A CONCEPTUAL MODEL FOR A UNIVERSITY – K-12 PARTNERSHIP UTILIZING THE INTERNET AND AFTER-SCHOOL ACTIVITIES IN TECHNOLOGY AND ENGINEERING: RESILIENCY APPROACH

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ABSTRACT

Because of the changing trends in engineering workforce, and despite indications that enrollments in engineering programs are growing, there is a need to increase retention and success among students enrolling in engineering and technology programs. Recognizing this need, many coalitions have developed K-12 engineering outreach partnerships and programs in order to make students aware of engineering-oriented careers. Although these outreach programs have had a significant impact on increasing participation among K-12 students in the science and engineering fields, there is still a high level of attrition among students especially minority and women once they enter colleges of engineering and sciences (Hewitt & Seymour, 1991; NSF, 2002). This paper explores a current effort offered by a K-12 engineering technology coalition focusing on activities and techniques that could be effective at increasing resiliency and in turn, impacts interest, retention, and the number of engineering and technology graduates. In this approach both Internet and on site hands on activities are proposed.

1. INTRODUCTION

1.1 Background

The fields of engineering and technology experienced declines in enrollment from the early 1990s through 1999. Both national and statewide data show that there was a continuous decrease in the enrollment of students in the field of science and engineering in this period; this trend was even more pronounced among underrepresented groups and women (Hill, 2002; NSF, 2002; NSF, 2002a; NCES, 2002; IBHE, 2004). Between 1990 and 1999, the number of students in the US graduating with engineering and technology degrees fell by 8.9% and 21% respectively. Although this trend is expected to change in the next ten years, it is paramount that structures are developed today to prepare students for engineering oriented courses. Indicators show that there was a 0.2% increase in enrollment between 1999 and 2000. Data from the National Science Foundation's Science and Engineering Indicators of 2002 project that enrollment in science and engineering will increase by 20.6 % by 2010. In fact, data collected by the American Association of Engineering Education (Gibbons, 2004) ASEE shows that between 1999 and 2003, enrollment in engineering programs increased by 13% and the number of engineering bachelor's degrees awarded also went up by 13.8%.

Although there are indications that the enrollment in engineering programs is beginning to increase, it is not proportionate to the demands of engineering and technology workforce especially among minority populations and women in the US. The Bureau of Labor Statistics (BLS, 2003) predicted that the demand for skilled workforce in the field of manufacturing engineering, primarily in areas of machining technology, numerical controlled machining (CNC) and computer-aided design, is expected to increase by 12% by the year 2010. According to Tech Trends (SME, 2003), manufacturing jobs being lost off shore are the low or single skilled types, mainly due to sub-constructing. Manufacturing job requirements are shifting toward highly multi-skilled or more integrated skills in electronics and automation, and computer applications in manufacturing. Therefore, the domestic labor force in manufacturing is being narrowed to areas of CAD, CAM, electronics, computer and networking applications in manufacturing. The change to *refocus* on more integrated manufacturing engineering and technology training will be successful if more superior skills and resilience is imparted to the K-12 student population.

1.2 K-12 Efforts

The trends in engineering labor force and enrollment has, for the last ten years, prompted a need to boost student numbers in engineering and technology programs, especially among underrepresented groups such as minorities and women. Engineering educators have responded by developing K-12 engineering outreach programs to create awareness among these students about engineering-oriented careers as early as possible. A summary of some of the significant programs have been presented by the American Society for Engineering Education's K-12 Center (ASEE, 2004). Among these programs are those that involve extra-curricular activities such as competitions to pique students' interests in engineering (Bottomley *et al*, 1999), and programs involving the inclusion of engineering based activities in K-12 math and science curriculums (Mooney and Laubach, 2002; Puffer, 1990). More frequently, such programs utilize a hybrid approach of both methods (Yoder, 2001; Rustler *et al*, 1997; King *et al*, 1998; Manno *et al*, 1998). Developing curricular modules require careful selection of activities that not only interest the students, but offer learning experiences and meet state standards.

Despite the fact that these outreach programs have had a significant impact on increasing participation among K-12 students in the science and engineering fields, there is still a high level of attrition among students, especially minority and women, once they enter colleges of engineering (Hewitt & Seymour, 1991; Hill, 2002). This calls for a need to find more innovative ways of increasing retention and success amongst these students. As mentioned, in the field of manufacturing, the skill sets are shifting to more multi-faceted techniques such as integration of CAD and CAM into manufacturing (CNC for instance), and it is imperative that students develop skills and attitudes (resiliency) to survive the demands of engineering programs. These skills may be developed through K-12 – University partnerships.

