AC 2012-4588: USING A CAMPUS-WIDE COMMUNITY OF PRACTICE TO SUPPORT K-12 ENGINEERING OUTREACH

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Tracey Collins is the Project Coordinator for the MISO Project. Responsibilities include implementing activities of the project, coordinating efforts among K-12 science, technology, engineering, and mathematics (STEM) outreach programs, and working closely with university enrollment management and data management professionals at the Friday Institute. She works closely with large and small STEM outreach groups like the Science House, the Kenan Fellows Program, and the Engineering Place, as well as small, individual-PI groups offering K-12 outreach to teachers and students. More specifically, Collins assists with planning, implementing, managing, and reporting of project activities which include survey development, coordination of data collection, interfacing with data managers, coordination of quarterly meetings of outreach providers to gather feedback, identify best practices, and disseminating findings to stakeholders. In addition, she assists with annual report writing and conference presentations. Prior to working at NC State, Collins was the Online Learning Project Manager for NC TEACH and Project Coordinator for NC TEACH II at the UNC Center for School Leadership Development. Key responsibilities there included the development, implementation, teaching, and assessment of the NC TEACH OnLine Program, NC TEACH II, and program website.

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Using a Campus-Wide Community of Practice to Support K-12 Engineering Outreach

Abstract

This paper describes the first phase of MISO (Maximizing the Impact of STEM Outreach through Data-driven Decision-Making), a campus-wide project, funded by the Nation Science Foundation, at North Carolina Sate University. This project seeks to both better understand and support the collective impact of K-12 STEM outreach efforts of the university. Described are the processes for creating a campus-wide community of practice of STEM outreach providers and the development of data-driven decision-making tools to help support the continuous improvement goals of these programs. This process including the creation of logic models for each program and the developing a set of common survey instruments that measured outcome goals for the programs. The collaboration of the MISO project and the Engineering Place outreach program is used to demonstrate this work.

Introduction

MISO (Maximizing the Impact of STEM Outreach through Data-driven Decision-Making) is a campus-wide project, funded by the Nation Science Foundation, at North Carolina Sate University (NCSU). This project seeks to both better understand and support the collective impact of K-12 STEM outreach efforts of the university. The project arose out of a campus-wide ad-hoc committee organized by the office of extension and engagement. Work by the committee pointed to a large number of outreach activities across campus, but no organizational network to provide a community of practice to facilitate communication and support among the different groups involved in this work. The MISO project resulted from a desire to provide an over-arching organizational mechanism to support this work.

The primary goal of the MISO project is to support data-driven decision-making by outreach providers. To meet this goal, the project needed to first bring together the key STEM outreach provider stakeholders on campus. Next, experts in educational evaluation worked with project leaders to devise evaluation strategies with two, synergistic goals. This data will allow individual outreach programs to better understand the impact of their strategies on STEM learning and engagement in their participants. The collective pooling of data across outreach programs will also allow the campus-wide community of practice to better understand which practices are demonstrating the highest efficacy in particular contexts and populations.

Ultimately, our evaluation goal is to determine the extent to which NCSU STEM outreach programs impact long-term educational outcomes for K-12 students and teachers. We are supporting the teachers indirectly by working with the outreach teacher programs, who by the nature of their individual programs, work toward the improvement of pedagogical practices and teacher confidence toward STEM-related content. Similarly, we work directly with the student outreach program coordinators, and therefore are supporting the work they do with the students. These outreach programs work to increase student STEM content knowledge, attitudes, motivation and career possibilities.

Campus-wide Community of Practice

The project constructed a campus-wide learning community that would bring together the K-12 STEM outreach providers and leaders, NCSU's student recruitment and enrollment management leadership, and experts in educational research and evaluation to collectively analyze and revise current outreach practices around robust data analytics. The campus network will foster communication, encouraging the formation and dissemination of new ideas around effective educational outreach and engagement practice. It will also provide a new infrastructure that allows the many program directors to put in place processes that would lead to real economies of scale and an approach that is sustainable long after the funding for this project would be over. This work is being supported, in part, by a full-time Project Coordinator.

