

# STEM Education in Southwestern Pennsylvania

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## Report of a project to identify the missing components

A summary report of focus groups and surveys of educators in Allegheny, Washington, Greene and Fayette counties conducted during the spring of 2008



**Leonard Gelfand Center for Service Learning and Outreach at  
Carnegie Mellon University  
and  
The Intermediate Unit 1 Center for STEM Education**

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## ABSTRACT

“STEM Education” has become a major topic of discussion and planning in the United States in recent years. Numerous reports, such as “Rising Above the Gathering Storm,” (U.S. National Academies 2005), emphasize that the competitiveness of our country is dependent on a strong educational program that prepares innovative scientists and engineers who will provide the innovations vital for a flourishing U.S. economy in this technological era, but the pathways that will lead to this goal are not clear. Educators – teachers, administrators and decision makers - who are vital to the preparation of students for careers in STEM areas find the term confusing and are unsure of its meaning and implications for teaching and learning. Institutions of higher education and representatives from business and industry are available to share content knowledge, skills and information with K-12 groups, but must be sure that their energies are aligned with the needs of educators as they work to deliver effective STEM education.

This report summarizes the information collected from hundreds of educators from Allegheny, Washington, Greene and Fayette counties during the spring of 2008. Teams from Carnegie Mellon University and the STEM Center at Intermediate Unit 1 gathered information through focus group discussions and a written online survey.

The major findings point to a need for greater awareness for educators as they work to learn about STEM education and how teachers at all levels – elementary, middle and high school - contribute to the preparation of scientifically and technologically literate citizens and STEM workers.

Other information gathered through this study indicates that teachers, administrators and counselors welcome the help of postsecondary institutions of education and industry groups as they work to learn what it means to be an engineer, technician or STEM professional. Teachers ask, “*How can I help children to know about these fields if I am not aware of the preparation that is required to have success in them?*” Programs which help the teachers and students understand how their course content is used by professionals in STEM careers are necessary to help make the information more relevant in the context of our world. Career awareness activities for all students in K-12 programs, especially opportunities to learn about and solve real-world problems, are also in demand.

Educators are concerned about the difficulty of finding time to implement interdisciplinary activities that demand innovative, team-based solutions which mirror the work of STEM professionals, but are interested in learning how to do this.

This report is a first step in identifying needs related to STEM education for our region. We are committed to strengthening and designing programs that will enable K-12 schools to prepare the STEM workforce for our region.

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## INTRODUCTION

STEM is an acronym for “Science, Technology, Engineering and Mathematics”, originally used by the Education-related programs of the National Science Foundation (NSF), but not explicitly defined by NSF. “STEM Education” is defined in many ways by different groups, and this causes questions to arise as K-12 educators are told that their work is key to ensuring that the United States remains competitive in the global market. Some of the questions surrounding STEM that were asked by teachers during focus groups and through written responses to a survey follow:

- In joining science, technology, engineering and mathematics are we saying that each component of STEM Education necessarily involves all of the STEM disciplines?
- Can you teach one of the areas, such as mathematics, and say that you are a STEM educator, since a strong knowledge of mathematics is necessary for success in science, technology or engineering?
- Is this about interdisciplinary education, or ensuring that students understand that content from each subject area is necessary to develop a strong understanding of the world?
- Do STEM educators help students understand the ways that science and mathematics support the work of engineers and technologists?
- Does STEM education, as is sometimes stated, recognize science and mathematics as the pillars with technology and engineering bridging the disciplines?
- Are teachers aware of the importance of connecting STEM to classroom instruction and career development activities throughout the school year?
- Exactly which jobs are referred to when saying that we have to increase participation in STEM careers?
- In our world of high-stakes testing, how can we evaluate the effectiveness of STEM programs?
- In a busy school day, when will there be time to include the activities that help to develop creativity and problem solving that are essential to innovation, and how do we know if students master these required skills?

Carnegie Mellon’s Leonard Gelfand Center for Service Learning and Outreach and the Intermediate Unit 1 Center for STEM Education partnered to survey, collect, and document educators’ knowledge of STEM and to identify the needs of K-12 systems in our region. The work included six focus group discussions held in March

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and April 2008, and an online survey completed by more than 350 area educators during May 2008<sup>1</sup>. The goal was to ensure that professional development activities and curricular programs designed by higher education, industry groups and others for the K-12 system are aligned with the needs expressed by the educators. With needs clearly defined by the data, targeted implementation of existing activities and programs can be achieved, and new programs can be designed to address and fill gaps.

## **NATIONAL, STATE AND REGIONAL STEM INITIATIVES**

“Tapping America’s Potential: Education for Innovation,” a report released by a coalition of leading business and technology associations in 2005<sup>2</sup>, highlighted several actions necessary to sustain American competitiveness in science and engineering, including the following:

1. Build public support for making improvement in science, technology, engineering and mathematics performance a national priority.
2. Motivate U.S. students and adults, using a variety of incentives, to study and enter science, technology, engineering and mathematics careers, with a special effort geared to those in currently underrepresented groups.
3. Upgrade K-12 mathematics and science teaching to foster higher student achievement, including differentiated pay scales for mathematics and science teachers.

As a 2007 follow-up to the report, the “American Innovation Proclamation<sup>3</sup>,” signed by 271 “leaders of American business and higher education,” urged Congress to act quickly on an agenda that will ensure continued U.S. competitiveness, enabling Americans to succeed in the global economy. Four specific areas of concern were outlined, including the need to improve student achievement in math and science through increased funding of proven programs

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<sup>1</sup> The survey was influenced by the work of the Arts Education Collaborative under the direction of Sarah Tambucci. The AEC collects information from educators in an effort to inform the decision-making process regarding professional development opportunities that are offered.

<sup>2</sup> Coalition members: AeA, Business-Higher Education Forum, Business Roundtable, Council on Competitiveness, Information Technology Association of America, Information Technology Industry Council, Minority Business Round Table, National Association of Manufacturers, National Defense Industrial Association, Semiconductor Industry Association, Software & Information Industry Association, TechNet, Technology CEO Council, Telecommunications Industry Association

<sup>3</sup> March 31, 2007 Proclamation; see [http://www.aeanet.org/governmentaffairs/gajil\\_proclamation0107.asp](http://www.aeanet.org/governmentaffairs/gajil_proclamation0107.asp)

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and incentives for science and math teacher recruitment and professional development. Other areas that were outlined focus on support of innovation through funding to national agencies that support this work, welcoming collaboration and work with foreign professionals, and R&D tax credits to encourage private-sector innovation investments.

Congressman Vern Ehlers (R-MI) and Congressman Mark Udall (D-CO) launched the bipartisan STEM Education Caucus to inform members of Congress about STEM Education. This group notes:

**STEM Education (from the STEM Ed Caucus Steering Committee, US Congress):**

Our knowledge-based economy is driven by constant innovation. The foundation of innovation lies in a dynamic, motivated and well-educated workforce equipped with Science, Technology, Engineering, and Mathematics (STEM) skills. However, the nature of our workforce and the needs of our industries have changed over time. Today, an understanding of scientific and mathematical principles, a working knowledge of computer hardware and software, and the problem solving skills developed by courses in STEM are necessary for most jobs. Therefore, STEM education is an enormous and pressing need.

**STEM Education is responsible for providing our country with three kinds of intellectual capital:**

1. Scientists and engineers who will continue the research and development that is central to the economic growth of our country
2. Technologically proficient workers who are capable of dealing with the demands of a science-based, high technology workforce
3. Scientifically literate voters & citizens who make intelligent decisions about public policy and understand the world around them

In response to the reports and calls for action, several distinct initiatives are underway. Pennsylvania is one of six states to receive a \$500,000 National Governors Association grant to establish science, technology, engineering and mathematics (STEM) centers. As noted in a July 2007 press release from the NGA:

*STEM centers will help state K-12 education systems ensure all students graduate from high school with essential competencies in science, technology, engineering and math. These competencies are integral to improving overall high school graduation and college readiness rates and supporting a state economy's innovation capacity related to the businesses that operate within their leading economic clusters.*

The Pennsylvania grant is targeted to the development of a statewide STEM network and five regional networks. All of the counties targeted by this study are

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part of the Southwest Pennsylvania network. The state initiative answers, ‘*What is STEM?*’ in the following manner:

*STEM stands for Science, Technology, Engineering and Mathematics—the four core disciplines critical to the development of America's technological innovations today and in the future.*

*STEM initiatives are efforts designed to foster the development and expansion of our nation's STEM workforce—individuals who receive sufficient academic and career exploration opportunities so that they can become contributors to our economic innovation and competitiveness.*

One goal of this developing Regional STEM network focuses on the inclusion of various types of institutions involved in ensuring the long-term competitiveness of southwestern Pennsylvania. The work will require the commitment of groups including K-12 school districts, intermediate units, colleges, universities, technical schools, workforce boards, economic development organizations, science and engineering centers, and informal education providers. Though difficult, it is imperative that these organizations collaborate to ensure our students are aware of and well-prepared for jobs that will enable the region to attract and retain companies.

