STEM Frameworks and Models
August 2014

INQUIRY

A Pacific region entity engaged in a strategic planning process for STEM (science, technology, engineering, and mathematics) initiatives requested information on the following question:

What are effective STEM models or frameworks currently being used, and what elements of STEM programs are deemed most effective?

As a first step in providing the requested information, REL Pacific at McREL conducted a web-based search for informational resources. Publications, reports, guides, and reviews relevant to each topic are provided. This information response organizes selected resources into the following sections:

- **Section one:** *Integrated STEM approach to curriculum*— Effective approaches to integrate science, technology, engineering, and science content as part of a coherent STEM curriculum for some or all students.
- **Section two:** *Magnet STEM schools and STEM academies*—A review of major STEM school models. Such models include magnet schools in which a STEM theme is integrated across all grades and courses, STEM learning is the focus, and STEM content is linked to other curricular areas. Other models include STEM academies, in which a portion of a school's student population follows a STEM strand or pathway for their courses.
- **Section three:** *Comparison of STEM schools and programs*—Characteristics and approaches of specific STEM-focused schools and curricular programs.
- **Section four:** *Out of school time*—STEM programs that are designed for after school, summer school, or other out of school learning time.

SEARCH TERMS USED

experiential learning; integrated STEM; integrating STEM; science, technology, engineering; science, technology, engineering, mathematics school within a school; STEM academy; STEM career academies; STEM certificate; STEM charter; STEM curriculum; STEM magnet; STEM pathway; STEM program; STEM school; STEM school within a school; STEM strand; students; yr (2000-2019)

DATABASES SEARCHED

Google, ERIC, ProQuest Education Journals

Resources identified in the search are listed below. The hyperlink to each resource is provided. Descriptions of programs and articles have been reproduced verbatim from their respective websites or abstracts.

Resource Overview

The provided resources were found via web-based searches. Criteria used for finding resources included publications in peer-reviewed research journals within the last five years. Criteria were then expanded to include information from non-peer reviewed journals in order to provide a comprehensive overview of the variety of STEM programs currently being implemented. Resources included also had to be available online and in English. Resources included in this document were last accessed in August 2014. URLs, descriptions, and content included in this document were current at that time.

Descriptions of the resources were quoted from the publication abstract (Abstract), the publication itself (Excerpt), or the publication's host website (Description, Program Description). An abstract was always used when available. However, if there was no abstract for a resource a relevant excerpt was pulled directly from the source to provide basic information.

Resulting Articles

Section one: Integrated STEM approaches to curriculum

This section includes publications and reports that identify the effectiveness of STEM programs or approaches that integrate science, technology, engineering, and science content as part of a coherent STEM curriculum for all students.

1. Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education: Innovations and Research, 12*(5), 23-37. Retrieved from http://ojs.jstem.org/index.php?journal=JSTEM&page=article&op=view&path%5B%5D=1509&path%5B%5D=1394

   Source: ERIC, ProQuest Education Journals

   Abstract: Within the literature there has been a call for the integration of science, technology, engineering, and mathematics (STEM) disciplines; however, little research has been conducted to investigate the effects of integrative approaches among STEM subjects. The purpose of this study was to synthesize the findings from existing research on the effects of integrative approaches among STEM subjects on students' learning. Meta-analysis was employed to address the research questions of this study. Twenty-eight studies were selected and thirty-three effect sizes were calculated to examine the effects of integrative approaches among STEM subjects. With respect to the grade levels, the effects of integrative approaches showed the largest effect size at the elementary school level and the smallest effect size at the college level. Regarding the types of integration, STEM, the integration of four subjects, presented the largest effect size, and E-M and M-S-T showed the smallest effect size. In addition, concerning the achievement through integrative approaches, STEM achievement showed the highest effect size and mathematics achievement showed the smallest effect size. The results of this preliminary meta-analysis reveal that integrative approaches among STEM subjects have positive effects on the students' learning. Further empirical research on the effects of STEM education needs to be conducted to confirm the findings of this preliminary meta-analysis.