K-12 – University partnerships are likely to develop programs that ordinarily would be out of reach for K-12. For example, positive experiences that can be achieved through interactive lab-oriented activities often require expensive equipment. Without receiving special funding, very few high schools can afford a small tabletop CNC mill. Compounded with this is the insufficient availability of science teachers who are well versed in these modern skills. There is evidence that in the state of Illinois many vocational programs in secondary schools are being phased out due to lack of resources and teachers♣. This paper explores the current efforts offered by a K-12 coalition focusing on activities and techniques that could be effective at increasing resiliency and in turn impact interest, retention, and the number of engineering and technology graduates.

1.3 Resiliency

Resiliency characteristics are the positive developmental outcomes of environment, educational and communal supports and opportunities for participation (WestEd, 2000). Environments that encourage active participation and accept youths as partners in both learning and service fosters youth involvement and enthusiasm as well as leadership development. Research has shown that students learn best when they are actively involved in meaningful experiences (Benard, 1996; Wasonga, 2002). Resiliency has received much attention as "integrative network for identifying and understanding individual and institutional resources that can be cultivated and mobilized to moderate the effects of individual vulnerability or environmental hazards" (Wang & Kovach, 1996, p. 17). Resiliency characteristics that have been identified that have impact on development and achievement include cooperation and communication, empathy, problem-solving, self-efficacy, self-awareness, and goals and aspirations.

WestEd (2000) describes the following resiliency characteristics. Cooperation and communication is the ability to work effectively with others, to effectively exchange information and ideas and to express feelings and needs to others. Empathy is the understanding and caring about other's experiences and feelings. Self-efficacy refers to the beliefs in one's own competence and the feeling that one has the power to make a difference. Problem solving refers to the ability to plan, to be resourceful, to think critically and reflectively, and to creatively examine multiple perspectives before making a decision or taking action. Self-awareness refers to a sense of one's own identity or knowing and understanding one self. Goals and aspiration are high expectations and hopes for oneself. These characteristics have been found to enhance persistence and survival in challenging situations.

Resiliency can be cultivated in individuals through programs with learning, educational experiences and supportive academic environments. Programs in which students are personally engaged in educational processes enable them to become self-directed learners who demonstrate curiosity and enthusiasm for new experiences and are knowledgeable problem solvers who think independently. Development of resiliency - adaptive characteristics that enable students improve their health, social, and academic outcomes - is an advantage to students pursuing challenging and demanding programs like engineering. This University-K12 partnership model is focused on utilizing Internet and after school activities engaging students on hands on activities to develop resiliency characteristics among the students.

♣ Informal discussions with the Illinois State Board officials, September 2004.

1.4 Academic achievement.

A correlation analysis of resiliency and academic achievement among urban high school students revealed significant relationship between resiliency and academic achievement in science and math. Table 1 presents the Pearson Correlations between resiliency characteristics and mean score in science and math achievement among urban high school students. In this study (Wasonga, 2002), empathy, goals and aspirations, and self-efficacy were found to be predictors of academic achievement. Salisbury and Jackson (1996) found that female students achieved good results by working cooperatively, supporting each other, conforming to a greater degree and working toward a clearly identified goal. Self-efficacy is the belief in one's competence and feeling that one has power to make a difference and engage in a certain domain of behavior. It was theorized by Bandura (1977) that self-efficacy determined whether one engaged in a behavior, how well one performed, and whether one persisted when there were obstacles. According to Betz (1997), efficacy was a factor in persistence in hard science. He found that low levels of efficacy among females kept them away from hard sciences. Empathy was found to lead individuals to override self-interest and act with compassion, an attribute that has been associated with the fact that girls were more attentive than boys in school (Hill & Row, 1998).

Table 1-Pearson correlation coefficient between mean score (Science & Math) and resiliency characteristics

	Cooperation & communication	Self Efficacy	Empathy	Problem-solving	Self awareness	Goals & Aspirations	Resiliency
Academic Achievement	.226**	.246**	.300**	.107*	.127	.237**	.243**

**p<.01; *p<.05

2. CONCEPTUAL FRAMEWORK

To respond to the low enrollments in science and engineering, educators have historically resorted to outreach programs. However, the production of a skilled workforce in engineering has been hampered severely mainly due to the demand of higher level math and calculus courses. In addition, there is inadequate prior preparation in terms of knowledge of what engineering and technology careers entail, and the differences between the various tracks in these fields. Educators have used various approaches to respond to this need; the majority of them comprise K-12 outreach programs. These programs have been designed to increase awareness and interest among the K-12 students. Despite their significant success, attrition rates persist with low enrollment in engineering programs. The conceptual model proposed in this paper goes beyond increasing interest and awareness. It recognizes the fact that educators must engage and develop students' innate abilities beyond interest and awareness. Educators need to develop models that prepare the students who enroll in engineering and technology to be resilient and well prepared to persevere through their college track.