Another regional initiative working to facilitate career education in schools is the Pittsburgh Regional Compact, coordinated by the Allegheny Conference on Community Development. This project seeks to “connect employers and educators to provide real-world career education to southwestern Pennsylvania students.” As of August 2008, 50 school districts and 105 employers have signed on as Compact members. While the focus is not solely on the STEM workforce, the continued development of the Compact and similar programs can help to create and strengthen the school district-employer partnerships that will be crucial to the economic success of the region.

## **STEM AWARENESS**

Interestingly, the majority of teachers who participated in the small focus group discussions<sup>4</sup> of STEM at Carnegie Mellon University or at locations in Washington, Greene, and Fayette counties had not been actively involved in activities held in

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<sup>4</sup> See the Process section of this document for details about the focus groups, held in the spring of 2008.

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their districts to learn about “STEM Education” prior to participation. While many teachers were able to determine that STEM was an acronym, the word *engineering* was frequently missing from the definition, with the word *education* being used instead (“science, technology, education and mathematics” was common.) Many thought of STEM as “a program” or curriculum. One administrator summarized that the power of STEM should come from integration of science and math skills and concepts into an engineering or problem solving process that utilizes appropriated technologies. He noted that in most K-12 programs today, the T & E are absent or weak and the S & M are taught in isolation.

Each focus group participant was given a copy of the Executive Summary for “Rising Above the Gathering Storm,”<sup>5</sup> and time was allotted for participants to read the statement on the front cover of the report (see box below). Just reading the statement seemed to provide an “a-ha” moment for many of the people in the groups. Comments such as, “I never knew about this problem,” or “I didn’t realize that this was so important for teachers,” were heard.

**Cover statement:** *In a world where advanced knowledge is widespread and low-cost labor is readily available, U.S. advantages in the marketplace and in science and technology have begun to erode. A comprehensive and coordinated federal effort is urgently needed to bolster U.S. competitiveness and pre-eminence in these areas. This congressionally requested report by a pre-eminent committee makes four recommendations along with 20 implementation actions that federal policy-makers should take to create high-quality jobs and focus new science and technology efforts on meeting the nation's needs, especially in the area of clean, affordable energy: 1) Increase America's talent pool by vastly improving K-12 mathematics and science education; 2) Sustain and strengthen the nation's commitment to long-term basic research; 3) Develop, recruit, and retain top students, scientists, and engineers from both the U.S. and abroad; and 4) Ensure that the United States is the premier place in the world for innovation. Some actions will involve changing existing laws, while others will require financial support that would come from reallocating existing budgets or increasing them.*

Through discussion with educators it became obvious that they recognize the importance of interdisciplinary education to provide students with the skills

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<sup>5</sup> *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academy Press, 2006.

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necessary to have success in 21<sup>st</sup> century careers and for solving the world's most challenging problems; however, they are concerned about when and how this can be achieved. Current educational programs present science and mathematics in the K-12 system in a segregated manner. Teacher participants in this project expressed concern about being able to effectively integrate technology as more than just the use of the computer as a tool for Internet searches or for typing reports.

The inclusion of engineering in the curriculum is seen in only a few programs, and some teachers questioned whether engineering is only for the older or “upper-level” students. Young children tend to be engineers first; building, making and doing projects long before they can explain the scientific principles that allow their buildings to stand or “canals” between puddles to carry water. The development of content knowledge and process skills, together with problem solving and creativity is something that begins in early childhood and continues throughout life. It is important that professional development programs help all K-12 teachers recognize the importance of their role in increasing student awareness of STEM careers. Focus group participants who have had success with engineering programs in K-12 classrooms note that the designing, creating and building completed in engineering challenges motivate many students to learn science and math concepts that will allow them to have more success with their projects.

Discussions sometimes focused on the fact that assessment frequently drives instruction. Skills that are necessary to complete engineering challenges or problem based learning activities such as teamwork, cooperation, communication of ideas, innovation, and learning from failure can be difficult to quantify or assess, so they may appear to be of less value, although this is not the case.

Historically, students who show an aptitude in mathematics and science have been encouraged to pursue engineering. Educators have heard that in many cases the students who are used to getting everything “right” the first time become frustrated in engineering programs where the response to a challenging problem may require several iterations and failures before a successful solution is determined. Educators are asking for more information to help them provide realistic expectations for their students.

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Some participants noted that the lack of inquiry based, problem solving activities at the secondary level was in part due to space and time constraints. One teacher may work with 150 students every day. Organizing materials and space for effective implementation of these activities is a challenge. The average class period of 41 minutes available for a science lesson is also a limiting factor. Teachers noted that while the Pennsylvania Academic Standards for Science and Technology include “Inquiry and Design” and process knowledge, their programs tend to be more focused on the content knowledge that will be assessed by the PSSA Science Assessment.

Teachers stated that students are given opportunities to complete interdisciplinary problem solving activities through competitions; however, these are frequently organized as after-school activities, an arrangement that limits the number of students who are able to participate. It was noted that students in gifted and talented programs are given more opportunities to participate in creative problem solving activities although all students can benefit from this type of activity.

Another area of variability across the region is the inclusion of career-focused activities throughout the K-12 system. The economic viability of the region depends on a prepared skilled workforce. Students need to be made aware of career opportunities, educational requirements and specific job skills for all areas, including STEM fields. The data collected through the written survey indicates that young children and high school students tend to participate in more career-focused activities and discussions while upper elementary and middle school students are not as likely to learn about careers associated with the content that they are learning. It is important to recognize that the relevance of content can be explored through a career application response to the frequently asked question, “*Why do we have to learn this?*”

When educators were asked, “in what ways can institutions of higher education and business or industry groups help prepare students for STEM careers?” the most common response was awareness. Teachers who participated in the focus group discussions mentioned that just being part of a ninety-minute conversation about STEM and the role of schools in preparing students for careers in STEM

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areas empowered and encouraged them to seek out more information. The fact that several reports were cited and made available to teachers helped expose another concern: educators were not aware of these reports. They noted it is difficult to remain current about workforce development issues while devoting full attention to implementing the best classroom instruction. Informational meetings, briefings, and discussion sessions could help educators become aware of their role in ensuring that America remains globally competitive.

The following pages highlight the process and results of the online survey that was completed by educators during May and June of 2008.



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## Process

This project grew out of a one-year period of planning and meetings that included the following individuals.

Carnegie Mellon	Judith Hallinen
Intermediate Unit 1	Robin Shoop
Catalyst Connection	Nancy Tsupros
Robert Morris University	Barry Nathan
Pittsburgh Technology Collaborative	Winston Erevelles
Bayer Foundation	David Landis
Benedum Foundation	Rebecca Lucore
	Jim Denova

Discussions focused on ensuring that the professional development programs designed to prepare students for STEM careers were aligned with the needs of the teachers. It was decided that the best way to determine these needs is to get the information directly from teachers and administrators in local districts.

A four-county region was targeted for this work: Allegheny, Washington, Greene and Fayette. To build on STEM-focused activities that are already in place, the region was divided into two areas with the Intermediate Unit 1 Center for STEM Education focusing on educators in Fayette, Washington and Green Counties and Carnegie Mellon focusing on Allegheny County educators.

The data collection activities were completed in two parts. A series of focus group discussions were held in each region during March and April 2008. Information collected from the focus groups was used to develop an online survey for teachers to complete during a three-week period from mid-May through June 10, 2008. The goal for the written survey was to provide options that made it possible for educators to complete in a few minutes, but also to provide opportunities for each participant to share additional comments, if desired. The following pages outline the data that was collected during each phase of the work.

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### Focus Group Sessions

Teachers and administrators in the targeted counties were invited to attend after-school focus group meetings in a dinner and discussion format to talk about STEM Education. The invitation is included in Appendix 1. Focus group sessions were held on the following dates:

	#	Location
	Participants	
Thursday, March 13	7	Carnegie Mellon
Tuesday, March 18	4	Carnegie Mellon
Tuesday, March 18	11	IU 1 – at Waynesburg
Wednesday, March 26	15	IU 1 – at Coal Center
Wednesday, March 26	6	Carnegie Mellon
Thursday, March 27	8	IU 1 – at Washington and Jefferson
Saturday, April 3	19	Carnegie Mellon
Total	70	

### School Districts (28) that were represented at focus group discussions:

Albert Gallatin	Laurel Highlands
Avella	McKeesport
Bethel Park	Mt. Lebanon
Bethlehem Center	Penn Hills
California Area	Peters Township
Canon McMillan	Pine Richland
Carmichaels	Pittsburgh Public
Central Greene	Plum Borough
Diocese of Pittsburgh	Southeastern Greene
East Allegheny	Trinity
Elizabeth Forward	Uniontown
Hampton	Washington
Jefferson Morgan	West Greene
Keystone Oaks	West Mifflin

The format for the focus group sessions was consistent across dates and locations. Educators introduced themselves and the following statement was read, in accordance with regulations related to the collection of opinions and ideas from human subjects<sup>6</sup>:

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<sup>6</sup> CMU IRB Protocol Number: HS08-027; approved January 15, 2008.