2. Householder, D. L., & Hailey, C. E. (2012). *Incorporating engineering design challenges into STEM courses.* National Center for Engineering and Technology Education, Department of Engineering Education Utah State University: Logan, UT. Retrieved from http://eric.ed.gov/?id=ED537386

   Source: ERIC, ProQuest Education Journals

   Abstract: Successful strategies for incorporating engineering design challenges into science, technology, engineering, and mathematics (STEM) courses in American high schools are presented in this paper. The developers have taken the position that engineering design experiences should be an important component of the high school education of all American youth. In most instances, these experiences in engineering design are infused into instruction programs in standards-based courses in science, technology, or mathematics. This paper is intended to provide guidelines for the development of authentic engineering design challenges, to describe instructional strategies for introducing engineering design experiences to high school students, and to offer suggestions for the assessment of the outcomes of engineering design activities. The information is intended to be useful in planning, organizing, and implementing the infusion of engineering design challenges in high school STEM courses. This paper is an exploration of the available research on the following questions dealing with the implementation of engineering design challenges in high school STEM courses: (1) Does the development of engineering habits of thought and action lead to improvements in problem solving abilities, systems thinking, integration of content, increased interest in engineering, and feelings of self-efficacy about pursuing additional engineering activities?; (2) What is the anatomy of the engineering design process and what are its essential components?; (3) What are the distinguishing characteristics of authentic engineering design challenges?; (4) In what ways do engineering design challenges fit into the national STEM scene and the high school STEM organizational structure?; (5) What are the content, context, and process elements of appropriate engineering design challenges for high school STEM courses?; (6) What instructional practices based upon engineering design challenges are effective in supporting student learning?; and (7) In what ways can teachers design and implement an authentic system for assessing student progress and completion of engineering design challenges? How can the assessment provide support for using engineering principles to solve design challenges in contrast to simple trial and error approaches?

3. Moore, T. J., & Smith, K. A. (2014). Advancing the state of the art of STEM integration. *Journal of STEM Education: Innovations and Research, 15*(1), 5-10. Retrieved from http://ojs.jstem.org/index.php?journal=JSTEM&page=article&op=view&path%5B%5D=1917&path%5B%5D=1581

   Source: ERIC, ProQuest Education Journals

   Excerpt (p 5): . . .high quality integrated STEM learning experiences include, but are not limited to, the following: engage students in engineering design challenges that allow for
   them to learn from failure and participate in redesign, use relevant contexts for the engineering challenges to which students can personally relate, require the learning and use of appropriate science and/or mathematics content, engage students in content using student-centered pedagogies, and promote communication skills and

teamwork (Moore, Guzey, & Brown, 2014). Implementation of STEM integration can involve one or more instructors (Roehrig, Moore, Wang, & Park, 2012), one or more classes (Berlin & White, 1995), and can require differing lengths of time to complete (Isaacs, Wagreich, & Gartzman, 1997).

There are two different ways to integrate content and engineering thinking: context integration and content integration. Context integration refers to an integration of engineering design as a motivator to teach some disciplinary content (usually mathematics and/or science). The learning goals are not about the engineering per se, but rather engineering design as a pedagogy to help students learn the content. Content integration refers to an integration of engineering thinking and mathematics/science content where learning multiple areas including engineering are part of the learning objectives for the activity or unit.

4. Siri, D. K., Zinner, J., & Lezin, N. (2011). BLENDING rigor and relevance. *Leadership, 40*(3), 8-11. Retrieved from http://eric.ed.gov/?id=EJ965881

   Source: ERIC

   Abstract: A collaborative at several sites across the state of California will offer evidence of how successful linked learning, which connects academics to real-world work, can be. This article presents examples that illustrate the powerful connections and linkages that are generated by combining academic rigor with the relevance of applying learning to real-world work and careers. The connection is compelling not only to students, but to teachers, industry, and funders as well. The article also presents highlights that describe challenges, successes, and lessons learned from the work of the Alliance for Regional Collaboration to Heighten Educational Success (a statewide organization) with six regional collaboratives as they plan and implement linked learning approaches in specific school sites, with the support of the Irvine Foundation

5. Southern Regional Education Board. (2012). Focusing on challenging content and practical applications in science, technology, engineering and mathematics (STEM) studies in middle grades schools, high schools and technology centers. *High schools that work.* Atlanta, GA: Author. Retrieved from http://publications.sreb.org/2012/12V09w_BestPractices_FocusingOn_STEM.pdf

   Source: ERIC, ProQuest Education Journals

   Abstract: Schools that give students access to STEM (science, technology, engineering and mathematics) studies are accomplishing several objectives: introducing students to higher-level academic and career studies, expanding project-based learning in the curriculum, enticing students to remain in school until graduation, and preparing students for challenging majors in college and modern, high-skill careers after further education and training. Students who never realized they could master science, technology, engineering and math are joining fellow students in taking courses that will put them ahead in college and careers. This issue of "High Schools That Work" contains the following articles: (1) What Are the Characteristics of a Successful STEM Program?; (2) STEM Academies: Preparing Students for High-Demand, High-Wage Careers; (3) Students Learn to Solve Authentic Problems From Business and Government; (4) Literacy Strategies for CT Teachers and Students; (5) Engaging Career/Technical (CT) Students in Textbook and Other Assigned Reading; (6) Teaching Hands-On Science in a Title I School; (7) Integrating Engineering Problem Solving Into Mathematics, Science and

