STEM Explore:
A Summer Program for
Middle School Students
Engaging in STEM Activities and Careers

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Abstract: The purpose of this research is to investigate and promote STEM (Science, Technology, Engineering, and Mathematics) careers to middle school students (grades 6-8) through a two week, on-campus program at a state university, with special focus on opportunities and activities in science, technology, mathematics, and engineering (STEM). This STEM program hopes to increase the number of underrepresented groups by providing opportunities for middle school students to participate in STEM activities, integrate field trips and STEM projects to nurture inquiry, and engage in meaningful discussions with STEM professionals regarding their careers. In addition, this program will be implemented by preservice STEM teachers from the universities' department of education. The expected outcomes are to increase awareness and interest of STEM careers with middle school students. This program will also target a student's experiences and applications of STEM ideas based on the new Revised State Science Standards.

Purpose: This research is motivated by the undersized numbers, nationally and regionally, of capable high school students going into STEM majors at the college level. This underrepresentation is even more pronounced for diverse students in an urban area. It is the purpose of this program to promote STEM careers to middle school students (grades 6–8) through a two-week, on-campus program at the local state university, with special focus on opportunities and activities in STEM related areas. Three research questions are the foundation of this research:

1. What will be the degree of awareness/interest in STEM disciplines among middle school students as a result of this program?
2. What will be the degree of STEM career interest among middle school students as a result of this program?
3. Is there a correlation between STEM interest and possible STEM career choice among middle school students after this program?

Therefore, the expected outcomes of this project include:

- Ÿ Increased awareness and interest with middle school students of STEM disciplines and careers.
- Ÿ Experiences for middle school students with STEM content and their applications based on the new Revised State Science Standards.
- Ÿ Foster the development of scientific attitudes, such as curiosity, excitement, appeal and interest in the world around them.

Theoretical Framework: The mathematics and science courses that students take before college have been found to determine who will receive further trainings in STEM fields (Anderson, 1996; Chang, Cerna, & Saenz, 2008; Denson, Avery & Schell, 2010; National Science Foundation, 2006). Further research has shown the enrollment of underrepresented minorities is limited in mathematics and science courses in K-12 (Bonous-Hammarth, 2000, 2006; Moore, 2006; Simpson, 2001). Many students' lack of interest in STEM fields coupled with inadequate preparation in high school leads to fewer numbers of graduates in STEM majors (National Center for Education Statistics, 2009. Research has shown there are six factors in K-12 that contribute to the success among underrepresented minorities in STEM education: (1) parental involvement and support, (2) bilingual education, (3) culturally relevant teaching, (4) early exposure to careers in STEM, (5) interest in STEM projects, and (6) self-efficacy in STEM domains (Museus, Palmer, Davis & Maramba, 2011).

Researchers, Tyler-Wood, Ellison, Lim, and Periathiruvadi conducted an eight year study with middle school students to measure the effectiveness of an environmental program for increasing students' interest in science careers (Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012). Results of this study indicate that those students who participated in their program significantly gained science content knowledge but also increased their placement in STEM careers. Results stated the participants had a much stronger awareness, appreciation, and confidence in STEM fields than before they began the program. These researchers utilized the STEM Semantic Survey and the Career Interest Questionnaire as measures of student self-efficacy regarding STEM content and careers.

One of the most important characteristics of effective science curriculum is early timing and interventions. Interventions should occur prior to high school in order to be effective (Subrahmanyan & Bozonie, 1996). Providing students the opportunities to see advantages of selecting a science career at an early age should increase the opportunity for students to select a STEM career (Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012). Students with more confidence in STEM subject areas are more likely to pursue careers in math and science (Herbert & Stipek, 2005).

Linda Brody, in her research measuring effectiveness of STEM initiatives with middle school students suggests the following elements which seem to impact encouraging students to aim for mathematical and scientific careers:

- Solid preparation from an early age in math and science content
- Experience with hands-on content
- Awareness of the utility of school-based learning in the workplace
- Exposure to role models and mentors who work in these fields
- Access to peers who share interests (Brody, 2006).

Brody also describes the need for more well-funded research studies that measure both short-term and long-term effects of programs. Thus, she suggests, studies must be longitudinal (Brody, 2006).

Research indicates that critical examination of the factors that effect mathematical scientific achievement in middle grades is needed because these years are when students consider future career and academic pathways (Singh, Granville & Dika, 2002). The results of Ricks study, “A Study of the Impact of an Informal Science Education Program on Middle School Students’ Science Knowledge, Science Attitude, STEM High School and College Course Selections, and Career Decisions”, suggests that innovative hands-on learning activities, problem-solving experiences and opportunities for reflection were important elements for students meaningful understanding of math and science concepts that impact science learning, attitudes, interest, and career decisions (Ricks, 2006).

