistent. In those cases, the best resources available may include, for example, reports, white papers, guides, reviews in non-peer-reviewed journals, newspaper articles, interviews with content specialists, and organization websites.

Resources included in this document were last accessed on June 5, 2019. URLs, descriptions, and content included here were current at that time.

This memorandum is one in a series of quick-turnaround responses to specific questions posed by education stakeholders in the Appalachia region (Kentucky, Tennessee, Virginia, and West Virginia), which is served by the Regional Educational Laboratory Appalachia (REL AP) at SRI International. This Ask A REL response was developed by REL AP under Contract ED-IES-

17-C-0004 from the U.S. Department of Education, Institute of Education Sciences, administered by SRI International. The 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.