In March of last year, an Advisory Board was assembled and included a broad representation of partners throughout the NCSU STEM outreach community. The Advisory Board is comprised of the directors of key pre-college programs and high-school-to-college transition programs, and its purpose is to guide the Executive Team and Project Coordinator. Included in the Advisory Board is the Director of the Engineering Place, the primary outreach arm of the College of Engineering. An inaugural Advisory Board meeting was convened and key strategies discussed and developed, with a second Advisory Board meeting held in the latter part of the year.

One immediate need emerged from the first meetings with the outreach programs: a website to promote outreach programs to the broader community of students, parents, and teachers. This need was combined with the goal of using a website to support the on-campus community to guide the design of the project website. Leveraging existing extension funding from one of the MISO program participants, a website was created to support all of the university outreach programs. The outward, community facing portion of the website (http://miso.ncsu.edu/) includes tabs for outreach programs for students, outreach programs for teachers, resources, and an "About MISO" section. It includes an easy-to-use search engine to find K12 STEM outreach opportunities for teachers, students and educators, such as camps, academies, workshops, group activities and departmental tours. A web-based form allowed individual programs to submit their program information to the MISO website. There are currently 14 K12 STEM outreach groups with program info on the MISO website. A second phase of web site development will create an inward facing portion of the website for use by outreach providers on campus to share information with each other and support the community of practice. Information and events that are pertinent to the broader NC State K12 STEM community is also being shared via an email listserv that was created and is currently maintained by the MISO Project Coordinator.

Over the course of the summer and fall, nine NCSU K-12 STEM outreach programs officially became "pilot project partners." They signed a Memo of Understanding, committing to piloting either the teacher or student survey. They were:

- New Literacies Collaborative Teacher Leader Institute
- Kenan Fellows Program for Leadership and Curriculum Development
- Imhotep Academy
- Sustained STEM Support (S – cubed)
- 4-H School Enrichment Program
- Kyran Anderson Academy
- Engineering Place – Engineering Camp
- Young Investigators Nuclear Engineering Camp
- NC Quest

During an initial campus-wide workshop, the pilot project partners, along with other participant programs, created logic models for their programs. A logic model, or map, provides a tool for conceptualizing the relationships between project inputs, strategies, objectives, and goals[1], thereby providing an effective means of presenting a project[2] and identifying the process and outcome goals.[3] [4] The logic models were beneficial to the individual programs with an initial opportunity to revisit their program goals, strategies and ultimate outcomes prior to the implementation of the large-scale data collection system. Figure 1 is an example of one of the created logic models. The logic models also benefited the MISO project staff, as they were able to look at the collective project goals and outcomes across the university. In later months, the logic models were again used at a meeting of partners to identify common variables of student and teacher data that will be used in later analyses (Figure 2). A review of workshop feedback indicated that the participants found the workshop useful in understanding the link between program strategies and ultimate outcomes and many responses to the feedback showed that participants found value in networking with their outreach program peers. This workshop was the first in a series of workshops that will continue throughout the life of the grant.

A second campus-wide workshop was held to explore how programs could strategically make use of evaluation data, use the data to continuously monitor and make effective decisions to improve their programs for the benefit of their stakeholders, and promote their programs to the community. To this end, the three goals of the workshop were: 1) to assist participants with learning MISO survey development procedures, 2) exploring possible survey data uses in their research projects, and 3) expanding their understanding of the MISO website features to promote their projects. A data analytics flow chart created by the MISO team was used to help them better understand the different data sources that MISO would be using (Figure 3).