Reports by both education foundations and government entities have sounded the alarm that the size and quality of the U.S. science and technology workforce is the key factor to the capacity of the U.S. innovation enterprise, including energy and the environment. The caliber of this workforce will in turn be determined by the quality of STEM education at all levels. Mathematics and science courses that students take before college determine who receives further training in STEM fields (Anderson, 1996; Chang, Cerna, & Saenz, 2008; Denson, Avery & Schell, 2010; National Science Foundation, 2006). Regionally, data from the 2010–2011 academic year for a large local urban school district indicates a tremendous need to improve student performance in math and science [Ohio Report Card http://ilrc.ode.state.oh.us/]:

Eighth Grade Science and Math Ohio Achievement Test (State Requirement 75%).

School district / County	% students at and above proficient level Science	% students at and above proficient level Math
Urban / County M	19.2	29.4
Urban / County M	46.1	78.7
Urban / County T	38.2	40.1
Suburban / County M	72.4	83.1

This table disproportionately reflects groups in Ohio which have been historically underrepresented in STEM disciplines. Groups include the economically disadvantaged, blue collar background, first generation, rural, and ethnic minorities (African-Americans, Hispanic Americans, and Native Americans, including Pacific Islanders). This underrepresentation occurs both nationally and regionally in higher education and in STEM professions. Since STEM disciplines are a primary economic driver, this underrepresentation deprives the economy and society as a whole of the talents of underrepresented individuals who have the potential to do STEM based work. The National Science Foundation's 2007 National Action Plan makes the case that, to build the talent pipeline, all students—not just those naturally interested in STEM—need to develop their capabilities in STEM to levels beyond what was considered acceptable in the past. STEM competency impacts each person's ability to contribute to economic success both nationally and globally [http://www.nsf.gov/news/news_images.jsp?cntn_id= 109857&org=NSF].

Other research has shown that key factors in K–12 that contribute to the success among underrepresented minorities in STEM education include early exposure to careers in STEM, interest in STEM projects, and self-efficacy in STEM domains (Museus, Palmer, Davis & Maramba, 2011).

It is known that energy and the environment can be used effectively to introduce students to STEM careers as well as improve their competence in STEM disciplines. Researchers, Tyler-Wood, Ellison, Lim, and Periathiruvadi conducted an eight year study with middle school students to measure the effectiveness of a an environmental program for increasing students' interest in science careers (Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012). Results of this study: indicate that those students who participated in their program significantly gained science content knowledge but also increased their placement in STEM careers; and stated the participants had a much stronger awareness, appreciation, and confidence in STEM fields than before they began the program. These researchers utilized the STEM Semantic Survey and the Career Interest Questionnaire as measures of student self-efficacy regarding STEM content and careers.

The above research, and other research cited below, informs our approach to building the pipeline of a future STEM trained workforce in energy and the environment in Ohio.

Problem-based and project-based learning for both single and team assignments is an excellent way to emphasize key concepts in all STEM fields. As (Hsieh and Knight, 2008) claim, "Students are given a realistic scenario without a single correct answer. They are guided through a process of analyzing the problem, researching their alternatives, and presenting a recommended solution." Therefore, an open-ended assignment provides the students with an opportunity to devise a solution to a problem that has several possible correct solutions. Summer programs are an effective way of providing students an opportunity to solve problems by applying STEM concepts, as well as enabling them to work individually and collectively (in small groups). Most students feel comfortable working on projects independently; however, working in small groups and being required to share ideas and formulate a solution based on several group members input is another tremendous benefit of problem and project based learning. Thus, just as professionals work with groups of people who have expertise in various backgrounds, the students enrolled in this summer program will collaborate with other students who have a variety of talents and who will all contribute to the problem solving process. This coincides very closely with "real-world" education and work experience and aligns with (Kolmos, 2006), who states "education needs to contain interdisciplinary aspects and the development of process skills, such as being able to analyze and interact during the creation of technology which involves cooperation, project management, communication, etc."

Methods: As a result of the research cited above and the lack of middle school STEM programs, it is proposed that STEM Explore, a summer 2012 program targets students in three large urban and five suburban middle schools. Six preservice teachers will be involved under the direction of university faculty to develop age and content appropriate experiences on the university campus.

STEM Explore will integrate field trips and STEM activities to nurture inquiry and help students make connections between what they are learning in the laboratory and classroom with applications. Examples of these field trips include a scavenger hunt and preparing "medicine" from an 1880's recipe at the Medical Museum, a day of exploration at the local children's Science Museum, Planetarium, the university's student recreation center, the Mineral Museum, and the Historical Society Museum. These field trips extend the opportunity for students to explore and engage the new Revised State Science Standards.