Technology Courses; (8) Multi-State Initiative Works With SREB to Develop High-Quality CT Courses; (9) School-Based Enterprises: Student Work Is Real Work; (10) Mobile Learning Devices Make Assignments Meaningful for Students at a Career Center; (11) Online Portfolios Allow Students to Organize and Showcase Their Work; and (12) Tutoring With Skype: A High School Student's Dream.

Section two: Magnet STEM schools and STEM academies

This section includes publications and reports that describe STEM school models. Such models include magnet schools in which a STEM theme is integrated across all grades and courses, STEM learning is the focus, and STEM content is linked to other curricular areas. Other models include STEM academies, in which a portion of a school's student population follows a STEM strand or pathway for their courses.

1. North, C. (2011). *Designing STEM Pathways through Early College: Ohio's Metro Early College High School.* Boston, MA: Jobs for the Future. Retrieved from http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED523098.

   Source: ERIC, ProQuest Education Journals

   Abstract: Calls for improved outcomes in U.S. science, technology, engineering, and mathematics education are frequent and insistent. In 2009, the Commission on Mathematics and Science Education, convened by the Institute for Advanced Study and Carnegie Corporation of New York, concluded that: "Knowledge and skills from science, technology, engineering and mathematics--the so-called STEM fields--are crucial to virtually every endeavor of individual and community life. All young Americans should be educated to be "STEM-capable," no matter where they live, what educational path they pursue, or in which field they choose to work." Implicit in this conclusion is the pressing need to dramatically reduce and eventually eliminate the enormous achievement gaps in high school completion, college preparedness, and completion of STEM degrees between, on the one hand, white and Asian students and children from relatively prosperous families and, on the other hand, black, Hispanic, and Native-American students and children from poorer families. Among the models illuminating the way forward are STEM-themed schools built on Early College Designs. These early colleges are a compelling illustration of how school can be done differently--and how high levels of math and science achievement can be realized by a broad spectrum of students. Now in its ninth year, the "Early College High School Initiative" has grown into a network of 230 schools committed to providing access to advanced learning in high school. Early colleges provide students with opportunities to earn college credit at a partner college at the same time as they meet local and state requirements for high school graduation. This paper profiles a STEM-focused early college high school, Metro Early College High School in Columbus, Ohio.

2. Scott, C. (2012, Oct-Dec). An Investigation of Science, Technology, Engineering and Mathematics (STEM) Focused High Schools. *U.S. Journal of STEM Education: Innovations and Research, 13* (5). 30–39. Retrieved from http://ojs.jstem.org/index.php?journal=JSTEM&page=article&op=view&path%5B%5D=1629

   Source: ERIC, ProQuest Education Journals

   Abstract: This study examined the characteristics of 10 science, technology, engineering and mathematics (STEM) focused high schools that were selected from various regions across the United States. In an effort to

better prepare students for careers in STEM fields, many schools have been designed and are currently operational, while even more are in the planning phase. Data collected, analyzed and documented in this report included websites, national statistics databases, standardized test scores, interviews, and published articles. A comparative case design was used to identify key components of STEM high school designs. Results from this study indicate that students who attend STEM-focused high schools outperformed their peers at similar institutions. Although programs varied, a common theme that emerged from these schools was focus on more rigorous course requirements with electives centered on STEM content and application. Students who attended STEM schools were engaged in real-world problem solving and completed internships and/or a capstone projects to fulfill graduation requirements. Most students attending STEM schools in this study were admitted based on a lottery system while two out of the ten schools admitted all applicants. The student population was comprised of a higher number of minority students compared to other schools in the United States. The findings in this study are significant because they indicate that many students, when given the opportunity and support, are able to successfully complete rigorous STEM academic programs that go beyond the basic graduation requirements.

Section three: Comparing STEM schools and programs

This section includes publications and reports that describe the characteristics and approaches of specific STEM schools and curricular programs that have been implemented and studied in recent years.