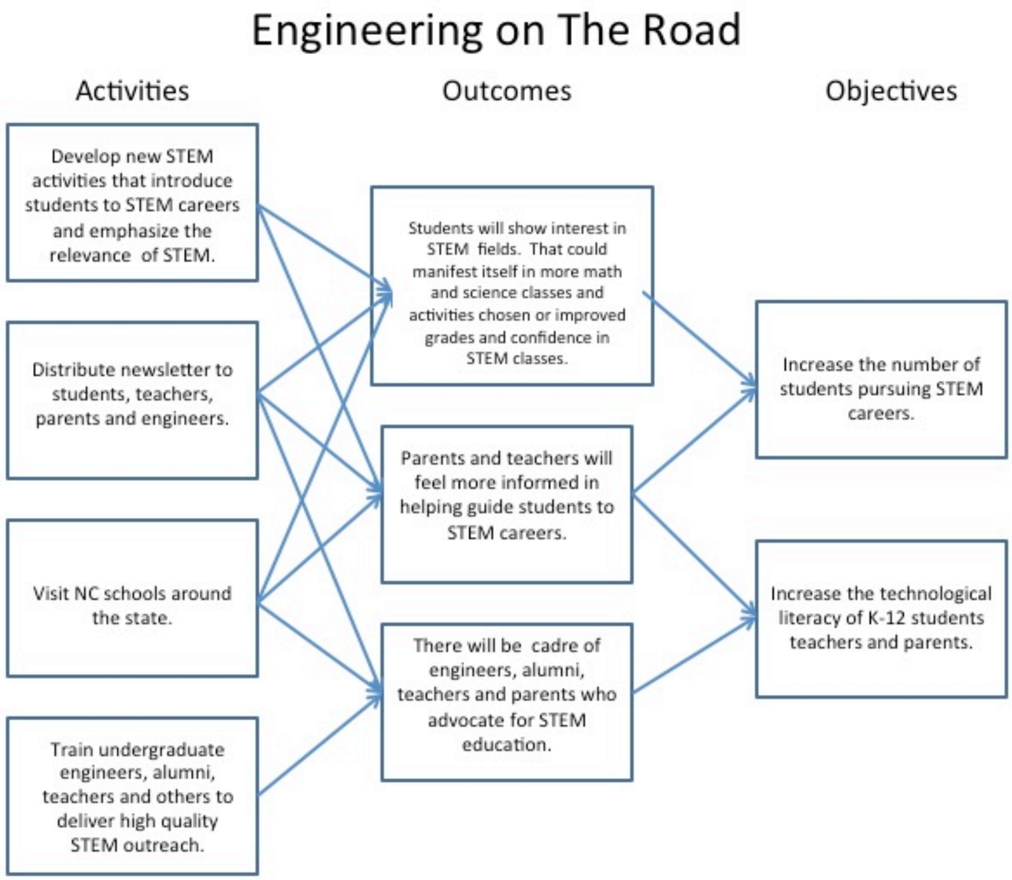

Figure 1. Logic model created by the Engineering Place

Common Student Variables	Common Teacher Variables
Gender	Gender
Race	Race
Age/DOB	Age/DOB
District	District
County	County
School	School
Free/Red Lunch	# years in system
ESL Status	Licensure add-ons
EOG/EOC Scores	Master's PhD
Course Enrollment	National Board
Graduation	Certification
Highest math course	Highest Education Level
Highest science course	Years Teaching Total
Algebra 1	Subject Area Certification
	Where they went to school
	Lateral Entry or Regular
	Graduate course hours
	CEU credits

Figure 2. Common student and teacher variables.

Data Analytics Strategy

In order to support data-driven decision-making by the STEM outreach programs, the project aimed at evaluating students and teachers involved in STEM education outreach programs in a longitudinal manner—data that has rarely been available to individual programs. To do so, a STEM Outreach Evaluation Protocol was developed that has common survey instruments used by outreach providers, matched with longitudinal student and teacher data from state-wide public instruction databases. The goal will be to track students and teachers across multiple years, through multiple STEM outreach experiences and, for students, eventual matriculation to colleges and universities (including NCSU).