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### **Focus Group Statement**

We are working on a project entitled ***Science, Technology, Engineering, Mathematics (STEM) Education in Southwestern Pennsylvania: A plan to identify missing components*** with the goal of developing a report that will help regional institutions develop programs that meet the needs of teachers in the region. We would like to include your input on how outside groups can be most helpful to schools.

This focus group is intended to elicit your thoughts and knowledge on the subject of science, technology, mathematics and/or engineering education. As an expert in one of these fields, we are trying to get your opinions on how STEM topics are currently taught and the ways that outside groups such as industry and higher education can support this process. The information that we collect during these focus group meetings will be used to develop a written survey that will be distributed widely in the region to develop a more complete picture of STEM education in southwestern Pennsylvania.

This focus group should last approximately one hour and fifteen minutes. The ideas and thoughts you express will not carry your nametag, so when we develop the report from this meeting it will simply include that you participated but the document will not specifically link statements with the individuals who suggested them.

You have the right to refuse participation in this focus group. If at any point you feel as though you would like to discontinue participation in the focus group, you are welcome to do so without stating rationale or reasoning.

The discussions for each session centered on the participants' familiarity with STEM education, problem-solving, inquiry based, and interdisciplinary activities conducted in their schools, career education, and partnerships with business and institutions of higher education. Scribes were present at each session to record the comments and ideas shared by participants. The responses to the discussion questions were used as the basis for the comments in the previous section of this report. For the entire list of questions, see Appendix 2.

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## Online Survey of Educators

Using the information gathered from teachers and administrators during the focus group sessions, an online survey was created to facilitate the collection of input from a greater number of educators in the region. Knowing that requests to participate in online surveys are frequently ignored, the program coordinators sought to present questions in a format that could be completed in a short period of time but still provide important information. Simple click and choose items were included on the survey, along with multiple options for teachers to provide comments in response to questions. A discussion of the responses to each item follows. For the full ten-question survey, please see Appendix 3.

A request to complete the online survey was mailed to teachers and administrators in all of the districts in Allegheny, Washington, Greene and Fayette counties in May 2008. The Pennsylvania Science Teachers Association also disseminated the request for participation through the “Building a Presence for Science” contacts in the region. The message that was sent follows:

Dear Educator,  
Carnegie Mellon and Intermediate Unit 1 are working together on a project that is designed to identify the career education and professional development activities that will lead to more effective preparation of students for 21st Century jobs in science, technology, engineering, and mathematics (STEM) fields. We have posted a nine question survey that will help us to learn from you, and it can be found at <http://www.cmu.edu/gelfand-center/stemsvr.html>. We would like to hear from elementary, middle and high school teachers of science, mathematics and technology and from counselors and administrators (please share this message with your colleagues!). All educators who complete the survey will be entered into a drawing for Barnes and Noble gift cards.

The information that we collect from this process will be used to inform institutions of higher education and business partners of the activities that will be most beneficial to teachers and students in our region.

This project is funded by the Benedum Foundation.

If you have any questions, please contact Judith Hallinen at Carnegie Mellon.

Thank you for your help!

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The survey was completed by 354 teachers before the June 10 deadline for review of data. Participants identified themselves according to these categories:

Administrator	23
Counselor	13
Teacher	318

Respondents were affiliated with the following types of schools:

Elementary	24.8%
Middle	32.5%
High	42.7%

Public	95.2%
Private	4.8%

Teachers identified themselves as teaching the following subjects:

Science	35.0%
Technology	11.5%
Mathematics	20.2%
Other	33.3%

“Other” was used for elementary teachers who listed multiple subjects or “all (elementary teachers)” in response to Discipline.

The table on the following page lists the school districts of responding educators.

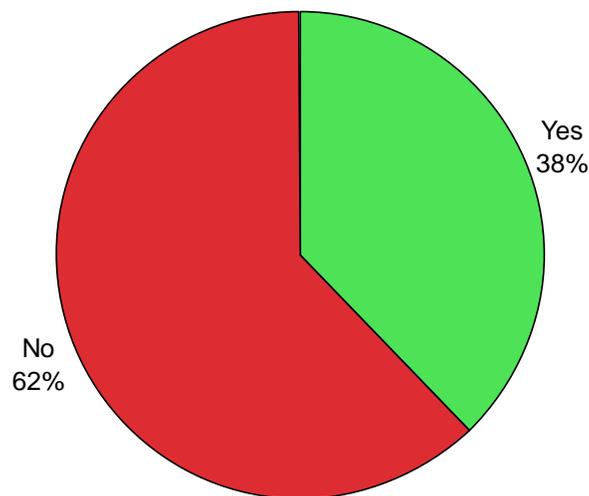
<b>Washington/Greene/Fayette</b>		<b>Allegheny County</b>		<b>Other</b>	
Albert Gallatin	14	AIU Alternative Ed program	1	Diocese of Greensburg	1
Bethlehem - Center	6	Allegheny Valley	9	Norwin	1
Brownsville Area	3	Baldwin Whitehall	4	Somerset	1
Burgettstown Area	1	Bethel Park	10	Informal Education	1
California Area	14	Carlynton	2	total	4
Canon McMillan	6	Charter School	1		
Carmichaels Area	2	Clairton City	5		
Central Greene	1	Deer Lakes	1		
Charleroi Area	1	Diocese of Pittsburgh	9		
Chartiers-Houston	4	East Allegheny	1		
Connellsville Area	2	Elizabeth Forward	9		
Fort Cherry	1	Fox Chapel	3		
Frazier	11	Hampton Township	16		
IU 1	1	Highlands	4		
Jefferson Morgan	1	Independent	6		
Laurel Highlands	19	Keystone Oaks	3		
McGuffey	15	McKeesport Area	3		
Peters Township	33	Montour School	3		
Ringgold School	1	Moon Area	8		
Southeastern Greene	1	Mount Lebanon	3		
Trinity Area	4	North Allegheny	4		
Uniontown Area	20	North Hills	3		
	Total	161	Northgate	2	
			Penn Hills	4	
			Pine-Richland	6	
			Pittsburgh Public Schools	27	
21 districts + IU teacher			Plum Borough	2	
			Quaker Valley	1	
			Riverview	5	
			Shaler Area	5	
			South Allegheny	1	
			South Fayette	8	
			Steel Valley	1	
			Upper St. Clair	9	
			West Allegheny	4	
			West Jefferson Hills	2	
			West Mifflin Area	1	
			Wilkinsburg	1	
			Woodland Hills	2	
				189	
			35 districts + AIU + Diocese + independent		

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**1. Has "STEM Education" been a topic of discussion in your district and/or school?**

The majority of teachers and administrators report that STEM Education has not been a focus of discussion in their district, with more teachers in the Washington, Greene, Fayette County group responding yes to this question. (Allegheny County: yes=34%; Washington, Greene, Fayette: yes=42%). The IU 1 Center for STEM Education has been working to increase awareness of STEM education and this may be one reason that the responses are higher in that area.

**"STEM Education" Discussion Within District or School**



Some comments provided by teachers on the final (optional) comment area address the inclusion of STEM Education in professional development activities. Some educators believe that STEM is just a trend that will soon be forgotten:

*This sounds very good but like many hot topics in education this will come and go. Because of the demands of everyday teaching and the flood of the next "great trend" this will make little impact on the system. The demands are too great on teachers today and the pressure to attain standardized test results leave little time for this type of program.*

Another teacher noted:

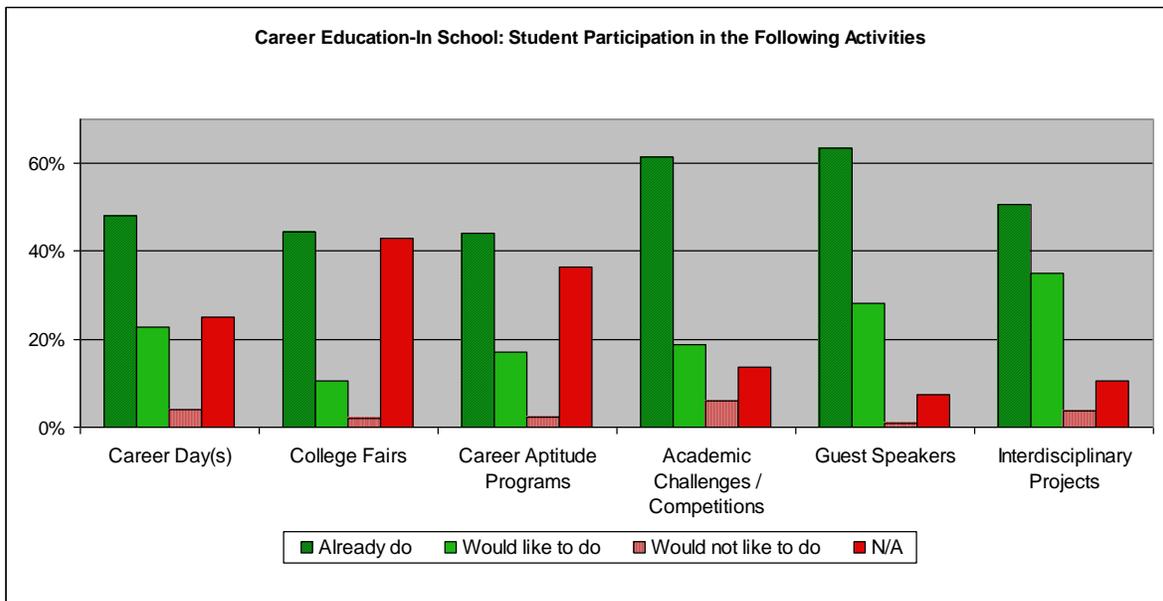
*Teachers and students are not fully aware of the importance of connecting STEM to classroom instruction and career development activities throughout the school year.*

Programs are needed to develop teachers' awareness of the importance of STEM skills and the ways to integrating them into "the demands" listed above.

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## 2. CAREER EDUCATION: In School

**Do the majority of students in your building participate in the following types of activities?**



It is encouraging that half of the respondents said their students participate in interdisciplinary activities. An additional 35% of the teachers asked for activities and programs to help achieve this while still enabling students to prepare for PSSA tests. Teachers were also interested in conducting career days and hosting guest speakers. This is an area of need that can be filled through partnerships with higher education and business groups, although guidelines and expectations must be communicated to employers to ensure that the programs are effective.

When analyzing the responses to this question by grade level, it appears that students tend to participate in career awareness activities in elementary school and in high school, with few activities at the middle school. There is also a disparity in services offered to students. In response to this question, one teacher provided a comment that is especially important if a goal of STEM education is to ensure that all citizens are scientifically and technological literate:

*The school offers these opportunities and the high end students take advantage of these experiences. I have very high end and very low end students. The low end students participate only in the first three items [career days, college fairs and career aptitude programs].*

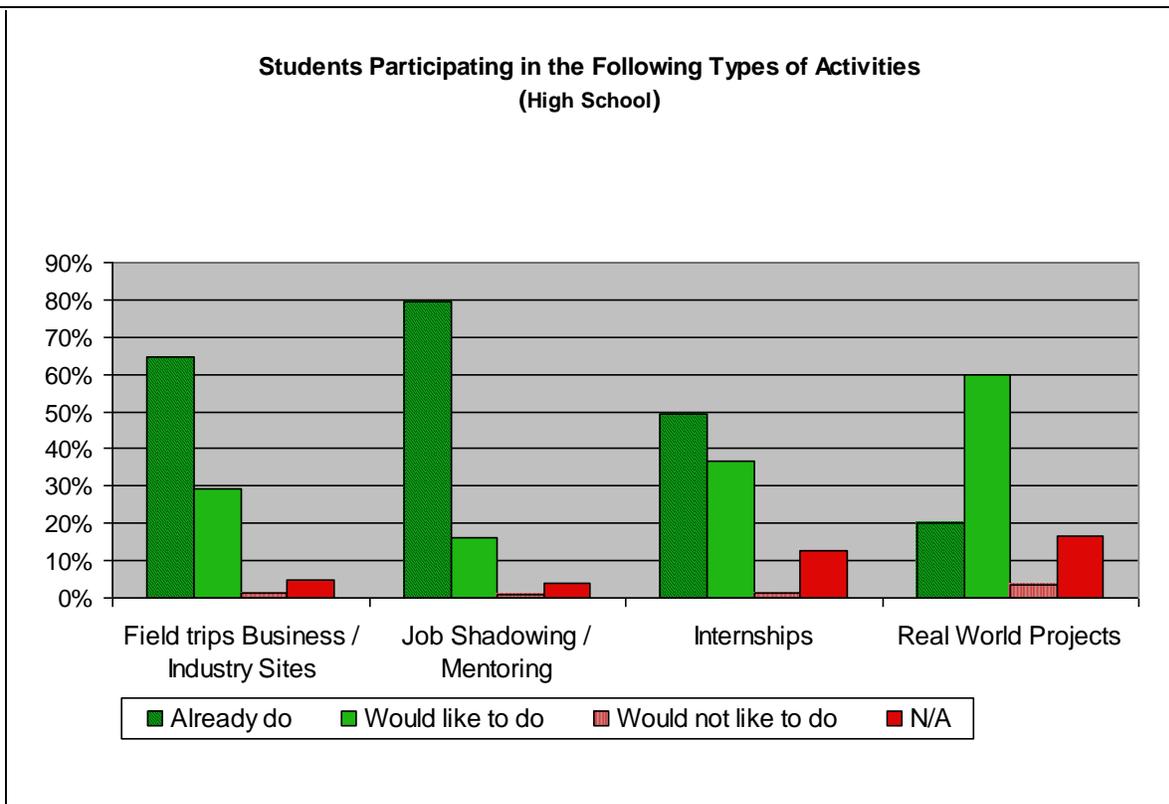
And this was seconded by another teacher:

*Only the select few get to participate in those competitions. Just our gifted and talented kids get to participate in them. I wish all the students had the opportunity to join or try out for the Science Olympiads or any other Science competition. Same with Career Days; only the gifted students get to go ...it is not available for the whole school to experience these programs. How can you offer programs for the whole school not just the gifted few???*

### 3. CAREER EDUCATION: University or Business Partnerships

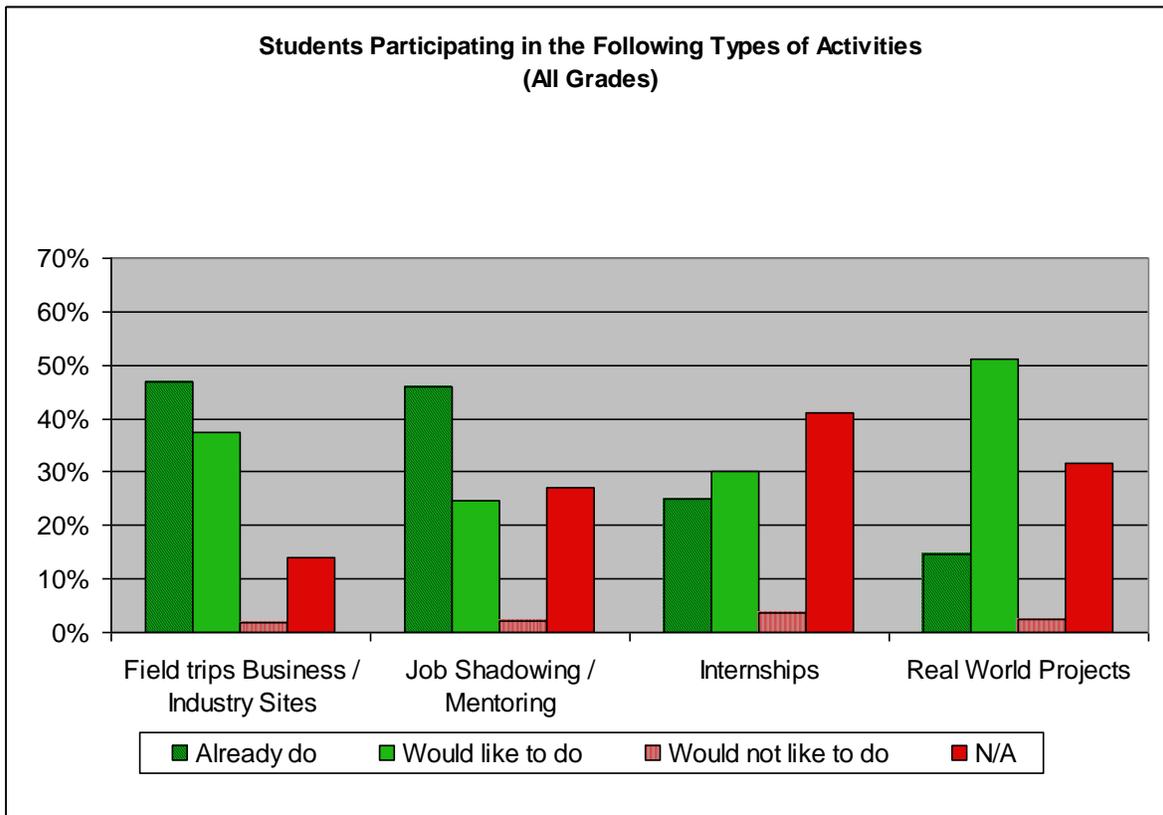
#### Do students in your building participate in the following types of activities?