1. Bayer Corporation. (2010). Planting the seeds for a diver U.S. STEM pipeline: A compendium of best practice K-12 STEM education programs. Retrieved from http://www.bayerus.com/msms/web_docs/compendium.pdf

   Source: Google web search

   Introduction Excerpt: Despite the global recession, the United States continues to face a workforce shortage in science, technology, engineering and math (STEM) fields. We must do a better job of tapping the talent of citizens who are underrepresented in STEM fields: women, African-Americans, Hispanics and American Indians. Our global competitiveness depends on our ability to attract and retain future generations in areas such as chemistry, engineering, the physical sciences, mathematics and the computer sciences.

   There are some encouraging signs that show progress in this area. Science-based companies like Bayer are responding. They're building business-education partnerships to develop the scientists and researchers we need to compete internationally and grow our economy. This updated booklet provides examples of effective K-12 STEM education programs and resources. They work. And they can be copied or tailored to meet specific needs.

   Excerpt (p. 8): . . . to be considered for inclusion in *Bayer Corporation's Planting the Seeds for a Diverse U.S. STEM Pipeline: A Compendium of Best Practice K-12 STEM Education Programs*, a program had to meet the following four criteria:

   1. Challenging Content/Curriculum
   2. An Inquiry Learning Environment
   3. Defined Outcomes/Assessment

4. Sustained Commitment/Community Support

2. Careless, J. (2011). Making STEM happen. *Tech & Learning, 32*(4), 36-41. Retrieved from. http://www.techlearning.com/features/0039/making-stem-happen/51895

   Source: ProQuest Education Journals

   Excerpt: The importance of science, technology, engineering, and math (STEM) is a popular subject. But who is actually doing something about it? Here are some examples of STEM innovations in action, compiled by Tech & Learning. [*Each example includes a description of the program or school, the tools used, how it was executed, program results, and grants received, if any.*]

3. National Research Council (2011). *Successful K–12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics*. Washington, DC: The National Academies Press. Available from http://www.nap.edu/download.php?record_id=13158

   Source: Google web search

   Abstract: Science, technology, engineering, and mathematics (STEM) are cultural achievements that reflect our humanity, power our economy, and constitute fundamental aspects of our lives as citizens, consumers, parents, and members of the workforce. Providing all students with access to quality education in the STEM disciplines is important to our nation's competitiveness. However, it is challenging to identify the most successful schools and approaches in the STEM disciplines because success is defined in many ways and can occur in many different types of schools and settings. In addition, it is difficult to determine whether the success of a school's students is caused by actions the school takes or simply related to the population of students in the school.

   Successful K-12 STEM Education defines a framework for understanding "success" in K-12 STEM education. The book focuses its analysis on the science and mathematics parts of STEM and outlines criteria for identifying effective STEM schools and programs. Because a school's success should be defined by and measured relative to its goals, the book identifies three important goals that share certain elements, including learning STEM content and practices, developing positive dispositions toward STEM, and preparing students to be lifelong learners. A successful STEM program would increase the number of students who ultimately pursue advanced degrees and careers in STEM fields, enhance the STEM-capable workforce, and boost STEM literacy for all students. It is also critical to broaden the participation of women and minorities in STEM fields.

   Successful K-12 STEM Education examines the vast landscape of K-12 STEM education by considering different school models, highlighting research on effective STEM education practices, and identifying some conditions that promote and limit school- and student-level success in STEM. The book also looks at where further work is needed to develop appropriate data sources. The book will serve as a guide to policy makers; decision makers at the school and district levels; local, state, and federal government agencies; curriculum developers; educators; and parent and education advocacy groups.

With respect to criteria related to schools, we identified three types of STEM-focused schools (selective, inclusive, and CTE) that have different goals, strategies, and student populations – all with the potential to improve STEM learning. Because of the challenges with conducting causal research on these schools, little research is available that demonstrates the effectiveness of STEM-focused schools in comparison with other schools or that contrasts the relative effectiveness of their different approaches on a variety of student outcomes.

4. Young, V., Adelman, N., Cassidy, L., Goss, K., House, A., Keating, K., et al. (2011). *Evaluation of the Texas High School Project. Third comprehensive annual report.* Austin, TX: Texas Education Agency Available from http://www.sri.com/work/publications/evaluation-texas-high-school-project-third-comprehensive-annual-report.

   Source: Google Search

   Excerpt (p. ES-6–8): The T-STEM program established a new network of schools that offered STEM-focused education and a statewide infrastructure of regional centers to provide TA and PD to these schools. The T-STEM initiative ultimately aimed to improve math and science achievement overall and to stimulate students' interest in STEM careers. T-STEM academies were new small schools or schools within schools. The T-STEM Academies Design Blueprint (2010)4 guided the schools' development and implementation.

