WaterWorks: A Collaborative Curriculum for Women in Engineering

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Although many factors influence a young woman's choices regarding college majors and careers, evidence suggests that early intervention programs can be effective influences. A wide variety of pre-college women-in-engineering programs are now offered in nearly every state, usually through institutions of higher learning. Certainly, the continued or improved success rate of any intervention program is dependent on attention to and monitoring of the program goals based on results. If a program, upon close examination, does not appear to be effectively meeting its goals, change is necessary.

Breaking the Mold

Oregon Institute of Technology (OIT) recently had cause to investigate the effectiveness of its own Teen Women in Science (TWIST) program, and was forced to answer this question. In 1995 the success of the program, measured by those girls entering college to study SEM majors, was seriously questioned by members of the TWIST Steering Committee. The committee recommendation, followed and supported by the administration, was to take a hiatus to review the program and reorganize the curriculum to more effectively address the mission and goals. The actual hiatus and program revision took a full year to accomplish, and consisted of "breaking the mold." That is, a complete re-focus and revision of the curricula.

This paper discusses the revisioning process undertaken for the TWIST program and the collaborative effort which supported the successful prototype, *WaterWorks*. The organization and orchestration of the curriculum revision process is offered as a successful model of the collaborative effort which the authors believe is essential to the improved ability of such programs to positively influence young women to investigate and choose SEM career paths.

The TWIST Program

The TWIST program has been offered since 1990 as a week-long, residential summer program for girls entering the tenth grade. From its inception, TWIST has provided female high school students with the opportunity to explore careers in engineering technologies and related science and math fields, and to broaden their career options by encouraging academic preparation in math and science courses during high school. Within this mission, the TWIST Steering Committee has identified several specific objectives for the program.

- To inform teen women students of the technical career opportunities available to them in various non-traditional careers.
- To encourage collaborative learning by active participation through a variety of hands-on experiences.
- To demonstrate the connection between high school preparation in math and sciences necessary to successfully complete a technical/engineering baccalaureate degree program.
- To influence teen women students to make educated choices based on their individual technical interests and strengths.

Program Design

TWIST curriculum and planning is accomplished on a yearly basis by a steering committee and various volunteers including OIT faculty and staff and high school teachers. The program is presented as a one-week campus residential program serving between 60 and 80 participants. Students generally arrive Sunday afternoon and depart Saturday morning. Students are grouped into teams guided by a senior and junior counselor for the week's activities, which include technical sessions, field trips, and social activities.

The TWIST curriculum consisted of individual two to three hour technology or science sessions with no curricular ties or themes existing between them. Participating faculty developed sessions independently, without guidance in high school learning styles. Faculty frequently reported frustration in communicating their enthusiasm for career opportunities to students. Student did not evidence understanding of the connection between mathematics and science students, and the engineering courses. While the program had support from many sources, this curriculum was not meeting the objectives of the TWIST program.

RECASTING THE MOLD

Two members of the TWIST Steering Committee were selected to co-chair the curriculum development process. A core group of faculty were invited to participate on the basis of demonstrated teaching ability, interest in the TWIST program objectives, potential for interdisciplinary and collaborative efforts, and availability during the summer.

The TWIST Curriculum Development team included engineering technology faculty representatives from civil, computing, electronics, manufacturing, mechanical, natural sciences and surveying; faculty from communications and management; high school math and science teachers; industry and government representatives; and guest instructors in learning styles.

TWIST Curriculum Development Workshop

The heart of the program revision process was the TWIST Curriculum Development Workshop, financially supported by the provost who provided compensation to the faculty and covered incidental costs. The team was charged with meeting specific objectives in the development of the re-visioned program, including:

- Develop a "theme-based" approach to the curriculum.
- Promote the concept of team approach to problem-solving.
- Develop an interdisciplinary approach to the curriculum, showcasing as many different science, mathematics and engineering disciplines as possible.
- Improve the teaching climate to more effectively target the tenth grade audience.
- Assist students in recognizing connections between scholastic preparation and career options.

The workshop was conducted over a four-week period during the early summer. Intensive, focused meetings were scheduled to encourage collaborative efforts and teamwork in developing the curriculum. The initial meeting was a day-long program introducing the workshop goals and objectives during the morning session and providing time for getting acquainted as a team. The afternoon session was devoted to learning styles focusing on TWIST participants: tenth grade girls. Several half-day brainstorming and collaborative sessions were held during the next two weeks, with goals, guidelines and expectations clearly identified for each meeting (i.e., an early goal was for each faculty to develop a concept for a TWIST session they would teach and share it with the group for feedback). Final documentation for individual sessions was due one month later. Workshop co-chairs were responsible for the final drafting of the week's curriculum.

The Curriculum Solution: *WaterWorks*

A curriculum based on a central water program in a local community, supplemented by water-related projects and activities was the outcome of the workshop effort. The theme of "water" was selected because it offers an extensive approach to exploring college majors in SEM fields with the opportunity to demonstrate the interdisciplinary nature of SEM-based careers in identifying and solving real-world problems. Additionally, the locale of the Klamath Basin provides numerous opportunities for field and lab investigations related to water. Water is also an important theme for the western United States from both a supply and quality standpoint, and globally from an environmental perspective. With the current emphasis on environmental considerations in the news and many K-12 schools, it provided a natural interest and familiar focus for the students. Details of the student activities are described in the following section.

