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GK-12: Sensors!

John F. Vetelino

Principal Investigator; University of Maine, Orono

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Final Report for Period: 05/2002 - 06/2006

Submitted on: 10/25/2006

Principal Investigator: Vetelino, John F.

Award ID: 0139324

Organization: University of Maine

Title:

GK-12: Sensors!

Project Participants

Senior Personnel

Name: Vetelino, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Vetelino was born in Westerly R.I. He received the B.S., M.S., and Ph.D. in electrical engineering from the University of Rhode Island in 1964, 1966, and 1969, respectively. He was one of the founding members of the Laboratory for Surface Science and Technology at the University of Maine and is currently leader of the solid state research group. Four sensor companies û the BIODÉ Corp. in Westbrook, ME, Microsensor Conversion Technology in Brookings, SD, Sensor Research and Development Corp. in Orono, ME and Mainely Sensors, also in Orono, ME û have been incubated from his research group.

Dr. Vetelino's research in acoustic wave and metal oxide sensors served as the motivation for the GK-12 Sensors program. He previously served on many NSF Science Education Review panels for NSF Undergraduate Research Participation (URP), NSF Local Course Improvement (LOCI), NSF Student Science Training (SST), NSF instructional Scientific Equipment Program (ISEP) and NSF Small Business Innovation Research grants (SBIR) proposals. He also served in many NSF workshops and various panels relating to research addressing national needs.

As Principal Investigator, Dr. Vetelino makes the final decision on fellow selection, directs fellow activities, sets guidelines for module development, facilitates communication between the six GK-12 Sensors! schools and UM faculty, writes and submits supplemental and related grants for the program, establishes guidelines for fellow journal articles on the GK-12 program, and attends GK-12-related conferences.

Dr. Vetelino also serves as the advisor for GK-12 Sensors! fellows Lester French, Jesse Parks, Wade Pinkham and Chris York.

Name: Godsoe, Stephen

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephen Godsoe is from Bangor, Maine and has 37 years of high school teaching experience. Mr. Godsoe was the K-12 Mathematics Coordinator in Bangor from 1975-1983 and 1989-1991 and has served on several state committees to establish mathematics standards. He has taught all levels of high school mathematics, statistics, and computer science. He was one of twenty-eight teachers in the US to receive the Edith May Sliffe award in 2001. Since 1994, Mr. Godsoe has also taught 'Teaching K-8 Mathematics' at the University of Maine.

As Co-P.I. for GK-12 Sensors, Mr. Godsoe is an active team member in the classroom, helping GK-12 fellows. He directs the program's collaboration with the state and city agencies, and works to support the program with new initiatives. Mr. Godsoe organizes GK-12 activities at our largest site, Bangor High School. In this capacity, he pairs fellows with appropriate teachers, produces GK-12 press releases for the school paper, and regularly communicates with GK-12 satellite schools on issues relating to technology in the classroom.

Name: Holden, Constance

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Constance Holden has significant teaching experience at the local high school, University College of Bangor and the University of Maine. She has supervised student teachers, helped to develop the curriculum on workshops for secondary school teachers, and authored publications for professional journals related to teaching science and engineering.

As Co-P.I. for GK-12 Sensors, Dr. Holden brings her teaching experience to the task of supporting and training the GK-12 fellows. She teaches Spatial Science and Technology Information at the University of Maine, as well as meeting with the fellows on a

one-to-one basis, interacting with civic leaders, developing GIS programs for BHS courses, and helping to administer the program.

Name: Crowley, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

Adam Crowley is from Caribou, Maine and has taught at The University of Maine and Beal College. As the 2003-04 program manager, Mr. Crowley coordinated all GK-12 activities, set up meetings, promoted the program to the public, prepared reports, maintained the website, designed PowerPoint presentations on GK-12 Sensors, and assisted in the development of modules.

Name: Boyle, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

As program evaluator, Dr. Boyle gathered information on fellow classroom activities and surveyed GK-12 teachers to assess the impact of fellows on classroom activities. Dr. Boyle left the program February 2005.

Name: Arsenault, Jr., Joseph

Worked for more than 160 Hours: Yes

Contribution to Project:

Joe Arsenault has taught at The New School for Social and Behavioral Research (NYC) and at The University of Maine. As program manager from 2004 to present, Mr. Arsenault has coordinated all GK-12 Sensors activities and meetings; acted as a liaison between Co-PIs, fellows and teachers; prepared articles, reports and informational presentations on GK-12 Sensors!; assisted fellows in the development of modules and conference presentations; represented the program at national conferences; advocated for establishing ongoing State financial support for GK-12-type programs; worked with fellows to establish auxiliary support for GK-12 related activities.

Name: Hart, Suzanne

Worked for more than 160 Hours: Yes

Contribution to Project:

Suzanne Hart, Research Associate/Policy Analyst at the Center for Research and Evaluation (CRE), College of Education & Human Development, University of Maine, was the fall 2004-summer 2005 GK-12 Sensors! program evaluator. As such, Hart reviewed past and current evaluation efforts and instruments and performed additional analyses on prior evaluation reports. She administered and analyzed 2004-2005 evaluation data and developed an evaluation plan for the successful GK-12 Sensors! Track II proposal submitted June 2005. During fall 2005, she was transitioned seamlessly by the CRE from the position. A colleague at the Center has assumed her responsibilities.

Name: Doore, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Brian Doore became GK-12 Sensors! evaluator during the fall of 2005. He is responsible for all aspects of program evaluation.

Post-doc

Graduate Student

Name: Berkenpas, Eric

Worked for more than 160 Hours: Yes

Contribution to Project:

Eric Berkenpas from Northwest Iowa attended South Dakota State University where he received his undergraduate degree in Electrical Engineering with a Computer Science minor. Eric received the MS Electrical Engineering from UM in Summer 2005. His graduate research involved development of a novel sensor for detecting bio-terrorism pathogens. Eric worked with electronics classes at BHS and JBMHS and with chemistry and physics classes at Sumner Academy. Eric left the GK-12 program January 2005.

Name: Kenney, Crystal

Worked for more than 160 Hours: Yes

Contribution to Project:

Crystal Kenny is from China, ME. She received the Bachelors Degree from UM in Engineering Physics and Computer Engineering. She completed her Masters degree at UM in Electrical Engineering in August 2005. Her research involved magnetic flux sensors in hearing aid applications, with advisor David E. Kotecki. She worked with physics teachers at JBHS. Crystal left the GK-12 program in July 2005.

Name: Donovan, Danielle

Worked for more than 160 Hours: Yes

Contribution to Project:

Danielle Donovan is from Presque Isle, Maine. She received her Bachelors Degree from the University of Maine in Spatial Information Science and Engineering. In Summer 2005, she received the Masters degree in Spatial Information Science and Engineering at the University of Maine, specializing in remote sensing and geographic information systems (GIS). Danielle was instrumental in the development of the Sensor Sensitive program at BHS, detailed in a later portion of this report. Danielle also worked with life science teachers at RBMS. Danielle was one of two fellows who worked with NASA to develop EarthKam modules for participating classrooms.

Name: French, Lester

Worked for more than 160 Hours: Yes

Contribution to Project:

Lester French is pursuing a Ph.D in materials science, focusing on acoustic wave sensors for use as liquid-phase chemical sensors. Lester received the BSEE with a minor in optical and illumination engineering from the University of New Hampshire in 1993. Lester worked as a commercial engineer for Duro-Test Corporation and as a research engineer for BIODE, Inc. on the modeling, testing, and packaging of acoustic wave devices as liquid-phase chemical sensors. He received his MSEE from the University of Maine in 2002. Prior to the 2005-06 academic year, Lester worked primarily with the Chemistry department at Bangor High School for the NSF GK-12: Sensors! project. In particular, Lester worked closely with BHS Chemistry teacher Helmut Koch, designing and implementing sensor modules that detect acidity and viscosity in various substances. In the spring of 2003, Lester traveled to Magdeburg, Germany to take part in a program related research experience at the Otto-von-Guericke University. Working with co-PI Stephen Godsoe of BHS, Les designed and taught a senior-level pilot course on sensor science and engineering. This year Lester has been working with teachers at Caravel Middle School and Hermon Middle and High schools.

Name: Hedefine, Eeva

Worked for more than 160 Hours: Yes

Contribution to Project:

Eeva Hedefine, a Maine native, is a MS student in the Department of Spatial Information Science and Engineering at the University of Maine. Eeva is researching privacy issues relating to sensors. She received a Bachelors Degree in Spatial Information Engineering from the University of Maine and an Associate Degree in Legal Technology from the University of Maine at Augusta. Eeva has worked with the Senior Seminar, Civics, Geography, and Advanced Drafting classes at BHS. In 2004 and 2005 Eeva was central to the development of the Bangor, Maine GIS Emergency Mapping Projects, detailed in a later portion of this paper.

Name: Kennard, Raymond

Worked for more than 160 Hours: Yes

Contribution to Project:

Raymond Kennard is from South Paris Maine. He graduated from Ithaca College in '99 with a B.S. in Chemistry and a minor in Physics. During the next four years, Raymond taught physical sciences at Fryeburg Academy (Fryeburg, ME). In the fall of 2002, he decided to return to school to pursue a Ph.D in Chemical Engineering at UM. Raymond is currently researching mesoporous thin films and their application to Sensor as a molecular prefilter. As a fellow, he has worked with chemistry faculty at BHS, faculty at DMS and CMS, and the downtown Bangor Discovery Museum.