2.1 Model for increasing the K-12 outreach through Internet

The Internet has the capability to reach more students using specialized modules and self-paced learning. Five areas of significance have been identified to formulate the basis of this project: manufacturing automation, numerical control machining, structural analysis, plastics processing and electronics assembly. Each module will consist of both Internet simulation/interaction and hands-on activities. The modules contain preliminary background information that will prepare the students for the activities. They encompass the principles of science and math in the activities, and will be based on the Illinois Learning Standards in math (goals 7, 8 and 9), and science (goals 12 and 13) (ISBE (2005). Within each module, themes are to be developed in relation to the objectives. Activities will be developed that center around these themes and objectives. Computer simulations are to be used when possible to augment the course materials which will be presented in a stepwise convoluted manner. Typically, each module area is developed by teams from the University and K-12 partners. The figure 1 below is an illustrative model the curriculum.

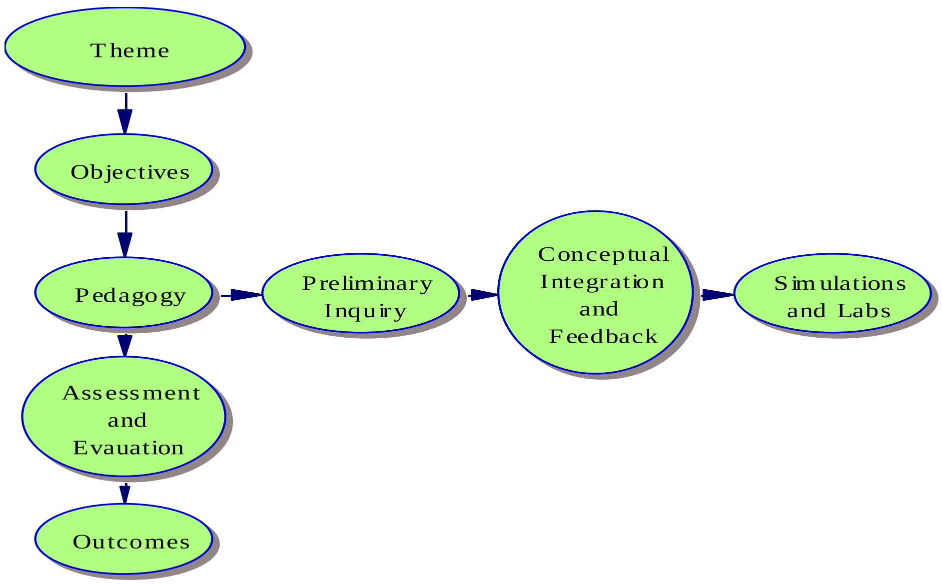

Figure 1: Curriculum model.

2.2 Modules in this partnership

The following is a description of each of the specific modules:

Fundamentals of Electronics - Covers introduction to electricity and electronic circuits. The students will build a simple circuit to control blinking lights or other simple devices. Scientific principles covered include electricity, basic electronics, and experimental design. Circuit simulations over the Internet will be utilized.

CNC Machining - Covers basic principles of machining and applications of computer programming in machining. Skills acquired will include geometry, measurement skills and design skills. The students will machine plastics with their initials.

Structural Design - Covers an introduction to the mechanics of structural design. Students will develop a basic structure, such as a bridge or truss, out of materials supplied. The students will test the structure to determine its load bearing characteristics.

Plastics processing – Student will come to the NIU's Department of Technology laboratory to explore the different types of plastics and methods used to produce plastics products. Prior to this, they will perform exploratory activities over the Internet introducing them to polymeric materials, their properties and applications, and methods of processing.

The Internet Laboratory – Although proposed, this may not be implemented in this project at this time due to funding limitations. This lab involves remote access to control a simple assembly processes.

3. SUMMARY

In this paper, research findings have been presented on the effectiveness of K-12-University outreach programs. It has been shown that the majority of these programs are designed to boost interest and awareness among K-12 students in engineering and technology careers. The successes of these programs have been documented and evidenced through increase in numbers entering colleges of engineering and technology. The issue is of retention and success among students entering the colleges of engineering and technology remains unresolved. This paper has taken the resiliency approach to improve retention and success. Research has indicated that resilient students persist, adapt and find ways to overcome adversities. Based on this, this project proposes Internet and after school engagement hands on activities that promote resiliency characteristics. The modules proposed are designed to focus on and develop cooperation and communication, self-efficacy, empathy, self-awareness, problem-solving and goals and aspirations among K-12 students. As a result of engagement and greater participation in science oriented activities, the students develop an awareness and appreciation of engineering and technology. They also develop abilities to persist and overcome rigor that is required in the programs.

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