

Work In Progress – Integration of Sensors into Middle School Classrooms

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Abstract - The University of Maine (UM) with support from the National Science Foundation (NSF) is involved in an outreach effort to introduce sensor science and engineering into Maine secondary school curricula. Graduate students in sensors, a high profile UM research area, are partnered with secondary school teachers to integrate sensors into their classrooms and to serve as career role models. The goal is to motivate students to pursue science and engineering disciplines and associated career paths. The primary mechanism for establishing direct contact with schools is a sensor-oriented UM-NSF Research Experience for Teachers (RET) program. Prior to the 2004-05 academic year, the effort was targeted at high schools. Recently, however, the focus has been middle schools. In this paper, the program organization, the motivation for focusing on middle schools, the mechanism used to introduce GK-12 *Sensors!* into middle schools, 2004-06 activities and future work are presented.

Index Terms - GK-12, Middle School, Sensors.

BACKGROUND & OBSERVATIONS

GK-12 *Sensors!* at UM is an NSF-funded program in its fourth year placing graduate students whose research involves sensors in secondary schools. The main goal of the program is to convince secondary school students to pursue science and engineering disciplines and careers. When initially funded, the program focused on introducing sensors into high-school (grades 9-12) curricula using sensor modules developed by high school teachers and GK-12 *Sensors!* fellows. However, in the last two years the program has increasingly recognized the importance of middle school integration [1]. During the past year, GK-12 *Sensors!*, as part of its successful proposal to NSF for renewed funding, established grades 6-8 as the primary focus for initial curricular integration.

In grades 9-12, GK-12 *Sensors!* assumed a uniform flexibility of student interest across disciplines. What was observed however during the first two years of the effort was increasing inflexibility of interest with grade level. By grade 12, significant changes in a student's academic or career interests were unlikely; instead, a small shift in interest (e.g. from chemistry to chemical engineering) was noted. Student feedback suggested that by grade 11 most students are focused toward aligning their personal interests with declared academic and career aims. While ninth and tenth graders may

be less focused relative to educational decisions determining career paths, the aspirations of college-preparatory, vocational-technical, and general studies track students varied significantly. These curricular differences and the social significance placed on these differences appeared to affect the degree to which non-college preparatory students were willing to consider pursuing STEM disciplines. Both career predetermination and high-school academic tracks generally limited the GK-12 *Sensors!* program efforts to convince grade 9-12 students to consider science and engineering opportunities.

In contrast, wide-ranging student curiosity and interests are promoted as part of the grades 6-8 educational efforts, which emphasize personal awareness based on social contexts while promoting emergent higher-level cognitive functionality. Students are encouraged to explore career possibilities as avenues for determining their future educational plans. Social stratification is not predicated on rigid self-identifications based on career interest/development, nor are single-grade classes divided into academic and non-academic oriented achievement tracks as they are in high schools. As a result, students in grades 6-8 may be more strongly influenced by the GK-12 *Sensors!* program.

Many of the students in participating GK-12 *Sensors!* schools live in rural, economically depressed regions of central Maine and potentially represent the first generation of college attendees for their families. Establishing a middle-school presence is particularly important to encourage these students to follow an educational path leading to an engineering or science career. This is particularly true for females, who are currently underrepresented in engineering and science related professions. The middle school therefore serves as a window of opportunity for male and female science and engineering role models (GK-12 fellows) to convince students who may initially have no interest in STEM subject matter to pursue science and engineering pathways.

PROGRAM STRUCTURE

The people involved in GK-12 *Sensors!* currently are the Principal Investigator (PI) (John Vetelino), two co-PIs (Stephen Godsoe and Constance Holden), a program manager (Joe Arsenault), ten fellows working with more than two dozen middle and high school teachers, and a UM program evaluator who works with program participants to develop instruments for measuring program effectiveness. Each fellow

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is assigned to at least one teacher, with whom s/he works throughout the school year. Each fellow spends ten hours per week with her/his teacher developing and implementing learning modules into the curriculum.