Name: Krassikoff, John

Worked for more than 160 Hours: Yes

Contribution to Project:

John Krassikoff received the Ph.D Physics in Spring 2005. He was involved with the Laboratory for Surface Science and Technology where he performed research tasks related to sensor development for monitoring high temperature oxidation of SiAlON fracture resistant thin films. John served, in various capacities, during ten years in the United States Air Force. He subsequently worked as an electronics technician for Hipotronics, a high-voltage test equipment company and was an engineering technician for the United Parcel Service at its R&D facility, working on voice recognition systems. Finally, John worked as a staff engineer at Lorex Industries working on the design of optical and acoustic measurement systems for the telecom and semiconductor industries. He left industry to attend graduate school after completing his second bachelor's degree, in Physics, at

the State University of New York at New Paltz. At John Bapst High School, John worked closely with students from general physics classes to help them produce sensor-oriented projects for annual physics project competition. Furthermore, John introduced electricity into the curriculum of ninth grade science classes. John Krassikoff left the GK-12 Sensors! program in October of 2003.

Name: Lampron, Kenna

Worked for more than 160 Hours: Yes

Contribution to Project:

Kenna Lampron from Standish, Maine received her Bachelors degree from the University of Maine in Electrical Engineering August 2003 and began working on her MS at the University of Maine in the same field as her undergraduate study. Her research involved semiconducting metal-oxide (SMO's) sensors. Kenna worked with biology classes at BHS, developing portable learning modules for biology classes focusing on PH sensing. Kenna left the GK-12 program August 2004.

Name: Lewark, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Michael Lewark from Jonesport, Maine, was a candidate for a PhD in Electrical Engineering at the University of Maine. He received his undergraduate degree in Electrical Engineering from the University of Maine in May of 2003. Michael's area of research was in material characterization for microwave acoustic applications. During the 2003-04 academic year and fall of 2004, Michael worked with science classes at Jonesport-Beals High School (JBHS). In the fall of 2004, Mike was instrumental in reviving the school's Electric Car Club. Mike left the GK-12 program January 2005.

Name: Martin, Andrea

Worked for more than 160 Hours: Yes

Contribution to Project:

Andrea Martin from Indiana and received her degree in forensic chemistry from Ohio University. She is currently pursuing her PhD in chemistry at the University of Maine and works on the development of a nitric oxide gas sensor in the Laboratory for Surface Science and Technology. At Bangor High School, Andrea is working with the students in the chemistry classes. As a fellow, Andrea has developed one of only two air quality monitoring stations in the state of Maine. This station is located at Bangor High School. She has designed a number of modules around the station and has developed a system for the dissemination of this information to our satellite schools. In the summer of 2003, Andrea traveled to Brescia, Italy to take part in a program related research experience at the University of Brescia.

Name: McCarthy, Erik

Worked for more than 160 Hours: Yes

Contribution to Project:

Erik McCarthy, originally from Greene, ME, is a graduate of Leavitt Area High School in Turner. He received a B.S. degree in Electrical Engineering from the University of Maine in May, 2003 and currently is working on a Master's degree in Biological Engineering. His graduate research is focused on attaching selective biomolecular layers to sensors that may be used to detect pathogens in aqueous environments. Erik joined the GK-12 Sensors! program in February, 2004 working at BHS, Lee Academy and SHS in a variety of subject areas, including calculus, physical science, chemistry and computer programming. During the 2004-05 academic year, Erik worked at BrHS, collaborating with teachers to design and implement an electronics unit for 9th-grade physical science classes. Erik left the GK-12 program July 2005.

Name: Neumann, Brad

Worked for more than 160 Hours: Yes

Contribution to Project:

Brad Neumann, from Northern Michigan, received his Master of Science in the UM Department of Resource Economics and Policy in August 2005. He received his Bachelor of Science degree from Northern Michigan University, where he dual-majored in Economics and Land Use Planning, and studied Geographic Information Systems (GIS) as a minor concentration. Brad has worked as a GIS intern for Environmental Systems Research Institute, Inc., and has also worked as an independent consultant on GIS and land use planning projects. His research at the University of Maine primarily dealt with evaluating the effects that preserved land has on neighboring property values. Brad was brought into the program in 2003 as a social science fellow. He worked at Bangor High School in the Social Studies Department and was involved in Senior Seminar, Civics, and World Geography classes. Along with fellow Eeva Hedefine, Brad developed the Bangor, Maine Emergency Response GIS Project and several related projects. Brad left the GK-12 Sensors! program in July 2005.

Name: Pitcher, Stephanie

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephanie Pitcher received the MS degree in Electrical Engineering. Stephanie's research was focused on developing an impedance-based metal-oxide gas sensor for ethylene detection and fruit ripening. Stephanie grew up in Washington State during elementary and high school, and studied at the University of Colorado at Colorado Springs for her undergraduate BS degree in Electrical Engineering. She worked with the BHS biology department. Stephanie is one of two fellows who worked with NASA to develop GK-12 Sensors! classroom modules. Along with fellow Danielle Donovan, Stephanie was central in the development of the Sensor Sensitive program, detailed in later section of this report. Stephanie left the GK-12 program in July 2004.

Name: Puckett, Anthony

Worked for more than 160 Hours: Yes

Contribution to Project:

Anthony Puckett received the PhD in mechanical engineering. His research focused on ultrasonic methods for material characterization using solid cylindrical waveguide used in non destructive sensing. Anthony was born and raised in New Mexico. He received his BS and MS in Mechanical Engineering from Colorado State University. Anthony worked mainly with pre-calculus classes at BHS. Anthony Puckett left the GK-12 Program in April of 2004.

Name: Woodward, Becky

Worked for more than 160 Hours: Yes

Contribution to Project:

Becky Woodward received the Ph.D in biology in 2004. In her research she conducted a cross-species comparison of the morphologies and performance abilities of four baleen whale species. Her work involved the use of suction-cup attached, multi-sensor data logging tags to monitor the underwater movements of large whales at sea. Becky designed a whale watching module that brought students from several schools to the coast of Maine to observe and classify the habits of humpback whales. Becky Woodward left the Gk-12 Sensors! program at the end of 2003.

Name: Reed, Allison

Worked for more than 160 Hours: Yes

Contribution to Project:

Allison Reed has been assisting Dr. Boyle in his evaluation of the GK-12 Sensors! program.

Name: Ozdemir, Smera

Worked for more than 160 Hours: Yes

Contribution to Project:

Smera Ozdemir has been assisting Dr. Boyle in his evaluation of the GK-12 Sensors! program.

Name: Clark, Aaron

Worked for more than 160 Hours: Yes

Contribution to Project:

Aaron Clark is from Hermon, Maine. He is currently working on his Ph.D. in Chemical Engineering at the University of Maine. His research involves the development of metal-oxide chemical microsensors for gas sensing applications. He received his Bachelors Degrees from the University of Maine in Chemical Engineering and Mathematics in 2002, and a Masters Degree in Chemical Engineering in 2004. Aaron is a second-year fellow with the NSF GK-12: Sensors! Program; he works with teachers in the Bucksport School System.

Name: Gallimore, Dana

Worked for more than 160 Hours: Yes

Contribution to Project:

Dana Gallimore attended UM and received an undergraduate degree in Electrical Engineering, with a minor in mathematics. Dana is currently a Ph.D. student in Electrical Engineering. Her research involves determining the elastic properties of biofilms on surface acoustic wave sensors. Dana worked with the BHS mathematics department. Dana left the GK-12 program July 2005.

Name: Isenberg, Douglas

Worked for more than 160 Hours: Yes

Contribution to Project:

Douglas Isenberg was a Masters student in Electrical Engineering at UM during the 2004-05 academic year. He received his BS in Electrical Engineering at the University of North Carolina at Charlotte. Douglas worked with computer classes at Hermon Middle School, introducing the students to computer programming and robotics. Douglas left the GK-12 program July 2005.

Name: Pinkham, Wade

Worked for more than 160 Hours: Yes

Contribution to Project:

Wade Pinkham is from Damariscotta, Maine. He received his BS in Electrical Engineering from UM in 2004 and is currently working on a MS degree in Electrical Engineering at UM. He is specializing in applying bulk acoustic wave sensors to pesticide detection. Last year, Wade worked with physics classes at CHS in Corinth, ME. This year, he is working with middle school science teachers at CMS and SVMS.

Name: Parks, Jesse

Worked for more than 160 Hours: Yes

Contribution to Project:

Jesse Michael Parks was born in Calais, ME and is currently pursuing a Ph.D. in Electrical Engineering at UM. He received his BS in Electrical Engineering from UM in 1999 and worked at Sensor Research & Development in Orono, ME and Edwards Systems Technology in Pittsfield, ME before returning to UM in 2004. Jesse's research interests include sensor design and modeling and sensor response analysis. He is a second-year fellow with the NSF GK-12 Sensors! He has worked with teachers at BHS, CMS and DMS.