The new data-driven assessment tools will be used for MISO project research and will be available to any STEM outreach campus program. In this way, any STEM outreach project affiliated with NCSU, big or small, will have access to a valid analytic tool to evaluate the impact of their project, as well as MISO research results. In order to support the campus-wide community of practice, projects will have the opportunity to work collaboratively during twice yearly workshops, providing a venue for opportunities for communication and the sharing of evaluation theories, issues, approaches, and practices in extension and informal education.

In the latter part of the MISO project, results and evaluation methods will be shared with other institutions in the University of North Carolina system, therefore giving other institutions the ability to evaluate their own STEM impact through outreach and extension programs via our replicable model.

Parallel with the building of the campus-wide community and working with the Executive Team and Advisory Team (during quarterly meetings), the Data Analytics Group began to build consensus around a core set of data to gather through the STEM outreach evaluation protocols. The Data Analytics group developed an online survey for Outreach Program Coordinators to administer to teachers and/or students (depending on their target population), thus beginning the work of establishing a valid and reliable tool for measuring STEM outcomes. (see Appendix).

These survey tools were developed as a result of an extensive literature review and piloted in the summer and fall with outreach programs. Five different teacher surveys were developed, based on the STEBI (Science Teaching Efficacy Belief Instrument) survey[5]. Different versions were created for science, math, engineering, technology, and elementary teachers. Each survey seeks to measure teacher confidence and efficacy in teaching STEM related content. The student survey was based upon a STEM attitudes survey for women in engineering (Erkut & Marx, 2005)[6]. This survey seeks to measure student attitudes toward each STEM subject, interest in various STEM careers, and 21st century learning skills. Since the initial development of these surveys, the student survey has been split into two different forms: one for middle and high school students, and one for upper elementary students. The major difference being the wording of the questions, to allow understanding and comprehension from a younger audience. The student survey has been statistically analyzed and revised, guided by discussions with key stakeholders and psychometrics experts. These revisions included changes to the Engineering attitudes portion, as well as the career section. Over the next several months, these revised student surveys, as well as the teacher surveys, will undergo analysis to establish reliability and validity of the instruments. An important part of this process was the development of Institutional Review Board (IRB) protocols for this extensive, campus-wide data collection effort, as well as developing training materials for the participating projects.

As an outcome of feedback from pilot project partners, a data analytics model was developed to help them better understand the different data sources that MISO would be using (Figure 2). The MISO team also used this data analytics model when they met with staff members from the NC Educational Research Data Center (NCERDC) at Duke University (http://www.childandfamilypolicy.duke.edu/project_detail.php?id=35), who have the contract to provide statewide student and teacher data from the NC Department of Public Instruction, to initiate the process needed to extract the student and teacher variables data from the public databases.