The consensus among 2003-04 participants suggested that the greatest impact on grades 6-8 students, especially females, can be achieved by using appropriate role models to introduce sensors into middle school curricula. GK-12 *Sensors!* subsequently began pursuing interactions with teachers at the middle schools associated with participating high schools. In 2004-05, GK-12 *Sensors!* expanded its efforts into new school systems by targeting middle schools. The 2005-06 program objectives refocused initial curricular integration on grades 6-8, seeking thereafter a grades 6-12 continuity of presence. As of the 2006 spring, the effort has established a presence in seven of eight participating systems. Student interest established at the middle-school level can be cultivated and reinforced throughout high school. The presence of a GK-12 *Sensors!* fellow becomes a normative aspect of STEM (and social studies) classroom dynamics.

PROGRAM PARTICIPATION MECHANISM

Since 2004 a UM NSF RET program has been the primary mechanism for establishing a direct contact with schools. Up to ten middle and high school teachers each summer are awarded eight-week fellowships at UM to be involved in cutting-edge research in sensor theory, design, fabrication, testing, and/or applications.

Teachers interact daily with faculty, senior researchers, graduate students, GK-12 *Sensors!* fellows, and NSF Research Experience for Undergraduates (REU) students in the UM Laboratory for Surface Science & Technology (LASST). The RETs are involved in research on biosensors, chemical sensors, and fluid-phase sensors, and become familiar with state-of-the-art sensor-related science and technology facilities and neighboring sensor businesses. RETs also enroll in a course entitled *Introduction to Sensors*, which presents the theory and applications of various types of sensors, for which they receive academic and recertification credit. RETs work in concert with GK-12 fellows developing possible modules to be introduced into high and middle school curricula. The summer program concludes with the August Summer Workshop, where RETs share both their summer research experience in formal presentations and their proposed modules. All RET participants become GK-12 *Sensors!* cooperating teachers, continuing working relationships established during the summer RET program with GK-12 fellows.

2004-06 ACTIVITIES SUMMARY & FUTURE WORK

During the 2004-05 academic year, GK-12 *Sensors!* was introduced to an estimated 650 grades 6-8 students in 45 classes in six area middle schools. The 2005-06 program expanded to nine schools, impacting more than 850 students in 58 classes. To date, the infusion of sensors into middle school curricula has benefited courses in life science, environmental science, computer science, integrated science, animal and

human biology, mathematics and social studies. Many of the sensor modules involve the human body, hydrogen cars, robots, toothpick bridges, the home and community, and the International Space Station's EarthKAM. GK-12 *Sensors!* also organizes tours to UM to expose students to LASST, the advanced wood composites, geographical information, and marine sciences laboratories. Since 2004 more than 550 students have visited UM's high-technology laboratories.

Recent grades 6-8 surveys of 120 students indicate significant positive impact. 87% of respondents felt the GK-12 fellow and program helped them learn subject matter. 58% felt more confident about subject matter learned through GK-12 *Sensors!* modules, and 56% liked the subject matter more as a result of GK-12 interaction [2]. Longitudinal tracking of grades 6-8 cohorts will determine how self-reported student aspirations are impacted throughout high-school matriculation.

During the academic year 2005-06, GK-12 *Sensors!* has also had an effect on pre-middle-school students. "Sam the Ram," an emergency preparedness education project involving GK-12 *Sensors!* and Bangor High School (BHS), targets grades 2-5. In a sequence of presentations and activities, students learn about emergency preparedness from BHS mascot, Sam the Ram, and his 'helpers'. Each presentation includes sensor technology and raises the awareness of career opportunities related to the topic of consideration. These grades 2-5 students will proceed to Bangor area middle schools, in which GK-12 *Sensors!* has established integration of sensors into the curricula. Grades 6-8 survey instruments will be designed to register the influence of primary grade program interaction. Further indications of impact will be solicited during biennial middle-school teacher focus groups.

Additionally, an experienced GK-12 *Sensors!* fellow is interacting with the Maine Discovery Museum (MDM), located in downtown Bangor, ME, developing a large-scale interactive sensors-based learning module appropriate for ages 5-14. MDM, the largest children's museum in the northeastern US north of Boston, has seven interactive exhibit spaces on three floors. Scheduled for fall 2006 implementation, GK-12 *Sensors!* will achieve significant exposure with parents and children from throughout central and northern Maine, including area schools where efforts are currently active.

GK-12 *Sensors!* participating schools and community agencies are discussing criteria and methods for determining the program's footprint and community impact.

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