Name: York, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

Chris York was born in Levittown Pennsylvania and attended high school in Belfast Maine. Chris earned his undergraduate degree in Electrical Engineering at the University of Maine and is currently working on an MS in Electrical Engineering. Supported by Dr. John Vetelino, Chris is part of a group developing the lateral field excited (LFE) acoustic wave sensor, a new sensor platform. In particular, he is examining the LFE for use in biosensor applications, such as detecting E. coli in water supplies. Chris was a NSF GK-12 Sensors! fellow for the 2004-05 year, working primarily with Jim Tyson at MCI, a high school located in the town of Pittsfield. Chris left the program in July 2005.

Name: Walker, Judith

Worked for more than 160 Hours: Yes

Contribution to Project:

Judith Walker is a 2005-06 first-year GK-12 Sensors! fellow. She is originally from New Castle, Delaware. Currently she is working on her Masters in the Resource Economics and Policy Department under the advisement of Dr. Kathleen P. Bell. Her research involves community selection decisions in rural coastal communities focusing on the importance of community characteristics. Judith completed her undergraduate program at the University of Delaware in 2004. She majored in Natural Resource Management and earned minors in Resource Economics and Legal Studies. As an undergraduate Judith was accepted to participate in Columbia University's Biosphere 2 Program in Arizona for a semester. This year she is working with Jim Smith, Margaret Chernosky, and other teachers in the History Department at Bangor High School.

Name: Nagy, Edwin

Worked for more than 160 Hours: Yes

Contribution to Project:

Born in Lincoln, NE, Edwin Nagy is a 2006 GK-12 Fellow pursuing a Ph.D. in Civil Engineering. His research focuses on mechanics of materials. Currently, he is developing a 3d morphological lattice model of softwood to enhance our ability to predict mechanical properties of wood subjected to complex stress states. The model is being built and verified with data from small scale physical testing. He received his masters degree from the University of Maine in 1998 based on research involving 3d X-ray Microtomography of concrete under load. He received his A.B. in math and physics from Amherst College in 1993. Between undergrad and the masters, Edwin worked as a Peace Corps volunteer in Niger, West Africa. His duties primarily consisted of teaching high school math. Between the masters and returning to pursue the doctoral degree, Edwin worked as a structural engineer in central Arizona. Throughout the years, Edwin has been active in local theater, mostly working on sets and lighting, although lately he has begun trying his hand at directing with the Orono Community Theatre. Edwin has worked with teachers and BrHS and BrMS.

Name: Duy, Janice

Worked for more than 160 Hours: Yes

Contribution to Project:

Janice Duy is a first-year graduate student in the Department of Electrical and Computer Engineering. She received her BS in Electrical Engineering from the University of Maine in 2005. Her current research involves the development of biosensors to detect the potato wart fungus. Janice grew up in Manila, Philippines. During the spring 2005-06 academic year, Janice has interacted with teachers from CaMS, HMS and HHS.

Name: Shareef, Ali

Worked for more than 160 Hours: Yes

Contribution to Project:

Fellow Ali Shareef works at BHS in computing and electronics while pursuing a Masters Degree in Computer Engineering. He obtained his BS in Computer Engineering from Purdue University May 2004. Ali is working on integrating microprocessors using Dynamic Voltage Scaling (DVS) with sensors in the area of tracking. His other interests include Artificial Intelligence, Imbedded Systems, and Cluster Computing. He is originally from India.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Bangor High School

Bangor High School:

2005-06 DATA

Number of Fellows: 5

Number of teachers impacted: 10

Number of classes impacted: 32

Type of School: urban

% of free or reduced price Lunch: 20%

% minority: 8%

Academic Standing: Exceeds state averages in math, reading, and writing.

Bangor High School Teachers:

Andrew Bouchard Physics
 Margaret Chernosky Geography
 Don Erb Math/Computer Science
 Stephen Godsoe Math
 Cary James Chemistry
 Felicia Llyons Geography
 Roger Reed Civics
 Jim Smith Civics
 Theodore Taylor Earth Science
 Geoffrey Wingard History

John Bapst Memorial High School

John Bapst Memorial High School:

2005-06 DATA

Number of Fellows: 1
 Number of teachers effected: 2
 Number of classes effected: 4
 Type of School: urban
 % of free or reduced price Lunch: This school does not have a lunch program.
 % minority: 6%
 Academic Standing: Exceeds state average for reading, writing and math.

John Bapst Memorial High School Teachers:

Scott Burgess Physics
 Kurt Klappenbach Physics

Bucksport High School

Bucksport High School:

Number of Fellows: 1
 Number of Teachers effected: 3
 Number of classes effected: 13
 Type of School: Urban
 % of free or reduced price lunch: 25.28%
 % minority: 2%
 Academic Standing: Fails to meet state average in reading, writing and math.

Bucksport High School Teachers:

John Mannette Physics, Physical Science, Earth Science
 Denise Smith Biology, Earth Science
 Virginia White Chemistry

Sumner Memorial High School

Sumner Memorial High School:

Number of Fellows: 1
 Number of Teachers Effected: 2
 Number of classes effected: 5
 Type of School: Rural
 % of free or reduced price Lunch: 31.89%
 % minority: 2%
 Academic Standing: Fails to meet state average in reading, writing and math.

Sumner High School Teachers:

Henri Gignoux Physics
 Mike Benjamine Physical Science

Lee Academy

Lee Academy:

Number of Fellows: 12
 Number of Teachers effected: 1

Number of classes effected: 4
 Type of School: Rural
 % of free or reduced price lunch: 53%
 % minority: 23%
 Academic Standing: Fails to meet state average in reading,
 writing, and math

Lee Academy Teacher:

John Simone Chemistry

Jonesport-Beals High School

Jonesport-Beals High School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected: 3
 Type of School: Rural
 % of free or reduced price lunch: 41%
 % minority: 0%
 Academic Standing: Fails to meet state average in writing, reading
 and math.

Jonesport-Beals High School Teacher:

Lynn Alley All Science Classes

Bangor, Maine City Council

The council has taken a role in the development of the 2004 Bangor, Maine GIS Emergency Mapping Project and the 2005 Emergency Mapping Project for Bangor International Airport, developed by GK-12 Sensors! fellows in collaboration with faculty at Bangor High School.

Bangor Maine Fire Department

By loaning materials and training time, the Bangor Fire Department has assisted the development of the 2004 Bangor, Maine GIS Emergency Mapping Project and the 2005 GIS Emergency Mapping Project of the Bangor International Airport.

Bangor, Maine Police Department

Bangor Police Department has provided data, facilities and staff assistance for the 2004 Bangor, Maine GIS Emergency Mapping Project, the 2005 GIS Emergency Mapping Project for Bangor International Airport, and the 2006 Bangor, Maine GIS OUI Mapping Project.

NASA

Two of our fellows have developed a number of modules using information they have received at Maine Teachers of Earth and Space Science Workshop 2003 in Washington, DC. This workshop was sponsored by NASA.

Brewer High School

Brewer High School

2005-06 DATA

Number of Fellows: 1
 Number of teachers effected: 4
 Number of Classes effected: 15
 Type of School: Urban
 % of free or reduced price Lunch: 19.05%
 % minority: 3%

Academic Standing: Fails to meet state average in reading and writing; exceeds state average in math.

Brewer High School Teachers:

Arthur Libby Physical Science
 Andy Geaghan Physical Science
 Todd Hillier Physical Science
 Darrell King Physical Science, Physics

Caravel Middle School

Caravel Middle School:

2005-06 DATA

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected: 4
 Type of School: Rural
 % of free or reduced price lunch: 42.32%
 % minority: 1%
 Academic Standing: Exceeds state average in reading, writing and math.

Caravel Middle School Teachers:

Richard Burger Science

Central High School

Central High School:

Number of Fellows: 1
 Number of Teachers effected: 2
 Number of classes effected: 3
 Type of School: Rural
 % of free or reduced price lunch: 38%
 % minority: 2 %
 Academic Standing: Meets state average in reading; fails state average in writing and math.

Central High School Teachers:

Robert Littlefield Physics
 Ed Lindsey Earth Science

Central Middle School

Central Middle School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected: 5
 Type of School: Rural
 % of free or reduced price lunch: 53.07%
 % minority: 2%
 Academic Standing: Meets state average in reading, fails state average in writing and exceeds state average in math.

Central Middle School Teacher:

Cathy Tilton Science

William S. Cohen School

William S. Cohen [Middle] School:

2005-06 DATA

Number of Fellows: 1

Number of Teachers effected: 2

Number of classes effected: 6

Type of School: Urban

% of free or reduced price lunch: 23.08%

% minority: 8%

Academic Standing: Exceeds state average in reading, writing and math.

William S. Cohen [Middle] School Teachers:

Timothy Surette Physical Science

Tracy Vassiliev Applied Science

James F. Doughty School

James F. Doughty [Middle] School:

Number of Fellows: 2

Number of Teachers effected: 2

Number of classes effected: 7

Type of School: Urban

% of free or reduced price lunch: 46.06%

% minority: 8%

Academic Standing: Exceeds state average in reading and math, fails state average in writing.