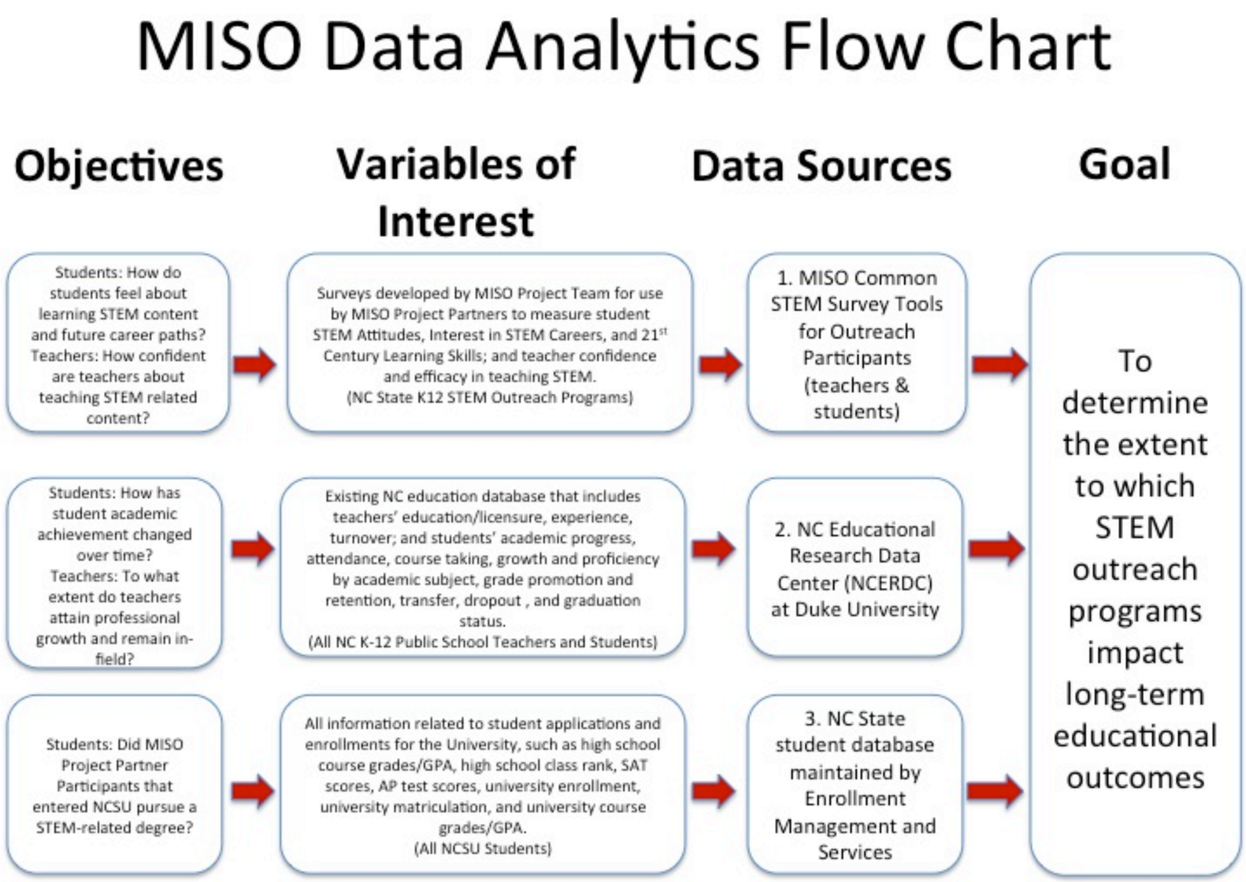

Figure 3. MISO Project data analytics model

Two more meetings were held: one for pilot project partners that used the student survey, and one for pilot project partners that used the teacher survey. As a collective effort, each group was able to explore in depth the available data sources, and how their program could benefit from them. In addition to the data sources listed in the Data Analytics Flow Chart, each outreach program itself was listed as a possible data source. Collective agreement was reached on a list of variables from the NCERDC databases that they deemed most beneficial. As a result of this process, MISO will be able to get data that is both of high value to the overall community of STEM outreach providers and the university as a whole, while also providing data relevant to individual programs.

Moving forward, pilot project partners will meet individually with the MISO Project Coordinator, to plan the implementation of the spring MISO surveys. One last round of feedback will also be collected from pilot project partners on the survey logistics and content. One obstacle that has become evident is the logistical aspect of the surveys. Program coordinators need to build in, in advance, adequate time and space for participants to take both the pre and post surveys. To help with this, the MISO Data Analytics team has put the survey online, as well as having Adobe PDF™ versions available.

Work with The Engineering Place

The MISO project's work in supporting the K-12 engineering mission at NCSU is a good example of how MISO was designed to provide organizational support and data analytics to outreach providers. To this end, MISO has partnered with the Engineering Place, the primary outreach arm of the College of Engineering. The mission of the Engineering Place is to educate, both directly and indirectly, the citizens of North Carolina, particularly K–12 students, about the true nature of engineering and the opportunities and careers within engineering through hands-on, inquiry- and problem- based programs and informational workshops and tools. Faculty and staff from the Engineering Place have worked collaboratively with MISO, participating in the project's advisory board and, agreeing to be part of the pilot phase of the MISO project during the summer of 2011.