   Overall, T-STEM academies were implementing the critical elements of the T-STEM Blueprint. They varied in how effectively they implemented some program elements, like project-based learning (PBL), and often prioritized elements that needed to be in place based on the grades they were serving. . . With Blueprint implementation being a work-in-progress, T-STEM students performed better than comparison school peers on a small number of outcomes. They performed similarly on a majority of the outcomes studied. T-STEM academy students exceeded their comparison school peers in passing Algebra I by ninth grade, on tenth-grade TAKS-Math and meeting or exceeding TAKS in all subjects, attendance, and promotion to the eleventh-grade. However, T-STEM students performed at the same levels as similar students in comparison schools across the majority of outcomes examined for grades nine through 12.

   In considering the T-STEM effect on student outcomes, it is worth noting that a wide variety of outcomes intended by the T-STEM initiative and pursued by the academies could not be measured well or at all with state data. Developing students' 21st-century work skills such as collaborating, using multidisciplinary approaches, problem-solving, and applying technologies were some of the key T-STEM outcomes that were not captured by the outcomes included in this evaluation. Longer-term outcomes such as college enrollment, persistence, graduation, and STEM major completion require linking high school to postsecondary data and are not easily tracked with the existing datasets.

Section four: Out of school time

This section includes publications and reports that describe the effectiveness of STEM programs designed for out-of-school time. Such programs are commonly implemented after-school, during the summer, or on the weekend.

1. Duran, M., Sendag, S. (2012). A preliminary investigation into critical thinking skills of urban high school students: Role of an IT/STEM program. *Creative Education* (3)2, 241–250. Retrieved from http://www.scirp.org/journal/PaperDownload.aspx?paperID=18789

Source: ERIC, ProQuest Education Journals

Abstract: This paper reports the development of critical thinking of urban high school students in an IT/STEM [out of school time] program-using information technology (IT) within the context of science, technology, engineering, and mathematics (STEM). The study used a quasi-experimental time-series design, involving 47 initial participants in an eighteen-month intervention period. Data were collected from the Test of Everyday Reasoning (TER), which provides an overall score on critical thinking skill (CTS) and five sub-scale scores (analysis, inference, evaluation, inductive reasoning, and deductive reasoning). Findings indicate that based on a mean score of 15.77, the average participant scored between the 16th and 19th percentiles at the beginning of the program compared to an aggregated national sample. Participants who completed the program and responded to all three time-series TER tests (14) significantly improved their critical thinking skills throughout the program. Program completers' overall post-program CTS test score was more homogeneous than the pre-program scores with a 20.07 mean score. In addition, data showed significant improvement in inductive reasoning skills of the program participants during the first nine months with continuing improvement in the second nine months. In contrast, data presented improved inference skills during the first nine months with significant gains during the second half of the program. The study estimates the relative effects of IT/STEM experiences with technology-enhanced, inquiry and design-based collaborative learning strategies on CTS of urban high school students.

2. Elam, M., Donham, B. & Solomon, S. (April, 2012). An engineering summer program for underrepresented students from rural school districts. *Journal of STEM Education: Innovations and Research (13*) 2, 35–44. Retrieved from http://ojs.jstem.org/index.php?journal=JSTEM&page=article&op=view&path[]=1619
Source: ERIC,

Abstract: A two-week summer program designed to promote interest and learning in the Science, Technology, Engineering, and Mathematics (STEM) fields is documented. The program included a week-long engineering emphasis. Students and teachers from ten rural and financially disadvantaged school districts participated in the program. Three middle school and three high school students were chosen from each district. Students were selected by their districts based upon interest and/or perceived potential in STEM fields, with an emphasis placed on underrepresented and first-generation college students. Additionally, one middle school and one high school mathematics or science teacher from each district participated in the program, enabling the program's curriculum to be transferred back to the secondary classrooms. Pre- and post-student surveys and parent surveys were administered to assess the success of the program. Results indicated the program had a positive impact on students' attitudes towards engineering.