James F. Doughty [Middle] School Teachers:

Patricia Bernhardt Life Science

Tracy Vassiliev Applied Science

Hampden Academy

Hampden Academy:

2005-06 DATA

Number of Fellows: 1

Number of Teachers effected: 2

Number of classes effected: 6

Type of School: Rural

% of free or reduced price lunch: 9.86%

% minority: 2%

Academic Standing: Exceeds state average in reading, writing and math.

Hampden Academy Teachers:

Marc O'Clair Physical Science & Earth Science

Danielle Donovan Physical Science & Earth Science

Hermon Middle School

Hermon Middle School:

Number of Fellows: 1

Number of Teachers effected: 1

Number of classes effected: 9

Type of School: Rural

% of free or reduced price lunch: 19.79%

% minority: 3%

Academic Standing: Fails state average for reading and writing, meets state average for math.

Hermon Middle School Teacher:

Alan Tweedie Computer Science

Maine Central Institute

Maine Central Institute:

Number of Fellows: 1

Number of Teachers effected: 3

Number of classes effected: 7

Type of School: Rural

% of free or reduced price lunch: 12.92%

% minority: 6%

Academic Standing: Exceeds state average in reading, writing and math.

Maine Central Institute Teachers:

Linda Amsden Statistics

Irma Cushing Algebra

Jim Tyson Physics, Integrated Science

Reeds Brook Middle School

Reeds Brook Middle School:

Number of Fellows: 2

Number of Teachers effected: 5

Number of classes effected: 10

Type of School: Rural

% of free or reduced price lunch: 13.35%

% minority: 2%

Academic Standing: Exceeds state average in reading, writing and math.

Reeds Brook Middle School Teachers:

Jen Bowman-Mckay Social Studies

Kim Haggan Social Studies

Robert O'Leary Life Science

Georgiana Piete Science, Social Studies

Deb Sykes Social Studies

Bucksport Middle School

Bucksport Middle School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected:
 Type of School: Urban
 % of free or reduced price lunch: %
 % minority:
 Academic Standing:
 Bucksport High School Teachers:

Jennifer Skala 8th Grade Life Science

Sebasticook Valley Middle School

Sebasticook Valley Middle School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected:
 Type of School: Rural
 % of free or reduced price lunch:
 % minority:
 Academic Standing:

Sebasticook Valley Middle School Teachers:

Jane Stork Math

Maine Discovery Museum

In 2005-06, Maine Discovery Museum interacted with GK-12 Sensors! Fellows to establish sensor-related exhibits in the museum, geared toward ages 2-10.

Bangor Historical Society/Museum

The Bangor Historical Society/Museum has helped develop several projects with GK-12 Fellows, students and faculty at Bangor High School, including the award-winning GIS-web-based 2005 presentation Historical Atlases of Bangor, Maine (view 2004-05 award at <http://www.esri.com/industries/k-12/atlas/index.html>).

Brewer Middle School

In Spring 2006, GK-12 Fellows began interacting with Brewer Middle School faculty.

Other Collaborators or Contacts

Other University of Maine Collaboration:

Dr. Robert Kennedy, President of the University of Maine
 Dr. Peter Hoff, Former President of the University of Maine
 Dr. Robert Lad, Director of the Laboratory for Surface
 Science and Technology (LASST) and Professor of Physics
 Dr. Carl Tripp, Associate Professor of Chemistry, LASST
 Dr. Bruce Segee, Associate Professor, Electrical and
 Computer Engineering
 Dr. Paul Millard, Assistant Professor, LASST
 Dr. Alfred Bushway, Professor of Food Science

Dr. Rodney Bushway, Chair and Professor of Food Science

Other Community and State Collaboration:

Dr. Robert Ervin, Superintendent of Schools, Bangor
 Mr. Norris Nickerson, Principal, Bangor High School
 Peter Arno, Assistant Police Chief, Bangor
 Jeff Cammack, Fire Chief, Bangor
 Stan Moses, Community Development
 Paul Nichols, DEP for the state of Maine
 Mark Whiting, DEP (water quality),
 Bob Goodwin, Department of Marine Resources,
 Susan Morse, Bangor Area Comprehensive Transportation System
 (BACTS)
 Ken Beland, Atlantic Salmon Commission, state of Maine
 Dave Gould, Bangor Planning,
 John Murphy, City Engineering
 Rebecca Hupp, Bangor International Airport Director
 Jim Ring, City Engineer, Bangor
 Don Winslow, Police Chief, Bangor
 Rod McKay, Community Development, Bangor
 Rob Kenerson, Bangor Area Comprehensive Transportation
 System, BACTS
 Anne Hartmann, Discovery Museum, Bangor

Fellow Advisors:

Dr. Peggy Agouris, Assistant Professor of Spatial Information Science and Engineering, University of Maine: Dr. Agouris serves as advisor to GK-12 fellow Danielle Donovan.

Dr. Kevin J. Boyle, Professor and Chair of Resource Economics and Policy, University of Maine: Dr. Boyle serves as advisor to GK-12 fellow Brad Neumann.

Dr. Mauricio DaCunha, Assistant Professor of Electrical and Computer Engineering, University of Maine: Dr. DaCunha serves as advisor to GK-12 fellows Eric Berkenpas, Dana Gallimore, and Michael Lewark.

Dr. William J. Desisto, Assistant Professor of Chemical Engineering, University of Maine: Dr. Desisto serves as advisor to GK-12 fellow Raymond Kennard.

Dr. Richard Eason, Associate Professor of Electrical and Computer Engineering, University of Maine: Dr. Eason serves as advisor to GK-12 fellow Douglas Isenberg.

Dr. David Kotecki, Assistant Professor of Electrical and Computer Engineering, University of Maine: Dr. Kotecki serves as advisor to GK-12 fellow Crystal Kenney.

Dr. Paul Millard, Assistant Professor of Biological Engineering, University of Maine: Dr. Millard serves as advisor to GK-12 fellow Erik McCarthy.

Dr. Harlan Onsrud, Professor of Spatial Information Science and Engineering, University of Maine: Dr. Onsrud serves as advisor to GK-12 fellow Eeva Hedefine.

Dr. John F. Vetelino, Professor of Electrical Engineering, University of Maine: Dr. Vetelino serves as advisor to GK-12 fellows Lester French, Jesse Parks, Wade Pinkham and Chris York.

Dr. Clayton Wheeler, Assistant Professor of Chemical and Biological Engineering, University of Maine: Dr. Wheeler serves as advisor to

GK-12 fellow Aaron Clark.

Post Doc and Other Professionals:

No post doc employees were involved in the GK-12 Sensors! program.

During 2003-04, Dr. Mark Anderson, UM Senior Instructor of Resource Economics and Policy, assisted former Program Evaluator Dr. Kevin Boyle in the evaluation of GK-12 Sensors!

David Frankel, Senior UM Research Scientist, George Bernhardt, UM Research Scientist, and Michael Call, UM Research Engineer, facilitated tours of various UM laboratories for visiting high school students.

Two UM graduate students in Resource Economics, Allison Reed and Semra Ozdemir, assisted former Program Evaluator Dr. Kevin Boyle in the collection and computation of GK-12 Sensors! data during 2003-04.

Activities and Findings

Research and Education Activities:

Supplemental Update for April-June 2006

Executive Summary

Since its inception in 2002, the GK-12 Sensors! Program has been focused on bringing cutting-edge research in sensors to high and middle school students in Maine in the anticipation of increasing the number of students pursuing a career in which science and engineering play a critical role. During the 2005-06 academic year, this project has been a collaboration between an interdisciplinary team of University of Maine (UM) engineers and scientists working in sensors, six Maine high schools (Bangor High School [BHS], Brewer High School [BrHS], Bucksport High School [BuHS], Hampden Academy [HA], Hermon High School [HHS] and John Bapst Memorial High School [JBMHS]) and nine Maine middle schools (Brewer Middle School [BrMS], Bucksport Middle School [BuMS], Caravel Middle School [CaMS], Central Middle School [CMS], William S. Cohen School [CoMS], James F. Doughty School [DMS], Hermon Middle School [HMS], Reeds Brook Middle School [RBMS], and Sebecook Valley Middle School [SVMS]). The goal is to use these high and middle schools as models and to extend the program to other Maine high and middle schools.

During our no-cost extension fourth year, the program intensified its presence throughout grades 6-12 of participating school systems, considerably facilitated by PI John Vetelino's successfully funded 2004-2006 RET-Sensors! site proposal. The initial GK-12 Sensors! proposal sought to establish links with area high schools through connections that participating BHS faculty had with faculty in those schools. In the spring of 2003, Vetelino was awarded funding for an RET supplemental program, allowing him to bring four area high-school teachers to work in sensor research during the summer of 2003. The RET program, which allowed RETs and GK-12 fellows to interact in research, proved a new, effective avenue for transitioning GK-12 Sensors into area high schools by preparing participating teachers through an intensive eight-week summer research experience. In the spring of 2004, Vetelino was awarded funding for the 2004-2006 NSF RET-Sensors program, ensuring an ongoing mechanism for locating and preparing participating GK-12 Sensors! teachers and schools. The 2005 RET program brought five high-school and five middle-school teachers to UM. All successful participants became 2005-2006 GK-12 Sensors! participating teachers. Three of the five middle-school teachers taught in schools systems with GK-12 fellows present at the high-school level. Consistent with findings in the 2004-2005 Annual Report, 2005-2006 GK-12 Sensors! introduced the program at the middle-school level while maintaining a significant presence throughout the high-school curricula of participating school systems.