As a central member of the outreach community on campus, Engineering Place was invited to join the Advisory Board of the project. Advisory Board meetings not only serve the purpose of guiding the MISO project team, but they can also be a great platform for networking and exchanging of information and activities. For example, the Director of the Engineering Place shared that she and some of her staff will be travelling to Washington D.C. in April 2012, and would welcome any collaboration if other programs were interested.

At the beginning of the project, the MISO Project Coordinator met with Engineering Place staff members. In the initial meeting, the goals and functions of the Engineering Place were explained to the Project Coordinator, as well as their current evaluation plan. Questions were presented and answered, and the Project Coordinator discussed the expectations of the partnership. Goals, challenges, needs and expectations from the Engineering Place could then be placed into consideration as the survey was being developed, along with the goals, challenges, needs and expectations that were simultaneously being gathered from similar meetings with other outreach program coordinators. Twenty-five participants in addition to the MISO team attended the first workshop, including the Engineering Place staff. Figure 1 shows the Logic Model developed by the Engineering Place, for its program "Engineering in the Road."

The pilot of the MISO surveys was conducted to establish validity and reliability of the survey instruments and to eliminate or rework specific survey items. As noted above, key to the development of the surveys was feedback from pilot project partners on the content validity of the survey items. To this end, a draft survey was sent out to all pilot project partners, asking them for feedback on the pilot surveys, and asking them what they might see as areas that need improvement or change in the revised surveys. Specific feedback was asked of the Engineering staff, as they are "content experts" in their field, and their expertise is highly valued. Over the course of the meeting, critical issues concerning the engineering portion of the survey were discussed, and positive changes were be made, based on the outcome of the meeting.

As noted in our first year external evaluation report:

> The potential success of any new initiative that involves a large number of groups strongly relies on the ability of those groups to move beyond cooperation to collaboration. An initial cooperation between the Engineering Place and the MISO

Project was a cornerstone is the establishment of the MISO proposal, and a continued collaboration has contributed to the success of the project thus far. Key staff members of the Engineering Place were influential in the formative and developmental stages of the MISO proposal. Collaboration and development of ideas took place during various meetings over the course of pre-planning year, organized by the office of extension and engagement. It became evident that many groups on campus were in support of one of the key strategies of the MISO project, which is to support data-driven decision-making by outreach providers. [7]

Successful collaboration between MISO and the Engineering Place to date includes:

- Input in the original grant proposal and dedicated support
- Participation on the Advisory Board
- Attendance and participations of workshops
- Attendance of individual meetings
- Collaboration and feedback of surveys
- Participation in pilot surveys

To date, the MISO project has been the primary beneficiary of the collaboration with the Engineering Place in the form of the advice and feedback Engineering Place staff have provided to the project. However, we believe moving forward, the data-driven decision-making process the MISO project has put in place will provide valuable evaluative guidance to the growth and evolution of Engineering Place's outreach mission. The gathered and analyzed data will be valuable to them, in part, because of the collaborative nature of how the tools and processes have been developed.

In conclusion, it can be seen that partnerships that are mutually beneficial have been successfully formed between the MISO Project, and K12 STEM outreach providers at NC State University. Pilot project partners will benefit by having input into the data-driven assessments that are being built and implemented, as well as being able to receive the data results and use them to support their programs. Our work with The Engineering Place is a good example of the partnerships MISO has begun to form through this project. The MISO project will benefit by being able to produce a valid and reliable common survey instrument, as well as being able to use the results of the surveys in their research. Without each other, neither of these results would be attainable.

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References

[1] W.K. Kellogg Foundation. (1998). *Evaluation handbook*. Kalamazoo, MI: Author.