As the activities mentioned in this question are most frequently implemented at the high school level, the following chart summarizes the response of high school teachers. While the previous question asked if a majority of students participate in this type of activity, the word “majority” was inadvertently omitted from this question. As a result it is clear that 79% of the teachers are in schools where at least some students participate in job shadowing or mentoring, but we cannot be sure this is an experience provided to the majority of students.



When reviewing the results across all grades for this question (below), some important needs become clear. Slightly more than half of the responses indicate that teachers would like to engage students with real world projects that enable collaboration with business and university partners. Where applicable, teachers would like to include field trips, internship opportunities, and job shadowing experiences to allow students to see people at work in STEM careers. Safety and logistical concerns related to these activities are complex, but the impact of these activities on students' awareness of career opportunities could be great, as noted in a teacher's comment:

*Many of my students come from backgrounds that do not readily give them access to the possibilities out there for satisfying careers. It is tiring to hear how industry is fed up with unprepared applicants or the lack of applicants. They need to actively recruit dynamic people from their respective industries to go out and fill the minds of these children with those possibilities for their futures.*

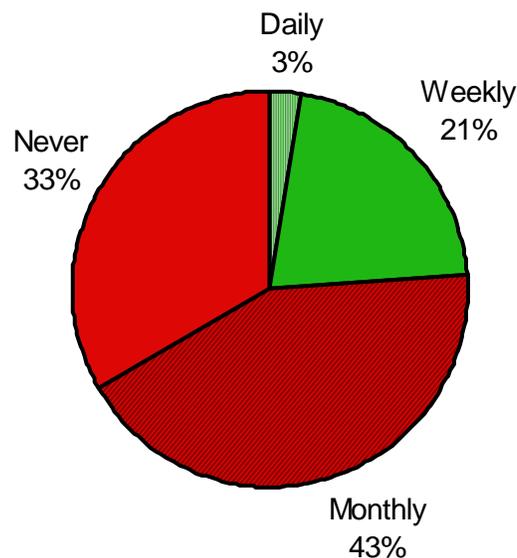


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**4. In a nine week period, how often are you able to integrate discussions that help students become aware of STEM careers?**

If students are to connect classroom content to career paths, it is important to make them aware of how the content they are learning is applied by individuals in STEM careers. This is important as districts plan for instruction that is aligned with the “Career Awareness and Preparation” areas of the Pennsylvania Academic Standards for Career Education and Work<sup>7</sup>. More than 40% of all teachers infrequently discuss STEM careers in the classroom, while one third of the teachers never include STEM career discussions in the classroom.

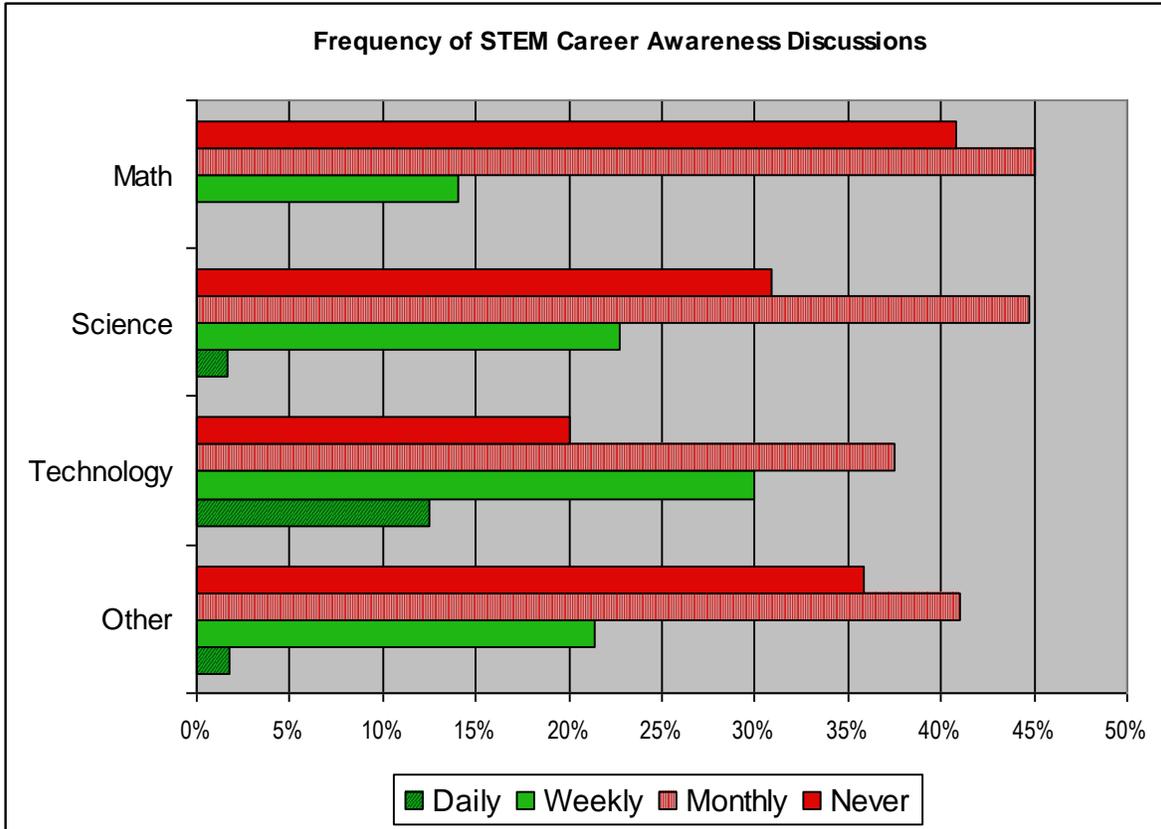
**Frequency of STEM Career Discussions Across all Teachers**



The chart on the next page presents the data when sorted by subject area. Technology teachers are more likely to include STEM career discussions in the classroom (43% do this daily or weekly) while mathematics teachers rarely include career discussions (14% do this weekly, none daily). This, together with the responses to Question 5, provides key information that can be used by employers and others who seek to design programs that address needs expressed by educators.

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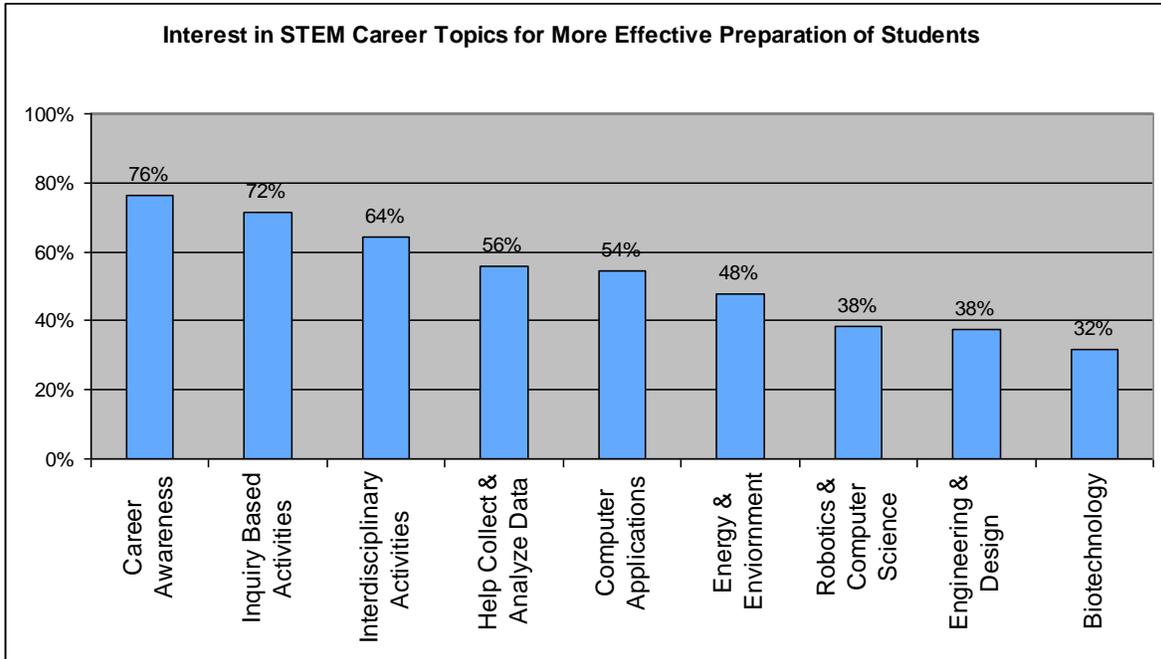
<sup>7</sup> 22 Pa. Code Chapter 4 - Appendix E; Career Education and Work Academic Standards; Pennsylvania Department of Education.