GK-12 Sensors! received commitment from UM Vice-President for Research Michael Eckardt for bridge funding to supplement 2005-2006 fellowships for seven graduate students already involved in the GK-12 program. This bridge funding allowed continuous operation of the program beyond the term of the Track I proposal.

A proposal for five-year Track II-NSF funding for GK-12 Sensors! was submitted in June 2005. The Track II GK-12 Sensors! proposal was

favorably reviewed and recommended for funding. The proposal was awarded January 2006. Three new Fellows entered the program February 2006, bringing the current total to ten Fellowships.

In the spring of 2005, Orono, Maine State Representative Emily Cain introduced Bill LD 119, an act to establish ongoing funds creating graduate fellowships within the University of Maine system geared at enhancing science and math education at the secondary school level. The proposed annual funding level each academic year was \$2.5 million. This bill had the strong support of University of Maine System Chancellor Joseph Westphal. The bill was passed in May 2005 as an engrossed bill, to be brought back before the legislature during its spring 2006 session to determine its funding level. LD 119 offers the promise of a degree of sustainability to the GK-12 Sensors! program. As of March 31, 2006, LD 119 awaits legislative action.

Other major fourth year accomplishments include a successful RET-GK-12 Sensors! summer 2005 workshop and subsequent transition of 2005 RET participants into the 2005-2006 GK-12 Sensors! program; intensification of GK-12 Sensors! integration into middle-school curricula; expansion of GK-12 Sensors! into six high- and nine middle- schools; establishment of initial contacts with new partner schools through the 2006 Research Experience for Teachers (RET) summer fellowships; first year activities of NSF REU-Sensors!, which funded UM research of 17 undergraduate students from Maine and throughout the country and offered undergraduates opportunities to address peers from their high-school alma maters concerning their 2005 summer research experience; establishment of links between collaborating schools and the University of Maine by coordinating guided tours of on-campus research facilities; strengthening community investment through expansion of 2005 pilot programs such as the Bangor Historical Maps projects at BHS as well as development of six projects involving Bangor municipal officers; addition of program evaluator Brian Doore, Research Associate/Policy Analyst, Center for Research and Evaluation, College of Education & Human Development, UM; implementation of 'Introduction to GIS' into BHS curriculum, an advanced geography course integrating sensor science and technology into understanding global information systems; initiation of 'Sam the Ram,' an outreach program to educate the public about Bangor City evacuation plans and homeland security centered on disseminating information through presentations to grades 2-5 students, with supporting activities involving parents, guardians and other family members; further refinement of teaching modules created by teachers and fellows during years one and two and creation of twenty new portable modules.

Introduction

The idea for the GK-12 Sensors! program arose in the summer of 2001 when Dr. John Vetelino from the University of Maine (UM) brought Stephen Godsoe, head of the Bangor High School (BHS) mathematics department, to UM in order to involve Mr. Godsoe in sensor research. As the summer progressed, Mr. Godsoe, Dr. Vetelino, and Dr. Constance Holden, a former high school teacher and currently an instructor at UM, began discussing various methods for encouraging Maine high school students to follow career paths in science and/or engineering. As a result of these discussions, it was decided that sensors would be the vehicle of choice to try to convince high school students to follow a science and/or engineering career path. This approach is unique in that it simply does not present interesting science or broad topics of science and/or engineering to high school students, but focuses on sensors. Students certainly know the impact of sensors by reading the daily newspaper and seeing articles relating to homeland security issues and environmental concerns. Students are also surrounded by sensors in their homes, schools and other places they frequent. Students, however, do not know the science or engineering that underlies sensors and sensor systems. This underlying science and engineering and how it relates to sensors can easily be integrated into high school classes such as physics, chemistry, biology, environmental science, physical science or general science, mathematics, computer science, social studies, civics, geography, history and health. As a result of the discussions between Dr. Vetelino, Mr. Godsoe, and Dr. Holden, a proposal was developed and submitted to NSF to integrate sensors into the high school curriculum. This proposal was subsequently funded and the program began in the spring of 2002. GK-12 Sensors! is now in its first year of Track II funding.

Benchmarks April-June 2006:

April 2006: Fellows submit new portable learning modules, to be included in online library.

Program Evaluator Brian Doore conducts focus group with GK-12 Sensors! Fellows.

Bucksport Middle School teacher Jennifer Scala and GK-12 Fellow Aaron Clark bring 7th grade students on field trip to site of the Waldo-Hancock Penobscot Narrows Bridge as part of Clark's sensors and building integrity unit.

Fellow Raymond Kennard serves as a judge at the Doughty Middle School Invention Convention.

May 2006: Article and Presentation 'Work in Progress: Introduction of Sensors into Middle-School Classrooms' accepted for 2006 IEEE Frontiers in Education Conference, San Diego, CA, October 28-31.

Program Evaluator Brian Doore initiates spring evaluation activities for students, fellows, teachers.

Program Evaluator Brian Doore presents preliminary results of 2005-06 evaluation activities.

2006 Research Experience for Teachers RETùSensors! participants selected and notified.

Fellow Judith Walker and participating Bangor High School teacher Margaret Chernosky work with advanced geography students to complete and submit BHS 2006 community atlas to Environmental Systems Research Institute, Inc. (ESRI), one of the world's largest Geographic Information System (GIS) mapping software and services providers, (the GK-12 Sensors!-Bangor High School 2005 GIS project, was selected as the top national 2004-05 model GIS K-12 educational project.) The project is available at <http://www.esri.com/industries/k-12/atlas/model.html>.

Fellow Janice Duy goes to Woods Hole, MA participate in a harmful algal bloom (HAB) survey at Massachusetts Bay and shares her experiences through presentations and active-learning exercises with the students of Hermon middle school teacher Alan Tweedie.

Fellow Raymond Kennard presents research poster presentation. 'Single Molecule Spectroscopic Characterization of Mesoporous Silica Membranes Prepared by Micellar Templating' at North American Membrane Society (NAMS) 2006 conference, Chicago, IL.

Fellow Raymond Kennard helps prepare for and accompanies Doughty Middle School students to the State of Maine Invention Convention competition, held in Brewer. The 8th grade Doughty team Kennard worked with receives several awards.

Fellow Jesse Parks Participates as Judge in Cohen Middle School Science Fair.

Fellow Wade Pinkham works with participating Central Middle School teacher Cathy Tilton to put on a 'star party' for 2nd graders at Kenduskeag Elementary School, Corinth. The party includes a play put on by the Central Middle School 8th graders (the students the students with whom Pinkham works) and three demonstration stations: one maintained by Tilton, another by Pinkham and the third by UM Physics professor David Stern.

Fellow Aaron Clark and Bucksport High School Teacher John Mannette bring 35 interested high school students on a field trip to UM to tour the Advanced Engineered Wood Composites Center (AEWC) the Laboratory for Surface Science and Technology (LASST). Students also experienced the UM Physics department's 'Mainly Physics Road Show'.

Fellow Aaron Clark and Bucksport Middle School Teacher Jennifer Scala bring seventh-grades students on a field trip to UM to tour the Advanced Engineered Wood Composites Center (AEWC) the Laboratory for Surface Science and Technology (LASST), the UM Electrical & Computer Engineering (ECE) Department's Robotics Laboratory. Students also experienced the UM Physics department's 'Mainly Physics Road Show'.

Fellow Wade Pinkham assists Fellow Aaron Clark by providing a tour of the ECE robotics lab to Bucksport Middle School students.

Fellow Eeva Hedefine and Reeds-Brook Middle School teacher Georgiana Piete brought Piete's three sixth grade science classes (approximately 55 students) to UM to tour LASST, AEWC and the UM Spatial Information Science and Engineering Department.

The Bangor, ME OUI Incidents Map is presented to Bangor Deputy Police Chief Peter Arno by fellows Judith Walker and Eeva Hedefine, teachers Jim Smith and Margaret Chernosky, and students in Smith's Senior Seminar class and Chernosky's GIS club.

June 2006: Fellow Jesse Parks and participating teacher Theodore Taylor of Bangor High School organize Earth Science field trip to Acadia National Park.

Fellow Wade Parks attends Sebec Valley Middle School 8th grade graduation and presents an engineering award.

Continued interaction with Paul Klenk of Duke University concerning inclusion of GK-12 Sensors! modules in LearnEngineering.com library

Program Evaluator Brian Doore concludes spring evaluation activities for students, fellows, teachers.

2006-07 GK-12 Fellows present GK-12 related activities at 2006 RET-Sensors! Kick-Off Meeting/Orientation

Weekly meetings of GK-12 Fellows and 2006 RET participants, to share expertise, discuss pedagogies and classroom related strategies

Fellows submit new portable learning modules, to be included in online library.

Program coordinator submits 'Spring 2006 GK-12 Sensors! Fellows Journals' to PI and co-PIs for review

Fellow Janice Duy leaves the program to pursue an IGERT fellowship at UM. Fellows Eeva Hedefine and Judith Walker graduate and leave the program.