Another key part of such summer programs are daily activities which expose students and teachers to current technology and the foundational science, engineering, and mathematics concepts which are fundamental to STEM careers, STEM literacy, and current and future STEM areas of research. Students built pasta bridges, solar cars, weather instruments, rockets, investigated a mock crime scene, and so much more.

Finally, to bridge the gap between STEM careers and STEM content and activities, guest speakers (academic / industry professionals) will work with students in seminars and workshops. Several professors from the local university provided workshops in geology, forensic science, podcasting, solar panels, just to name a few.

STEM Explore management will be provided by a management team comprising of an assistant professor from the university's Department of Teacher Education (Science Education), College of Education, an instructor from the department of School of Engineering Technology, College of STEM, and a professor from the Department of Chemistry, College of STEM.

Participants: The participants of this summer STEM Explore program were urban and suburban middle school students entering grades 6 – 8 for the 2012-2013 school year coming from three large metropolitan areas and from four diverse suburbs of that area. The program was designed to service 25 students in this first year with hopes of expanding the numbers the following summer. Of the 25 students that attended, 16 were males and 9 were females. There were 13 Caucasian students, 7 African American, 3 Latino, 1 Puerto Rican, and 1 Greek student.

Data Sources and Data Collection Process:

Appropriate assessment metrics include:

- Survey of program teachers following the two-week program.
- Daily +/Δ (positive statements, suggested changes) slips to be completed by middle school students each day of the two-week program.
- End of program survey of students.
- End of program survey completed by participant's parents regarding program satisfaction.
- Pre-program and post-program surveys filled out by the students regarding STEM disciplines and awareness of STEM careers. Instruments used will be the STEM Semantic Survey and the Career Interest Questionnaire, both designed to measure student self-efficacy regarding STEM disciplines and careers.

Results and Conclusions:

One of the objectives of this program was to increase awareness and interest with middle school students of STEM disciplines and careers. The results of the STEM Semantics Survey (SSS) and Career Interest Questionnaire (CIQ) provided information that showed significant gains in awareness and interest in STEM disciplines and careers as a result of this two week summer program.

On STEM Semantics Survey, participants use a scale (ranging from 1 – 7) to indicate how they feel about five different topics: science, technology, engineering, mathematics, and careers in STEM. Figure 1 shows the science subscale on the SSS. The other subscales are similar.

Instructions: Choose one number between adjective pair to indicate how you feel about the object.

To me, **Science** is:

1.	Fascinating	1	2	3	4	5	6	7	mundane
2.	Appealing	1	2	3	4	5	6	7	unappealing
3.	Exciting	1	2	3	4	5	6	7	unexciting
4.	Means nothing	1	2	3	4	5	6	7	means a lot
5.	Boring	1	2	3	4	5	6	7	interesting

Fig. 1 Science subscale of the STEM Semantics Survey

Table 1 outlines the participant's results for the SSS.

Table 1

STEM Area	M Pre-course	M Post-course
Science	2.42	1.73
Math	4.12	3.81
Engineering	2.86	2.73
Technology	2.29	1.93
STEM Career Interest	2.54	1.93

It is clear from the above table, the participants felt in increase in interest and awareness in the areas of science, math, engineering, technology, and STEM careers as shown by the significant decrease in mean scores for each area. The two areas with the largest significant change were science and STEM careers. Engineering had the smallest change. These results might indicate the program provided a stronger impact in science and career activities/trips/speakers than it did on the engineering aspect of STEM.

The Career Interest Survey (CIS) is a five point Likert-type scale (1=strongly disagree to 5=strongly agree) instrument composed of three subscales: interest, intent, and perception.

Part 1: Interest

1. I would like to have a career in science.
2. My family is interested in the science courses I take.
3. I would enjoy a career in science.
4. My family has encouraged me to study science.

Part 2: Intent

5. I will make it into a good college and major in an area needed for a career in science.
6. I will graduate with a college degree in a major area needed for a career in science.
7. I will have a successful professional career and make substantial scientific contributions.
8. I will get a job in a science related area.
9. Some day when I tell others about my career, they will respect me for doing scientific work

Part 3: Perception

10. A career in science would enable me to work with others in meaningful ways.
11. Scientists make a meaningful difference in the world.
12. Having a career in science would be challenging.

Table 2 outlines the mean score pre-program and post-program results of the CIQ.

Table 2

Statement	M Pre-program	M Post-program
Would like a career in science	3.16	3.63
Family interested in science courses I have taken	3.48	3.29
Would enjoy science as a career	3.64	3.49
Family has encouraged the study of science	3.12	3.17
Make it into college & major in area for a science career	3.16	3.29
Will graduate with college degree in a major for science	3.04	3.42
Have a successful professional career	2.92	3.17
I will get a job in science related area	3.20	3.25
Someday I will tell others about my career	3.16	2.96
Would enable to work with others in meaningful ways	3.44	3.38
Scientists make a meaningful difference in the world	4.32	3.79
Having a career in science would be challenging	3.80	3.54

As seen in the above results, many categories mean scores were lowered at the end of the program. This could be an indication that the STEM Explore team did not make clear connections to the experiences the participants had each day with real-world connections.