[2] Julian, D., Jones, A., & Deyo, D. (1995). Open systems evaluation and the logic model: Program planning and evaluation tools. *Evaluation and Program Planning, 18*(4), 333-341.

[3] Coffman, J. (1999). *Learning from logic models: An example of a family/school partnership program.* Cambridge, MA: Harvard Family Research Project.

[4] Julian, D. (1997). The utilization of the logic model as a system level planning and evaluation device. *Evaluation and Program Planning, 20*(3), 251-257.

[5] Enochs, L. G., & Riggs, I. M. (1990). *Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale*

[6] Erkut, S., Marx, F., & Wellesley Coll.,MA.Center for Research on Women. (2005). 4 schools for WIE. evaluation report. *Wellesley Centers for Women*

[7] Van Dyk, P. (June 2011), Maximizing the Impact of STEM Outreach Through Data-Driven Decision Making (MISO) Project Evaluation Report 2010-2011, 10.

Apendix

Directions and first 5 questions from "Engineering and Technology" section:
Scale: Stongly Disagree, Disagree, Neither Agree or Disagree, Agree, Strongly Agree

Please read this paragraph before you answer the questions.

Engineers use math, science, and creativity to research and solve problems that improve everyone's life and to invent new products. There are many different types of engineering, such as chemical, electrical, computer, mechanical, civil, environmental, and biomedical. Engineers design and improve things like bridges, cars, fabrics, foods, and virtual reality amusement parks. Technologists implement the designs that engineers develop; they build, test, and maintain products and processes. Engineers use math, science, and creativity to research and solve problems that improve everyone's life and to invent new products. There are many different types of engineering, such as chemical, electrical, computer, mechanical, civil, environmental, and biomedical. Engineers design and improve things like bridges, cars, fabrics, foods, and virtual reality amusement parks. Technologists implement the designs that engineers develop; they build, test, and maintain products and processes.

1. I like to imagine creating new products.
2. If I learn engineering, then I can improve things that people use every day.
3. I am good at building and fixing things.
4. Understanding engineering concepts will help me earn a living.
5. I am interested in what makes machines work.

First 5 questions from "21st Century Learning" section:
Scale: Strongly Disagree, Disagree, Neither Agree or Disagree, Agree, Strongly Agree

1. I am confident I can lead others to accomplish a goal.
2. I am confident I can encourage others to do their best.
3. I am confident I can make moral decisions.
4. I am confident I can produce high quality work.
5. I am confident I can act responsibly.

Directions and 5 questions from "Your Future" section:
Scale: Not at all interested, Not So Interested, Interested, Very Interested

Here are descriptions of subject areas that involve math, science, engineering and/or technology, and lists of jobs connected to each subject area. As you read the list below, you will know how interested you are in the subject and the jobs. Fill in the circle that describes how interested you are.

There are no "*right*" or "*wrong*" answers! The only correct responses are those that *are true for you*.

1. **Physics:** is the study of basic laws governing the motion, energy, structure, and interactions of things and matter. This can include studying the nature of the universe. *(aviation engineer, alternative energy technician, lab technician, physicist, astronomer)*
2. **Biology and Zoology:** involve the study of living organisms (such as plants and animals) and the processes of life. This includes working with farm animals and in areas like nutrition and breeding. *(biological technician, biological scientist, plant breeder, crop lab technician, animal scientist, geneticist, zoologist)*
3. **Earth Science:** is the study of earth, including the air, land, and ocean. *(geologist, weather forecaster, archaeologist, geoscientist)*
4. **Computer Science:** consists of the development and testing of computer systems, designing new programs and helping others to use computers. *(computer support specialist, computer programmer, computer and network technician, gaming designer, computer software engineer, information technology specialist)*
5. **Engineering:** involves designing, testing, and manufacturing new products (like machines, bridges, buildings, and electronics) through the use of math, science, and computers. *(civil, industrial, agricultural, or mechanical engineers, welder, auto-mechanic, engineering technician, construction manager)*