Two UM graduate students are awarded first-time GK-12 Sensors! Track II fellowships beginning July 1: Jason Bolton (Food Sciences & Human Nutrition) and Christie Mahaffey (Ocean Engineering).

Research and Education Activities:

2005 Summer Activities

In the summer of 2005, the University of Maine, with John Vetelino as PI and Constance Holden as Co-PI, conducted the second year of a three-year NSF grant, RET-Sensors (NSF-0401439). Five middle and five high school teachers from mostly rural areas were brought to UM and provided unique opportunities to be involved in research in sensor theory, design, fabrication, testing, and/or applications. Linkages to schools through the RET program enabled GK-12 Sensors! to expand into fifteen rural Maine high and middle schools: BHS, CoMS and DMS in Bangor, ME; BrHS and BrHM, in Brewer, ME; BuMS and BuHS, in Bucksport, ME; CMS, in Corinth, ME; CaMS, in Caravel, ME; HA, a high school, and RBMS, in Hampden, ME; HHS and HMS, in Hermon, ME; JBMHS in Bangor, ME; and SVMS, in Newport, ME. Teachers spent eight weeks becoming acquainted with cutting-edge sensor science and engineering through daily interactions with sensor faculty, senior researchers, graduate students, UM GK-12 Sensors! fellows, and Research Experience for Undergraduates (REU) students in the UM Laboratory for Surface Science & Technology (LASST). RETs were involved in research on biosensors, chemical sensors, and fluid-phase sensors.

Examples of RET research ranged from developing sensing systems for measuring motor oil degradation to detecting low levels of algae toxins and heavy metals in Maine lobsters.

In addition to working with a specific sensor research group, teachers became familiar with other state-of-the-art sensor-related science and technology facilities in the university and neighboring small sensor businesses. RETs also enrolled in ECE 465, an upper-level undergraduate course entitled Introduction to Sensors, which presented the theory and applications of various types of semiconductor, acoustic, magnetic, thermal and optical sensors, in order to give teachers a sound background in sensors. Teachers received academic and recertification credit for the course. The summer program concluded with the August Summer Workshop, during which the RETs shared their summer research experience in formal presentations and offered ideas for integrating sensor science and technology into their curricula. All successful 2005 RET participants became 2005-06 GK-12 Sensors! cooperating teachers, continuing working relationships established during the summer RET program with GK-12 fellows.

RET Sensors! established a formal bridge to GK-12 Sensors! and, as a result, a strong linkage between UM and participating secondary educational institutions. Furthermore, in school systems where GK-12 Sensors! had been established at the high or middle school level, the RET-Sensors! program has provided opportunity to extend its presence throughout grades 6-12 by offering fellowships to interested teachers in participating school systems. Expanding its presence from eleven to fifteen schools, nine of which are middle schools, GK-12 Sensors! anticipates achieving greater impact on student interest in pursuing careers in science and engineering. Introducing sixth, seventh and eighth graders to graduate researchers and engaging students in hands-on science and technology inquiries, and maintaining such exposure throughout high school, provides continuity of exposure throughout their secondary education.

'Introduction to GIS' Course at BHS

Bangor High School will implement a course embedding sensor science and engineering units into its 2005-06 curriculum. Piloted during the 2004-05 year, 'Introduction to GIS' is a hands-on, inquiry-based course being offered as part of the BHS advanced geography curriculum. First-year fellow Judith Walker and BHS teacher Margaret Cheronky, with input from teacher Jim Smith, designed the course. This course was in part developed in response to strongly positive feedback from students involved in other GIS-based inquiry-learning projects Walker

facilitated this fall and other fellows previously coordinated. The Bangor School Committee at its December 19, 2005 meeting unanimously voted to adopt 'Introduction to GIS' as a permanent curricular offering.

Bangor, Maine GIS Emergency Mapping Project and the Bangor, Maine GIS Emergency Map of Bangor International Airport

In addition to portable modules, fellows have been organizing community outreach programs, such as the 2005 Bangor, Maine GIS Emergency Map of Bangor International Airport (BIA). Fellows and BHS teachers and students presented the 2005 mapping project to the Bangor School Department and members of the Bangor City Council, Fire and Police departments, in May of 2005, three days before Bangor area emergency response teams tested the 2005 mapping project as part of its emergency preparedness test, a mock disaster at BIA. Because Bangor is willing to share its GIS equipment with our fellows, aspects of this project have been introduced to other school systems such as Caravel and Hampden at little or no cost.

Digital Community Atlas of the Historical Geographies of Bangor

A multi-class Global Information System (GIS) project was developed by fellow Brad Neumann with the History Department at BHS. The project, sponsored by Environmental Systems Research Institute, Inc. (ESRI), a world leader in GIS software development, involved creation of a digital community atlas of the historical geographies of Bangor. Known nationally as the Community Atlas Project, teachers and students were asked to define the nature of their community by creating maps, writing community descriptions, and compiling images to be combined in a visual presentation and posted on the Internet. The project involved four World Geography classes and two Civics classes, all at the first-year level and housed in the History Department. Students created their community atlas through the use of a Global Positioning System (GPS), GIS, basic html coding, digital cameras, scanners, and computer skills. As a result, they developed research skills, spatial skills, analytical skills, technological skills, and group work skills. The final product was presented to both the City of Bangor and the Bangor Historical Society as a display on the city's website, a digital PowerPoint presentation, and a physical poster presentation. ESRI awarded the GK-12 Sensors!-Bangor High School 2005 GIS project with recognition as the best national 2004-05 model GIS K-12 educational project (<http://www.esri.com/industries/k-12/atlas/model.html>).

Sam the Ram: Educating the Public About Evacuation Plans & Homeland Security Through Elementary Students

Working with the Bangor Fire Chief, GK-12 Sensors! Fellow Judith Walker and teacher Jim Smith of the Bangor High School (BHS) History department are coordinating an after-school Global Information Systems (GIS) mapping club program, three Senior Seminar classes (75 students) and three Computer Science classes (60 students) in designing portable presentations about emergency preparedness and homeland security. These presentations are given to classes of 2nd and 3rd graders in the Bangor area. Each lesson presents basic information on a topic (such as hurricanes) and incorporates emergency response information as well as descriptions of careers relating to the topics. Included in the description of the career is an example of a sensor encountered on-the-job. Each lesson is 'taught' by BHS mascot Sam the Ram, the Bangor High mascot.

Continued Module Development

On the basis of the success of portable module development in prior years, our 2005-06 fellows are each creating four new learning modules that can be easily transported, either in their entirety or partially, from school to school. Taking advantage of the Maine Teaching-Learning Initiative's PASCO probe sensor lending library, a wide range of hands-on sensor-based activities have been incorporated into some of the poorer schools in Maine. The State of Maine's so-called Laptop Initiative, which provides all 7th and 8th graders in the state with laptop computers, provides an additional resource for interfacing with PASCO-type sensors in module development.

Highlights: Integrating Sensors Into Secondary School Systems

Working with 2005 RET-Sensors participant (hereafter written 2005 RET) Jennifer Skala of BuMS 2004 RET John Mannette of Bucksport High School and other teachers, fellow Aaron Clark has implemented hands-on modules such as introducing the concept of sensors, measuring atmospheric pressure, making fruit batteries, sensing global warming, understanding wood composites. Using the middle school's climbing wall, he also helped start the Bucksport System Climbing Club in Fall 2005.

Fellow Lester French interacts with teachers at three rural schools, primarily 2005 RET Richard Burger of CaMS, 2004 RET Alan Tweedie of HMS and 2005 Joanna Lisker of HHS. At the middle schools, Les has introduced modules involving drinking water quality sensors, Global Positioning Systems, how sensors allow internet data storage such as photos from the International Space Station, and others. At the high school, Les has introduced hands-on activities involving quartz crystal microbalances to help teach concepts such as Newtonian and spring forces. Les also coordinated UM advanced research facilities tours for Caravel Middle School eighth graders.

Working with 2005 RET Marc O'Clair and former GK-12 Sensors! fellow Danielle Donovan of HA and 2004 RET Georgiana Piete of RBMS, fellow Eeva Hedefine has motivated discussions about sensors through hands-on activities involving Geographic Positioning Systems, online interaction with the International Space Station, force and motion sensors, spectrometers and spectroscopes, remote-sensing of black holes, and trips to the Challenger Learning Center (Bangor, ME). Eeva also works after-school with fellow Judith Walker, faculty and students at BHS on a GIS project for The City of Bangor.

Fellow Raymond Kennard has worked with 2005 RET Timothy Surette and 2004 RET Tracy Vassiliev at both CoMS and DMS, and the science faculty at John JBMHS, all located in Bangor, ME. He has introduced sensors into topics such as ink chromatography, spectrum analysis, the relation between the moon and the earth, monitoring solar activity. Sensors is the emphasis for the Spring 2006 DMS Student Invention Convention. Raymond is also working with staff at the Maine Discovery Museum (Bangor, ME) to develop permanent interactive exhibits relating to sensors, geared to ages 2-12.