**5. Please indicate topics that would help you to more effectively prepare students for STEM careers**

External groups interested in providing professional development for teachers may find these responses particularly useful. Options provided to the teachers included the following, and teachers were able to select any/all of the responses:

- Career Awareness "What are the jobs?" "What is necessary for success in these careers?"
- Implementing Interdisciplinary Activities integration of content learning in science, technology and math
- Inquiry-based activities develop curiosity and innovation skills
- Helping students to collect and analyze data
- Biotechnology
- Robotics and/or Computer Science
- Engineering and Design
- Energy and the Environment
- Computer Applications (Simulation, 3-D modeling, interactive educational gaming, etc.)
- Other topics of interest



Slightly more than 75% of the teachers noted Career Awareness as a topic that would help them to prepare students for STEM careers. Two other topics of interest for the majority of teachers included inquiry based activities and interdisciplinary activities. Teachers commented that the school schedule does not allow time for collaboration with their colleagues to develop activities to help students understand how content from a variety of subject areas must be used to solve problems.

Teachers expressed an interest in being able to talk with people who work in STEM careers to learn about the mathematics or science knowledge that is necessary for success in their careers. This would enable the teachers to include relevant career connections when content is presented in the classroom.

During focus groups and in two comments on the written survey, teachers stated that an understanding of the required training and educational paths of people in STEM fields would help them to more effectively prepare students for careers. Strong skills in mathematics and science are essential for success in STEM careers, but other skill sets are also required. Higher education and industry groups can prepare workshops and materials to help teachers and students learn about all of the factors that contribute to success.

Some comments indicate that there is confusion about what the T in STEM means; sometimes the use of computers as a tool is referred to as “technology use”

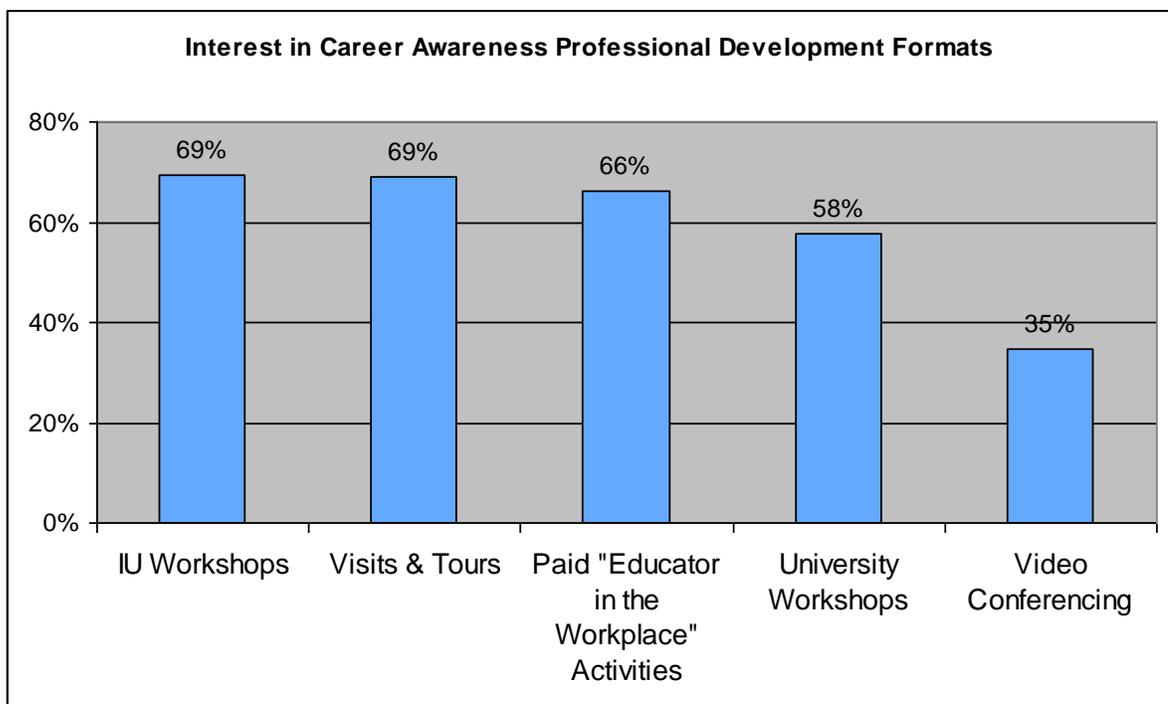
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while the true T or Technology in STEM is much broader. A broad definition: Technology consists of all the modifications humans have made in the natural environment for their own purposes - inventions, innovations, and changes intended to meet our wants and needs, to live longer, more productive lives.<sup>8</sup>

A school administrator summarized the importance of professional development in helping teachers support students in her district:

*As a high school principal, I am concerned that we get as much training to our staff as possible on these issues in order to ensure that our students have a better chance for careers in the future. Anything you can offer would be a big help to us. Our district is not wealthy, and neither is the population we serve. If we can get our students excited about careers where they have a chance to better their standard of living, plus be happy at their job because it's something they really want to do, then I'm all for any program we can bring to our school.*

**6. Which of these professional development options are of interest to help you provide more effective career awareness?**



A large majority of teachers are clearly interested in workshops and courses provided by Intermediate Units and universities. Two-thirds of the teachers are

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<sup>8</sup> Dugger, W. E., Jr. "Phase III Technology for All Americans Project." TECHNOLOGY TEACHER 60, no. 4 (December 2000-January 2001): 27-31.

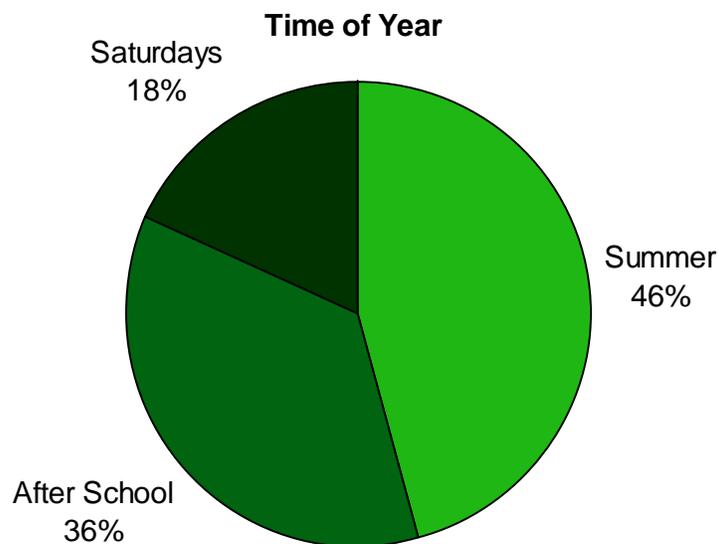
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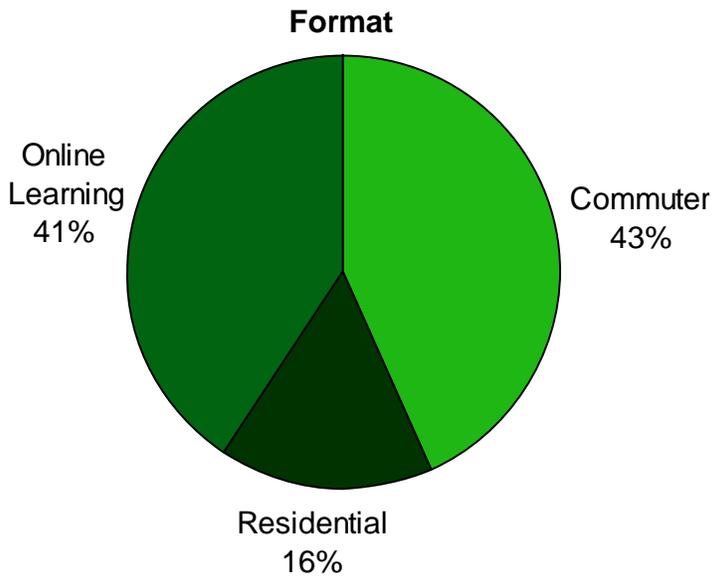
interested in tours and interactions in STEM worksites to enhance their understanding of this work and ability to provide accurate career messages to students. One teacher's comment stressed the importance of these activities:

*I had the opportunity to experience a taste of what STEM is by attending workshops at CMU. I feel strongly that this type of program for teachers is needed to help teachers better prepare students for the types of jobs that they would be facing when they graduate from college. I feel the more that teachers are trained, the better equipped they will be to share that information with their students.*

7. To help providers of professional development design programs that are aligned with the preferences of educators, teachers were asked to indicate the structure of professional development programs that were of interest to them.