3. Kaye, K., Turner, J.F., Emigh, J. (2011, Fall). The CSI academy: Encouraging diverse students to consider science careers and science teaching. *AILACTE Journal (8),* 66–82. Retrieved from http://www.ailacte.org/images/uploads/general/AILACTE_Journal_Fall2011.pdf#page=71

Source: ERIC, ProQuest Education Journals

Abstract: The CSI academies employed a multi-layered, collaborative approach to encourage diverse students to consider STEM careers, including science teaching. The academies recruited a diverse group of high school students. This was due, in large part, to the creation of a unique selection process that identified students with unrealized potential. The program included a highly functioning team of high school science teachers; faculty in teacher education joined by faculty in the arts and sciences; and college students as peer mentors. The program benefited from exceptional cooperation between a liberal arts college and a large urban university. A post-academy survey revealed students continued to have strong interest in studying science in college, a decreased interest in forensics as related to law enforcement and an increased interest in becoming science teachers. The authors identify specific success factors that could be applied in similar pre-college programs.

Excerpt: In response to a state-wide initiative in Ohio to increase student interest in STEM (science, technology, engineering and math) careers, faculty in the Division of Education at Baldwin-Wallace College and the Chemistry Department from Cleveland State University created a "CSI" academy. Titled "CSI: College Science Investigation—A Forensics Academy for High School Juniors and Seniors," the program was one of over a dozen different programs approved for funding by the state. The academy was designed to employ hands-on forensics science experience and relevant science coursework to encourage high school students to consider science-related careers. The academy included some direct guidance on science teaching as a career. The program was run twice over a two-year period, with a total of 60 participating high school students.

Each academy was divided into two parts, a two-week summer residential component and a fall session comprised of four half-day, Saturday classes with labs.

4. Sahin, A. (2013). STEM clubs and science fair competitions: Effects on post-secondary matriculation. *Journal of STEM Education: Innovations and Research (14)*1, 5–11. Retrieved from http://jstem.org/ojs/index.php?journal=JSTEM&page=article&op=viewFile&path%5B%5D=1781&path%5B%5D=1504

Source: ERIC, ProQuest Education Journals

Abstract: As the global economic competition gets tougher, American policymakers and researchers are interested in finding ways to increase the number of students pursuing STEM (Science, Technology, Engineering, and Mathematics)-related majors in order for the United States to continue its role as an economic powerhouse. A survey study was employed to investigate a multi-charter school system's (Harmony Public Schools [HPS]) after-school program in which doing a science fair project was expected for all 4th-12th grade students, and students were encouraged to participate STEM-related clubs (MATHCOUNTS, American Mathematics Competition [AMC], Science Olympiad, University Interscholastic League [UIL] and Science DEMO). In particular, the first part of the study focused on how related matriculation of this specific school system was with the national average (n = 230). In the second part, the relationships between students' science fair and STEM club participation and their STEM major selection was investigated (n = 149). Findings showed that HPS outperformed the national average in terms of post-secondary admissions and STEM major selections. Multiple years of science fair project competition were positively related with students choosing a post-secondary STEM major (x^sup 2^(4) = 5.32, p =. 255). There was also a statistically significant relationship

between the number of STEM clubs students participated in and their choice of STEM major (x^sup 2^(4) = 34.22, p < .001). Findings are discussed in light of developing STEM-focused after-school clubs.

5. Sahin, A., Ayar, M.C, Adiguzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning. *Educational Sciences: Theory and Practice (14*)1, 309–322. Retrieved from http://www.edam.com.tr/kuyeb/pdf/en/d57b8038ea1bd37196ec529cc5601bb3zelen.pdf

   Source: ProQuest Education Journals

   Abstract: This study explores the characteristics of after-school program activities at a charter school in the Southeast US highlighting students' experiences with and gains from these after-school program activities. A qualitative case study design was employed to understand students' views and opinions regarding the activities and their learning trajectories. Study data were collected through formal and informal observations, one-on-one semistructured interviews, and field notes. The study's findings indicated that such activities emphasize open-ended and collaborative scientific investigations in Science, Technology, Engineering, and Mathematics (STEM) fields and provided an arena for students to demonstrate various uses of 21st century skills. We have described and explained: (a) the importance of collaborative learning groups, (b) the popularity of after-school program activities, (c) interest in STEM fields, and (d) activities' contribution to developing 21st century skills. These findings show that STEM related activities have the potential to promote collaborative learning and inquiry as well as to contribute to the development of 21st century skills. These findings have also been discussed in light of how STEM related after-school program activities support students' learning.

This Ask-A-REL response was developed by REL Pacific under Contract #ED-IES-12-C-0010 from the U.S. Department of Education, Institute of Education Sciences. The Content does not necessarily reflect the views or policies of IES or the U.S. Department of Education, nor does the mention of trade names, commercial products, or organizations imply endorsement by the U.S. government.