Fellow Jesse Parks works with Physics teacher and 2005 RET Andrew Bouchard and Environmental Science teacher Theodore Taylor, also a 2005 RET, both of BHS. In physics classes, Jesse has incorporated sensor science and engineering into major modules in Energy and in Electronics. He has introduced sensors to Taylor's students through modules relating to plate tectonics, oceanography and meteorology.

Wade Pinkham engages 2005 RET Catherine Tilton-Davis's middle-school classrooms at CMS and 2005 RET Jane Stork's SVMS students. Starting from awareness exercises of human and everyday sensors, Wade has introduced students to sensors-related activities in techniques for biological sensing, velocity and acceleration, electricity, spectroscopy with diffraction gratings, hydro-fuel cells and Global Positioning Systems. Wade also coordinated a University of Maine advanced research facilities tour for Central Middle School eighth graders.

Judith Walker, who became a GK-12 Sensors! Fellow in July 2005, is engaged in a variety of sensor-related community-based projects with BHS students and faculty of the History Department. They have produced maps of both standard and hazardous-materials evacuation routes for Bangor; worked with Assistant Bangor Police Chief to use dispatch data in electronic format to geocode OUI data to alcohol providers; collaborated with the Bangor Historical Society to map the historical movement of area cemeteries, Jewish historical sites and Irish historical sites; used data provided by the Bangor Area Transport system to geocode Greater Bangor area public bus routes and census data. Walker also developed the classroom curriculum for a permanent BHS GIS course proposal that was adopted unanimously by the Bangor School Board in December 2005.

Findings: (See PDF version submitted by PI at the end of the report)

1. Crucial to the smooth integration of GK-12 Sensors! fellows into participating teacher classrooms is the preparation of teachers through participation in the RET program and the interaction of teachers and fellows during the summer, allowing them to establish working relationships and acquaint themselves thoroughly with each others' interests, styles, strengths and weaknesses. RET Sensors! serves as a formal bridge to GK-12 Sensors!, forming a strong linkage between UM and participating secondary educational institutions. Furthermore, in school systems where GK-12 Sensors! was established at one of the middle or high school levels, the RET-Sensors! program has provided opportunities to extend the GK-12 presence throughout the 6-12 school system by offering fellowships to interested teachers in participating school systems. Expanding its presence from eleven to fifteen schools, nine of which were middle schools (NOTE: 2005-06 has seen the program shift from a high school to a middle school emphasis), GK-12 Sensors! anticipates achieving greater impact on student interest in pursuing careers in science and engineering. Introducing sixth, seventh and eighth graders to graduate researchers and engaging students in hands-on science and technology inquiries, and maintaining such exposure throughout high school, provides continuity of exposure throughout their secondary education.
2. Both fellows and participating teachers have expressed interest of spending more time during the summer hiatus focusing on curricular preparation. The program is planning to provide periodic informal workshop events throughout the summer to address the need for more time and coordination for preparing fellows, especially new fellows. Teachers will have the opportunity to share in-class management skills and discuss teaching-learning styles. Advantages of this approach include producing teaching tools targeted to grade level and classroom, allowing fellows to develop strong sense of participating teachers' teaching styles, values and classroom management styles; generating a link strengthened by greater confidence of both fellows and teachers. The pedagogical objective is to establish clear understanding of roles, expectations, in-class instructional strategies, and role parity in order to foster strong collaboration throughout the academic year. The functional objective is to improve fellow-teacher preparation through efficient use of time and resources.
3. The introduction of GK-12 Sensors! into grades 6-8 has shown positive effects in terms of 9th grade student enthusiasm for both STEM subject matter and the presence of a GK-12 fellow in the 9th grade classroom. This enthusiasm provides support for the insistence on maintaining a GK-12 presence throughout middle and high schools in a single school system. It continues to be anticipated that a significant number of these students will go on to consider STEM career paths in high school and beyond. Anecdotal evidence from self-reported student

cases indicates a strong positive influence of GK-12 fellows on post-12 educational choices. Indeed, several post-12 students report having chosen to pursue STEM fields of study because of the presence of a GK-12 Sensors! fellow in the classroom. Middle-school teachers have reported very positively concerning student admiration of their fellows and have recounted stories of great student enthusiasm for activities-based STEM learning, especially on the days the fellow is expected in-class.

Thus crucial to achieving the GK-12 Sensors!'s main goal (namely to motivate students to follow careers in science and engineering, more generally in any STEM area) is the consistent presence of GK-12 Sensors! throughout a student's 6-12 education. Students need to be introduced to GK-12 Sensors! at the middle-school level, at the latest.

4. Evidence of the maturity of the linkage between UM and Bangor High School is given by 'Introduction to Global Information System (GIS),' a hands-on, inquiry-based course to be offered as part of the BHS advanced geography curriculum. This course embeds sensor science and engineering into each curricular unit. Piloted during the 2004-05 year, 'Introduction to GIS' was in part developed in response to strongly positive feedback from students involved in other GIS-based inquiry-learning projects facilitated this and previous academic years. The Bangor School Committee at its December 19, 2005 meeting unanimously voted to adopt 'Introduction to GIS' as a permanent curricular offering.

5. The perceived role of evaluation relative to program activities and administration has shifted significantly. In short, in order for the GK-12 Sensors! evaluation process to become successful, it should not be viewed as a static semi-autonomous entity that judges program impact and effectiveness, but instead should be viewed as a tool for reflection and communication that evolves with the program. The following description provides background, context and shows the intellectual shift that has occurred.

At the time when the GK-12 Sensors! was proposed, the perceived need for program evaluation was for quantitative program impact/outcomes reporting to GK-12 and NSF program officers and the U.S. Congress. However, no explicit impact or outcomes expectations or criteria had been established by NSF, and the importance of adequate evaluation became more strongly emphasized (and the emphasis on evaluation continues to strengthen) between the time of proposal submission and its award. Thus, a concern for GK-12 Sensors! management was obtaining assurance from program evaluators that the proposed evaluation scheme would be deemed adequate by federal reviewers. The tensions that resulted from the conflicting needs involved in meeting (1) agreed-to scope-of-work and (2) the shifting significance of program evaluation, limited first and second year efforts to equilibrate the evaluation component.

Whereas initial Track I efforts to devise evaluation plans focused on determining content of evaluation processes, little or no attention was paid to the actual administration of evaluation instruments. It was, rather, a black-box assumption that evaluations would be performed independent of and concurrent with other program activities. This in practice proved infeasible during the first year of Track I and the proposed second year solution, which involved fellows in a time-intensive, rigid, ongoing program of frequent in-class pre- and post-evaluations, periodic student attitudinal evaluations throughout the year, fellows and teachers surveys and interviews, proved overambitious at all administrative levels, which is partially reflected in the underdeveloped second-year program report.

The problems raised by the implementation failures of the initial modest evaluation plan and the succeeding year's overly ambitious plan pointed to the need for a fundamental shift in the perception of the role of program evaluation within GK-12 Sensors!. How that shifted perception should be constituted has taken a year-and-a-half worth's sustained study and dialogue with professional evaluators and colleagues at other GK-12 programs to articulate. Part of that articulation has involved a modular implementation process for building a workable, sustainable evaluation plan, one that is currently operational in its initial phases, with a plan for additional implementations over the next year.

Key to reconceptualizing the role of program evaluation was the idea of using program evaluation as an internal tool providing near-real-time feedback mechanism for program administrators. The evaluation program monitors and measures program effectiveness as a means for communicating areas in need of change/improvement. This strategy of using evaluations as an internal communications tool instead of an external reporting mechanism only took root during the third year of Track I.

A concerted effort on the part of the GK-12 Sensors! program administrators (PI, co-PIs and program coordinator) working with the Center for Research and Evaluation of the Maine Education Policy Research Institute, an agency external to the UM but housed on the campus, has over the last two years generated an evaluation program (one that now subsumes the Track II evaluation plan as a proper subcomponent) that repurposes the formal reporting requirement of evaluations as a communications tool facilitating open, frank and safe feedback to program management from fellows, teachers, administrators and community partners, grades 6-12 students, faculty advisors and other academic participants. Positioning evaluation instruments in this light has resulted in greater, more enthusiastic participation at all levels as well as more openness to bringing evaluation instruments into participating classrooms.

2005-06 evaluation report attached. (A report of all Track I, including extension Year 4, evaluation activities is in review and will be submitted to the GK-12 Sensors! Director before December 1, 2006.)

Training and Development:

2005 RET-GK-12 Interface

In the summer of 2005, ten teachers were brought to UM by the RET-Sensors program. As was the case with the RET's during previous summers, these teachers were paired with UM faculty members and worked closely with participants in the GK-12 Program. By bringing these teachers to UM, we have realized a significant increase in the number of schools we have influenced in Central and Northern Maine.

2005 Summer Workshop

In August of 2005, GK-12 Fellows, teachers from BHS, BrHS, BuHS, BuMS, CMS, CHS, CoMS, DMS, HA, HMS, HHS, JBHS, RBMS, and SVMS, and faculty members from UM met at UM for a two-day workshop to report on summer 2005 research activities and formalize GK-12 Sensors! activities for the 2005-2006 academic year. The workshop began with ten 2005 RET presentations of summer research. Participating teachers from the first three years of the program spoke to the challenges and accomplishments of the program. On the second day of the workshop, Dr. Vetelino established participant workgroups composed of participating RETS and other participating teachers from a single school system, along with the GK-12 fellow(s) assigned to that system, to plan schedules and modules for the 2005-2006 academic year.