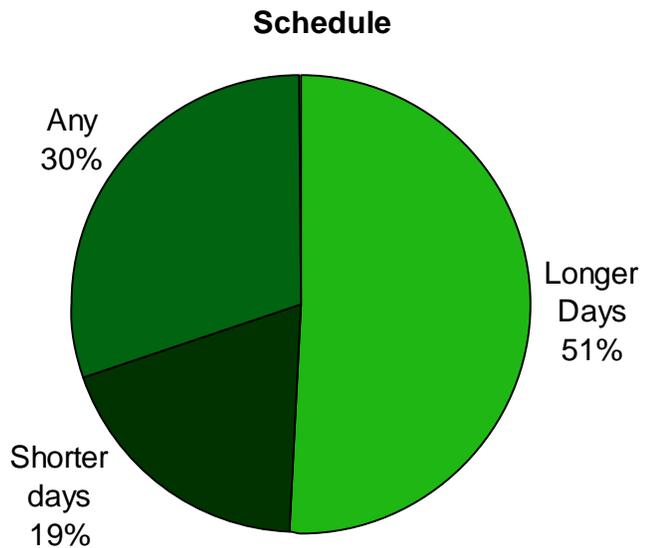
**TIME OF YEAR:** Summer was the preferred time of year. Saturday workshops during the school year are not popular with the educators who submitted survey responses.





**FORMAT:** Teachers prefer commuter over residential programs, and are interested in online educational activities that can help them to be better prepared without having to drive long distances.

**SCHEDULE:** Longer instructional days are preferred over programs that spread workshop activities over more days with shorter programs planned each day.



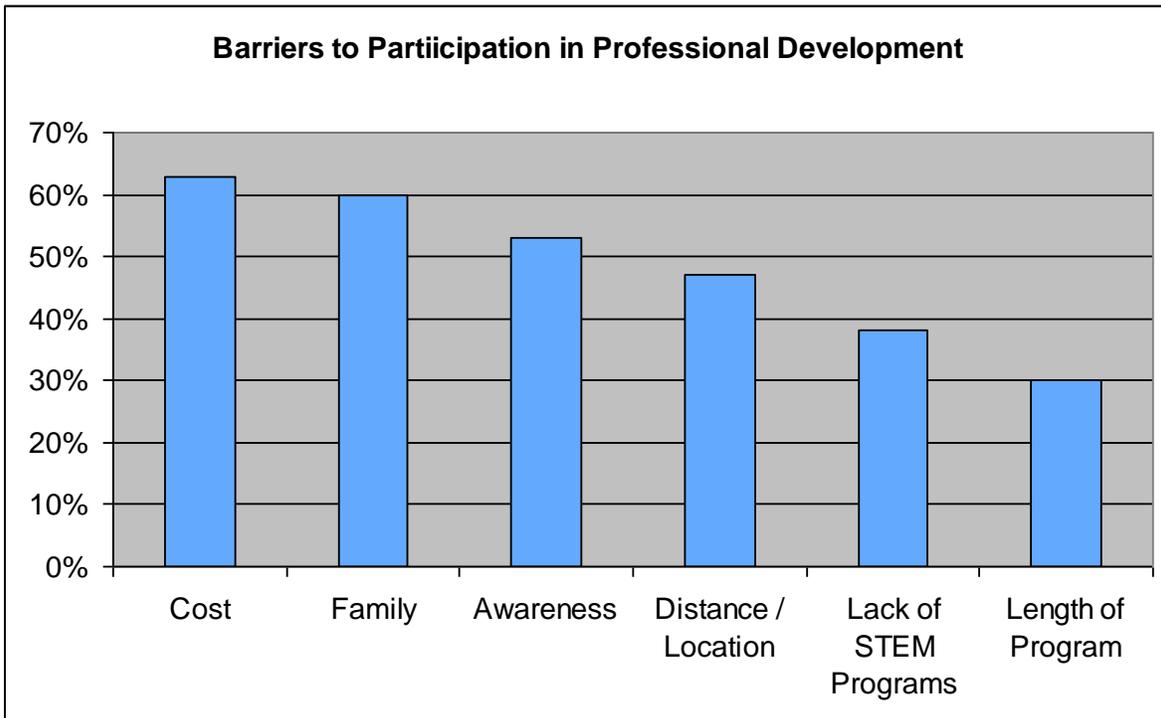
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**8. How far are you willing to drive for a professional development program? Enter a number of miles (a one way "commuter" drive).**

The responses to this question were difficult to analyze. The question asked for a number of miles, but respondents included comments on price of gas, drive time, and topic of interest. These are key factors in determining whether educators will participate in programs; however they could not be converted to a number for analysis. When comments such as these were removed, the responses indicate that educators are willing to commute 27 miles to a workshop. Additional information that can help program developers ensure success for their professional development offerings can be gleaned from the results to question 9.

**9. What are the barriers that prohibit your participation in STEM professional development activities? (select all that apply)**

- Distance / location
- Family obligations
- Length of the program
- Cost
- Lack of STEM-focused programs offered in my region or for my district
- Awareness of programs
- Other barriers



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Almost two thirds of educators listed cost and taking time away from family as reasons why they might not attend a professional development activity. Nearly half noted the distance that must be traveled as a barrier to their participation in STEM focused activities. A majority of the teachers are simply not aware of STEM activities that are taking place in their region and many felt there simply aren't programs to attend.

Survey participants were able to select any of the barriers above, and it should be noted that 17% listed five or six of the items as barriers. It is difficult to overcome all of these concerns. For those who indicated only cost and awareness or availability of programs in the area (nearly 20% of the educators), outside groups such as business and industry partners or institutions of higher education can work to provide effective programs at little or no cost to the teachers, in locations that are convenient to them.

#### **10. (Optional) Other Comments about STEM Education and/or STEM Professional Development that you would like to share.**

Sixty-seven of the educators took the time to share additional comments about STEM. Some comments that highlight important points about STEM Education follow.

- Many early childhood teachers are aware of their role in the process but note that other requirements in the school day make it difficult to focus on STEM:

*As a first grade teacher, I target the mathematical reasoning, logic, and problem solving component of STEM. I'm just learning how to use inquiry-based activities in my classroom. It is difficult for me to integrate the other components of STEM into my curriculum since 65% of my instruction centers on reading, writing, speaking, and listening.*

As noted in section 1, the involvement of teachers throughout the K-12 continuum is required to ensure that our children develop the knowledge and skills that will be necessary in the STEM workforce. The mathematical reasoning and problem solving skills incorporated by this first grade teacher, combined with continuing efforts throughout the educational program, will lead to success.

- Engineering and Engineering technologies accounted for 7.3% of the bachelor's degrees awarded by degree-granting institutions in 1990-91, while the number

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dropped to 5.5% of the bachelors degrees in 2005-06. Mirroring this data<sup>9</sup>, one high school teacher focused on the trend in career choices of students over his teaching career:

*In my honors level physics section and the AP physics, few students are choosing a physical science, engineering, or other solid science path other than computers, biology, and medicine, maybe. A big change in attitude since I first started those many years ago when more than half of our top students planned on going into engineering.*

To help teachers who have noticed this shift of student interests, a different high school teacher provided a comment that program and curriculum developers should keep in mind:

*STEM education could be a great resource for my teaching. I would love to have the background and curriculum needed to offer a project based engineering course for my students. Any time you can offer teachers lesson plans and curriculum that we can directly use in the classroom, teachers will be responsive and use the resources. If the information given can't be used or is too difficult to use or if students don't see the value in it, it won't be used.*

- Another commented on the integration of STEM and the arts:

*I am very interested in what happens when STEM becomes STEAM - when the arts are added into the mix. (Data visualization, conceptual art, game design, visual analysis, STEM-enhanced performance art, etc.)*

In summary, this supports the statements that interdisciplinary collaboration is necessary for success in the careers that will help to solve problems encountered by all in our global society. The collaborative work of K-12 school systems, higher education partners and industry groups will be necessary to help all students develop these skills.



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<sup>9</sup>Planty, M., Hussar, W., Snyder, T., Provasnik, S., Kena, G., Dinkes, R., KewalRamani, A., and Kemp, J. (2008). The Condition of Education 2008 (NCES 2008-031). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

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## APPENDIX 1

**STEM Focus Group Invitation: Sent via email to educators in Allegheny County; a similar invitation was used by IU 1.**

*Please share with teachers of mathematics, science and technology in your school. Thank you!*

# STEM

## Science, Technology, Engineering and Mathematics Education

### **Focus Group Discussions**

**Teachers:** We would like to hear about STEM education at your school. Carnegie Mellon University and Intermediate Unit 1 are conducting discussion sessions in Allegheny, Washington, Greene, and Fayette counties to learn from teachers about the ways that businesses and institutions of higher education can help you as you prepare students for 21<sup>st</sup> century careers. This information will be collected and assembled into a report that will help regional partners plan effective professional development programs and student activities.

We invite elementary, middle and high school teachers of science, mathematics and technology to participate in these sessions! Dinner will be served. Educational materials will be provided and all will be eligible for a raffle at each discussion session.