Another objective of the STEM Explore program was to provide opportunities/experiences for middle school students with STEM content and their applications based on the new Revised State Science Standards. Students were asked each day to provide written input regarding their "positive" experiences and "negative" experiences they would make regarding the day's activities, trips, and speakers. Overwhelmingly, students commented in a positive direction. The students were intermittently asked their opinions about the two week program. Following are responses that were mentioned three or more times and the frequency that they were made:

Positive:		***Negative:***	
Everything	23	Medical tasting	9
Anemometer/thermometer	15	Walking	7
OH WOW Museum	15	Research	6
Solar cars	14	Rocket launch	6
Rocket launch	10	Paper tower	4
Mineral Museum	10	Airplanes	3
Podcast	9		
Planetarium	8		
Ice cream making	7		
Collecting bacteria	7		
Soda explosion	7		
Van de Graff	6		
Stars and airplanes	5		
Wall climbing	5		
NASA	5		
Running track	4		

A Parent satisfaction survey was conducted at the end of the two weeks. Twenty-two out of twenty-five possible respondents were received. On a scale of 1 – 5 with 1=Strongly Dissatisfied, 2=Dissatisfied, 3=Neutral, 4=Satisfied, and 5=Strongly Satisfied, the following questions were asked:

1. How would you rate your overall satisfaction with the STEM Explore program?
2. How would you rate your child's satisfaction with the STEM Explore program?
3. How would you rate your satisfaction with the STEM Explore program's activities, field trips, and speakers?

Table 3 summarizes the results:

Table 3

	Strongly Dissatisfied	Dissatisfied	Neutral	Satisfied	Strongly Satisfied
1.	0	0	0	2	20
2.	0	0	0	3	19
3.	0	0	0	3	19

In addition to this survey, several parents took the time to email the management team to express their satisfaction. Below is one example that was received:

"My granddaughter, Karrena, is attending the STEM 2 week program for students entering Grades 6-8. I just wanted to drop you a note to tell you how happy we are with the teachers and the program.

Karrena is an "average" student, but loves Science and loves to build "things." She unwillingly said she would attend the program (summer school to her) because I told her that I had STEM training for teachers and that it wasn't "sit down and read this and answer these questions" kind of school.

Well, to make a long story short: SHE LOVES THE PROGRAM. She talks about what they do constantly. I have never seen her so excited about school! She told me about the DNA necklaces, the medical museum, the mineral museum, the trip to the stadium, the static electricity experiments, the rocket launching, and so much more. She even takes pictures to show me when she returns home. This morning when I dropped her off, she told me to hurry up because everyone is there by 8:45 and she didn't want to miss a minute of school. (Who is this child?)

Please forward my thanks to the faculty and staff of the program for a job well done. I know that many hours went into preparation to insure that these students were kept interested and involved! Tell them that to see my Karrena's eyes light up when she tells me about the teachers and activities, makes my grandmother's (and teacher's) heart skip a beat!

I am hoping that there will be more STEM programs offered in the coming summers for high school students!!!"

The six preservice teachers were also survey at the end of the two week program for their input as to their thoughts of the "highlights" of the program, changes suggested for future programs and lessons they learned in their first teaching experience outside of student teaching. In addition to providing ideas for future programs, the preservice teachers reflected on their own teaching and lessons they learned. Some example they provided were, "more patience needed", "always have back-up plans", "consider diversity of student's backgrounds when planning experiences", and "planning is the key". These comments suggest that this was a wonderful learning experience for the preservice teachers as well as the student participants.

Educational Importance of the Work:

There are several key components to sustainability of STEM Explore subsequent to summer 2012:

- Increasing the number of middle school students interested in STEM to participate in taking additional STEM courses.
- Trained and participating program teachers will help train/recruit colleagues for future STEM Explore programs.
- Word-of-mouth from program teachers and students to friends, parents, colleagues, administrators.
- Collaboration with university faculty and industrial professionals as resources.

With growing need of increasing the number of underrepresented groups by providing opportunities for middle school students to participate in STEM activities, and STEM projects to nurture inquiry, and engage in meaningful discussions with STEM professionals regarding their careers, it is imperative to provide programs such as the STEM Explore program. This program begins to identify the strengths and weaknesses associated with summer STEM programs for urban middle school students and hopes to provide insight in future programs. Follow up studies with these participants are critical to determine long term program effectiveness. The current program was an attempt to show that an overview of STEM disciplines and careers for urban middle school students can make a difference in the way young people view science and STEM careers.

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