INVESTING STUDENTS IN THE PROGRAM

A primary goal of the *WaterWorks* curriculum was to sequence the classes and activities to develop the students' skills within the week to a level where the groups could produce a team report and presentation beginning with skills and background knowledge common to students entering tenth grade. Some introduction to computers, writing, math through algebra and biology sans chemistry were technical levels for which the curriculum was designed. Activities related to the central problem included:

❑ *Project Introduction.* The water "problem" was introduced to the students via a skit in which the faculty portrayed local town residents, technical experts and representatives of various special interest groups speaking at a Town Hall meeting. Time for questions and answers followed the presentations, during which the fact that this skit and the proposed week's effort involved a real, rather than fictitious problem was emphasized and faculty were introduced. Interest in the problem developed rapidly as the students focused on the reality of the problem and recognized that they would be visiting the actual site of the contaminated water wells to gather data.

❑ *Skill Development.* Of real concern to the faculty was the ability of the students to determine the problem, work in teams and understand the chemistry, although simple, of the problem. Thus some time was set aside initially for classes in problem solving and critical thinking development, project management and basic water chemistry prior to the field work. Classes were generally activity-based with minimal lecture time. Counselors served as facilitators and lab assistants.

❑ *Field Trip & Data Collection.* An entire day was devoted to a site visit. During that time the students worked within their groups to gather a series of data pertinent to defining the water quality problem. They performed horizontal and vertical surveying to obtain a river level and benchmark well-head elevation. Water levels were obtained for several wells. Water quality samples were taken, with some testing occurring in the field

(pH, dissolved oxygen, nitrates and nitrites, conductivity and total dissolved solids) and several samples taken for laboratory testing for total coliform and fecal coliform bacteria). Stream discharge was measured and a scavenger hunt performed to identify organisms and record organism diversity in the river.

❑ *Data Analysis.* The goal of data analysis was to demonstrate links between mathematics and science with engineering data analysis, as well as to provide the students with some tools and insight regarding the process of developing meaningful relationships from raw data. Students worked with QuattroPro spreadsheets, AutoCAD computer-aided design and hand contouring methods to produce graphs depicting change in water elevation with time, site plans, and hydraulic gradient maps. By the end of these sessions, the students generally had evidence to support their team's problem definition.

❑ *Solution Development.* With a view to guiding the students toward a technically reasonable set of solutions without dampening their creativity, time was devoted to discussion of solutions which are actually being considered. Using available information technology, students were encouraged to contact faculty and industry experts for further information on any aspect of the problem. Each student was given an e-mail address and Internet access during the week, which they used extensively and creatively as evidenced in their final presentations.

❑ *Report Preparation.* To emphasize the importance of communication in all aspects of SEM careers and projects, instruction in those areas was provided. The students participated in a marketing workshop, a public speaking workshop emphasizing group presentations and were taught presentation graphics techniques as they produced transparencies for their presentations using Harvard Graphics.

❑ *Presentations.* The week's activities culminated Friday afternoon in a team presentation from each of the six groups. Students were given time to prepare and practice the presentations during the final afternoon. Presentation time was limited to 20 minutes for each group, including a question and answer period. Two concurrent sessions were held, with the instructors on hand in each session to provide feedback.

TESTING THE MOLD

The results of the curriculum revision far exceeded the expectations of the *WaterWorks* faculty. Most impressive was the students' success in matching a technically viable solution to their team's view of the water quality problem. Students were able to examine the data using critical thinking and problem solving skills introduced during the week to identify a unique solution.

The students proved to be enthusiastic participants in the program. With few exceptions they found the field work exciting and interesting. Best received sessions both in and out of the field were those in which the students actively participated and were responsible for either data gathering or data analysis activities. Computer applications were well received

and e-mail was heavily utilized to develop solutions. The final presentations of the "consulting teams" showed a remarkable skill level within one week in developing creative technologically current solutions. The students were clearly excited about their own achievements as well, which was reinforced by the audience--parents and faculty--response to the presentations.

Our success was most certainly a function of the coordination of interdisciplinary efforts and formative scheduling of the activities. Moreover, requests for information on the *WaterWorks* project have come to several faculty members, suggesting that the week had some amount of carryover value for at least some of TWIST participants.

GETTING THE WORD OUT

A one-week exposure at the tenth grade level is generally insufficient to change a lifetime's programming and information. But a program that incorporates follow-up strategies with a strong interdisciplinary curriculum is likely to have a more profound effect on young women by influencing more of them to pursue non-traditional careers such as civil or mechanical engineering, groundwater hydrology, manufacturing and computer engineering. New initiatives in place to contact prospective and past participants of the program include: a TWIST web page, newsletter, direct high school visits and proposed TWIST reunions in Portland and Medford. Also, the document, *WaterWorks '96,* was written to introduce the TWIST program and the new curriculum. In addition to providing a model to form similar programs at other institutions, the document will be instrumental in the program's funding efforts.

LOOKING FORWARD

While it will be years before true results of the new curriculum can be measured using the college enrollment in SEM majors as a yardstick, the initial results of the *WaterWorks* program were promising thanks to a diverse, collaborative faculty focused on a common goal. The program and faculty will stay essentially intact for at least one more year. The faculty reflect a strong team, solidified by their view of success and their observation of self-esteem attained by the students.

The *WaterWorks* curriculum development was a strong positive step in breaking the mold, and improving the TWIST program at OIT. As it exists, the *WaterWorks* program model could be utilized in other communities where interest exists. The model is non-gender specific, and could be adapted to wide variety of water-related issues. The interdisciplinary curriculum development team comprised of academia, government and industry participants is vital to the success of such a program because it enables the student to develop the connections between what they study in school, be it high school or college, and what tasks and activities they will be performing in SEM careers in the future.