Allegheny County Focus Group discussions will be held at Carnegie Mellon University on the following dates:

Thursday, March 13	4:45 – 7:00 PM
Tuesday, March 18	4:45 – 7:00 PM
Wednesday, March 26	4:45 – 7:00 PM
Saturday, April 3	9:30 – 11:00 AM

Note: Parking at the university is free after 4:30. Participants are asked to attend on only one date, but multiple sessions are scheduled so that we can hear from as many educators as possible. If you are able to attend on **one** of these dates, please register by contacting Judy Hallinen at Carnegie Mellon, [jh4p@andrew.cmu.edu](mailto:jh4p@andrew.cmu.edu), or call 412-268-1498. A map and more information will be sent to all registered teachers.

We thank you, in advance, for providing information through this process!

*This work is funded by a grant from the Benedum Foundation*

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## **APPENDIX 2**

### **STEM Focus Group Questions**

1. Have you heard the term “STEM Education”? Has it been discussed at your school / district?
2. How would you define STEM education?
3. Have you heard about or read reports such as “Rising Above the Gathering Storm”? Have they been discussed in your school district? *Distribute exec. summary and ask people to read statement on front page.*
4. How often and how do you implement inquiry-based, problem-solving activities in the classroom? Please describe.
5. Do students participate in extracurricular activities involving project-based, problem-solving activities? If so, please describe.
6. How often do you integrate career-focused discussions in your classroom? How is the process initiated?
7. Does your curriculum include discussions or introductions to careers in engineering and technology? How often and how diverse?
8. Are you able to collaborate with teachers in other disciplines to integrate mathematics, technology and science learning; i.e. do you work together with other teachers to plan problem solving activities which require the application of content from a variety of content areas?
  - If “no”: What are the barriers?
  - if “yes”: How is this achieved; what kind of support is in place that enables you to do this?
9. What would be necessary to increase the effectiveness of teachers in STEM areas? What resources would help teachers to become prepared to implement interdisciplinary activities?
10. Does your school collaborate with any industry/business groups for educational programs? Are there other types of industry partnerships in place (this could be financial support, etc)?
11. How can higher-education institutions better support your efforts to implement effective STEM programs?
12. We are trying to collect information from as many teachers/ administrators as possible and plan to use an online written survey to achieve this. How can we encourage participation in this work?

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## **APPENDIX 3 Written Survey that was used to Collect Educator Input<sup>10</sup>**

Carnegie Mellon University and The STEM Center at Intermediate Unit 1

Southwestern Pennsylvania

Science, Technology, Engineering and Mathematics (STEM) Education Survey

### **We need your input!**

In an effort to provide high quality professional development opportunities that meet the needs of science, mathematics, technology and engineering teachers in the region, we need your help. Please complete this brief nine-question survey by June 10, 2008. All participants will be entered into a drawing for Barnes and Noble gift cards (drawing on June 10). If you have any questions about this activity, please contact Judith Hallinen at Carnegie Mellon, [educational-outreach@andrew.cmu.edu](mailto:educational-outreach@andrew.cmu.edu)

The identifying information will not be stored with your responses; we will only contact you if you are the winner of one of the Gift Cards.

First Name

Last Name

Email

School district

School

Discipline(s)

Grade Level(s)

Position:       Teacher       Counselor       Administrator

**PLEASE KEEP THIS INFORMATION IN MIND AS YOU ANSWER THE FOLLOWING QUESTIONS.**

#### **STEM Education (from the STEM Ed Caucus Steering Committee, US Congress):**

Our knowledge-based economy is driven by constant innovation. The foundation of innovation lies in a dynamic, motivated and well-educated workforce equipped with Science, Technology, Engineering and Mathematics (STEM) skills. However, the nature of our workforce and the needs of our industries have changed over time. Today, an understanding of scientific and mathematical principles, a working knowledge of computer hardware and software, and the problem solving skills developed by courses in STEM are necessary for most jobs. Therefore, STEM education is an enormous and pressing need.

STEM Education is responsible for providing our country with three kinds of intellectual capital:

1. Scientists and engineers who will continue the research and development that is central to the economic growth of our country.
2. Technologically proficient workers who are capable of dealing with the demands of a science-based, high technology workforce
3. Scientifically literate voters and citizens who make intelligent decisions about public policy and understand the world around them

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<sup>10</sup> Survey was posted at <http://www.cmu.edu/gelfand-center/stemsurv.html>

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**SURVEY STARTS HERE**

**1. Has "STEM Education" been a topic of discussion in your district and/or school?**

- Yes       No

**2. CAREER EDUCATION: In School**

Do the majority of students in your building participate in the following types of activities?

	Already Do	Would Like to do	Don't Want to do	N/A
Career Day(s)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
College Fairs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Career Aptitude Programs (Work Keys, My Career Journey, etc)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Academic Challenges or Competitions (TSA, Science Olympiad)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Guest Speakers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interdisciplinary projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**3. CAREER EDUCATION: University or Business Partnerships**

Do students in your building participate in the following types of activities?

	Already Do	Would Like to do	Don't Want to do	N/A
Field trips to business / industry sites	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Job Shadowing / Mentoring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Internships	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Real world projects with businesses or universities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other Career Ed Activities (describe) _____				

**4. In a nine week period, how often are you able to integrate discussions that help students become aware of STEM careers?**

- Daily     Weekly     Monthly     Never

**5. Please indicate topics that would help you to more effectively prepare students for STEM careers;**

- Career Awareness - "What are the jobs?" "What is necessary for success in these careers?"
- Implementing Interdisciplinary Activities - integration of content learning in science, technology and math
- Inquiry-based activities - develop curiosity and innovation skills
- Helping students to collect and analyze data
- Biotechnology
- Robotics and/or Computer Science

- Engineering and Design
- Energy and the Environment
- Computer Applications (Simulation, 3-D modeling, interactive educational gaming, etc)

Other topics of interest:

**6. Which of these professional development options are of interest to help you provide more effective career awareness?**

- Visits to and tours of STEM Industry and/or research laboratories
- Paid "Educator in the Workplace" activities in local companies
- Video conferencing with personnel in industry or research labs
- University Workshops and activities
- Intermediate Unit or university workshops and courses (for Act 48 hours and/or credit)

Other Professional Development activities

**7. Indicate the structure of professional development programs that are of interest to you (select all that apply):**

- |               |  |   |   |
|---------------|--|---|---|
| Time of Year: | <input type="checkbox"/> Summer  | <input type="checkbox"/> Academic year / after school                         | <input type="checkbox"/> Academic year / Saturday |
| Format:       | <input type="checkbox"/> Commuter  | <input type="checkbox"/> Residential  | <input type="checkbox"/> Online Learning          |
| Schedule:     | <input type="checkbox"/> Longer days/ fewer sessions<br>(ex: Five 6-hour days) | <input type="checkbox"/> Shorter days/ more sessions<br>(ex: Ten 3-hour days) | <input type="checkbox"/> Any / All                |

**8. How far are you willing to drive for a professional development program? Enter a number of miles (a one way "commuter" drive). \_\_\_\_\_**

**9. What are the barriers that prohibit your participation in STEM professional development activities? (select all that apply)**

- Distance / location
- Family Obligations
- Length of the program
- Cost
- Lack of STEM-focused programs offered in my region or for my district
- Awareness of programs

Other barriers: \_\_\_\_\_

**10. (Optional) Other Comments about STEM Education and/or STEM Professional Development that you would like to share.**

**Thank you for taking time to complete this survey!**

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## **About the developers of this report:**

**The Intermediate Unit 1 STEM Education Center** builds on more than a decade of work with the 25 school districts and five vocational technical schools in Washington, Greene and Fayette Counties. IU 1 has replicated successful STEM programs and built an infrastructure capable of supporting future initiatives. IU 1's success has come from unique partnerships with the Benedum Foundation, Washington & Jefferson College, the business community, and state/federal grants. IU 1 continues to roll-out best practice K- 12 STEM programs. We are committed to building Industry partnerships that will:

- ✓ Introduce students/teacher to cutting edge technology and equipment
- ✓ Overcome stereotypes about who participates and achieves in STEM fields
- ✓ Connect teachers/students with real-life workforce problems

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Washington, PA 15301  
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E-mail: ntsupros@washjeff.edu

**The Leonard Gelfand Center for Service Learning and Outreach at Carnegie Mellon** is dedicated to creating and strengthening partnerships that allow Carnegie Mellon faculty, students and staff to share knowledge and skills with individuals and organizations in southwestern Pennsylvania and beyond. The focus on K-12 STEM education is in three broad strands, which provide an opportunity for all to share research strengths and expertise with educators and students in the region:

- Practical education and community outreach to formal and informal education providers
- Teacher professional development in STEM, instructional materials that are aligned with academic standards, and practical information that can help teachers to understand the connections between the content that they teach and the work of STEM professionals
- Student programs including competitions, career awareness and preparation activities and opportunities to interact with people who are in STEM careers

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