Future Training

ò Summer 2006 RET program

ò REU-Sensors! site

During the spring of 2005, Dr. John F. Vetelino received a REU site grant from the National Science Foundation. As a result, during the summer of 2005 and for each of the next two summers, 17 undergraduates will be brought to UM by the REU program.

ò 'Introduction to GIS' at BHS

This permanent inclusion in the BHS curriculum will begin academic year 2006-07.

Outreach Activities:

Conferences:

PI John Vetelino, evaluator Brian Doore and program coordinator Joe Arsenault presented a poster presentation entitled 'NSF GK-12 Sensors!' GK-12 National Meeting, March 24-26, 2006, in Washington, DC.

Fellow RET and GK-12 cooperating teacher Jane Stork of SVMS, assisted by GK-12 Fellow Wade Pinkham, presented RET-GK-12 Sensors! sensor integration activities at the Association of Teachers of Mathematics in Maine (ATOMIM) Spring 2006 meeting, March 25, 2006, Portland, ME.

Fellow Lester French provides overview of GK-12 Sensors! program at presentation given at the 'TWENTY-SIXTH STATE-WIDE MEETING OF HIGH SCHOOL PHYSICS AND PHYSICAL SCIENCE TEACHERS,' March 17, 2006, Orono, ME

PI John Vetelino presented a paper entitled 'Integration of Sensors into Secondary School Classrooms,' IEEE Frontiers in Education Conference, Oct. 19-22, 2005, Indianapolis, IN.

PI John Vetelino gave featured session talk at Pan-REU Conference, Arlington, VA. emphasizing integrative REU-GK-12-RET model. Project coordinator Joe Arsenault assisted with presentation.

Participating teacher Tracy Vassiliev presented a paper entitled 'Effects of Heavy Metals on Lobsters' at the 97th Annual Meeting of the National Shellfisheries Association, April 10-14, in Philadelphia, PA.

Fellows Brad Neumann and Eeve Hedefine, in collaboration with BHS teacher Jim Smith, presented a paper on their GK-12 Sensors! activities entitled 'Applying GIS Technologies to Enhance Emergency Response' at the National Science Teacher Convention (NSTA), March 31-April 3, 2005, in Dallas, TX,.

Participating teacher Patricia Bernhardt presented a paper entitled 'GK-12 Sensors!-related integration of RET research into middle-school classrooms' at NSTA, March 31-April 3, 2005, in Dallas, TX.

Journal Publications

- Carr, Crystal; Grant, Elaine; Puckett, Anthony, "Matrices and Digital Pictures", The Mathematics Teacher, p. , vol. , (). Submitted
- French, Lester; Koch, Helmut, "A Sensor Design Project For High School Chemistry Classes", The Journal of Science Education, p. , vol. , (). Submitted
- Lampron, Kenna; Hedlund, Wes, "The pH Sensor Lab", The Science Teacher, p. , vol. , (). Submitted
- James, Cary; Martin, Andrea, "Air Quality Projects In a High School Chemistry Curriculum", The Journal of Chemical Education, p. , vol. , (). Submitted
- Hedefine, Eeve; Neumann, Brad; Smith, Jim, "The Bangor, Maine GIS Emergency Mapping Project", The Science Teacher, p. , vol. , (). Submitted
- Chenosky, Margaret; Donovan, Danielle; Pitcher, Stephanie, "Using Satellite Remote Sensing to Investigate the 5 Themes of Geography", The Journal of Geography, p. , vol. , (). Submitted
- Burgess, Scott; Burkenpass, Eric; Lewark, Michael; Thiele, Jeremy, "Electronics Applied: The Light Sensor", The Physics Teacher, p. , vol. , (). Submitted
- Crowley, Adam, "It's All About CHOICES", Communique, p. 7, vol. , (2004). Published
- Hale, Sandra, "GK-12 Sensors! Partnership Opens Doors", Communique, p. 1, vol. , (2002). Published
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- Clark, A., Donovan, D., et al., "Spring 2004-2005 GK-12 Sensors! Fellow Journals, May 2005", (2005). Report, On record; available on demand
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- J. Arsenault, S. Godsoe, C. Holden, J. Vetelino, "GK-12 Sensors 2004-2005 Annual Report to NSF", (2005). Report, Submitted
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Collection: Proceedings: Frontiers in Education 36th Annual Conference
Bibliography: Arsenault, J., C. Holden, S. Godsoe, J. Vetelino. "Work in Progress--Integration of Sensors into Middle School Classrooms," Proceedings: Frontiers in Education 36th Annual Conferen

Web/Internet Site

URL(s):

<http://www.eece.maine.edu/research/gk12/>

Description:

This site contains information on current activities, fellows and modules.

Other Specific Products

Product Type:

Web page

Product Description:

A catalogue of current portable modules can be found at the following address:

<http://www.eece.maine.edu/research/gk12/portablemodule.htm>

Sharing Information:

This product will be shared over the internet. GK-12 Sensors is also collaborating with Dr. Gary Ybarra and Dr. Paul Klenk of Duke University to incorporate the GK-12 module library into their online resource TeachEngineering.com.

Contributions

Contributions within Discipline:

The principal disciplinary field of the project is sensors education. GK-12 Sensors! has developed and extended this field in the 6-12 environment through the ongoing development of portable modules, many currently available on our website. GK-12 Sensors is also collaborating with Dr. Gary Ybarra and Dr. Paul Klenk of Duke University to incorporate the GK-12 module library into their online resource 'TeachEngineering.com.' Indications of program success are described in 'Introduction of Sensors in Secondary School Classrooms,' which will be published in Proceedings of the 2005 IEEE Frontiers in Education Conference. (The document is attached to this report as an appendix.)

GK-12 Fellows Contributions:

Bangor High School will implement a course embedding sensor science and engineering units into its 2005-06 curriculum. Piloted during the 2004-05 year, 'Introduction to GIS' is a hands-on, inquiry-based course being offered as part of the BHS advanced geography curriculum. First-year fellow Judith Walker worked with BHS faculty to design the course, which was in part developed in response to strongly positive feedback from students involved in other GIS-based inquiry-learning projects Walker facilitated this fall and other fellows previously coordinated. The Bangor School Committee at its December 19, 2005 meeting unanimously voted to adopt 'Introduction to GIS' as a permanent curricular offering.

In addition to portable modules, fellows have been organizing community outreach programs, such as the 2005 Bangor, Maine GIS Emergency Map of Bangor International Airport (BIA). Fellows Eeva Hedefine, Brad Neumann and BHS teachers and students presented the 2005 mapping project to the Bangor School Department and members of the Bangor City Council, Fire and Police departments, in May of 2005, three days before Bangor area emergency response teams tested the 2005 mapping project as part of its emergency preparedness test, a mock disaster at BIA. Because Bangor is willing to share its GIS equipment with our fellows, aspects of this project have been introduced to other school systems such as Caravel and Hampden at little or no cost.

A multi-class Global Information System (GIS) project was developed by fellow Brad Neumann with the History Department at BHS, also in the spring of 2005. The project, sponsored by Environmental Systems Research Institute, Inc. (ESRI), a world leader in GIS software development, involved creation of a digital community atlas of the historical geographies of Bangor. Known nationally as the Community Atlas Project, teachers and students were asked to define the nature of their community by creating maps, writing community descriptions, and compiling images to be combined in a visual presentation and posted on the Internet. The project involved four World Geography classes and two Civics classes, all at the first-year level and housed in the History Department. Students created their community atlas through the use of a Global Positioning System (GPS), GIS, basic html coding, digital cameras, scanners, and computer skills. As a result, they developed research skills, spatial skills, analytical skills, technological skills, and group work skills. The final product was presented to both the City of Bangor and the Bangor Historical Society as a display on the city's website, a digital PowerPoint presentation, and a physical poster presentation. ESRI awarded the GK-12 Sensors!-Bangor High School 2005 GIS project with recognition as the best national 2004-05 model GIS K-12 educational project (<http://www.esri.com/industries/k-12/atlas/model.html>).

Working with the Bangor Fire Chief, GK-12 Sensors! Fellow Judith Walker and teacher Jim Smith of the Bangor High School (BHS) History department are coordinating an after-school Global Information Systems (GIS) mapping club program, three Senior Seminar classes (75 students) and three Computer Science classes (60 students) in designing portable presentations about emergency preparedness and homeland security. These presentations are given to classes of 2nd and 3rd graders in the Bangor area. Each lesson presents basic information on a topic (such as hurricanes) and incorporates emergency response information as well as descriptions of careers relating to the topics. Included in the description of the career is an example of a sensor encountered on-the-job. Each lesson is 'taught' by BHS mascot Sam the Ram, the Bangor High mascot.

On the basis of the success of portable module development in prior years, our 2005-06 fellows are each creating four new learning modules that can be easily transported, either in their entirety or partially, from school to school. Taking advantage of the Maine Teaching-Learning Initiative's PASCO probe sensor lending library, a wide range of hands-on sensor-based activities have been incorporated into some of the poorer schools in Maine. The State of Maine's so-called Laptop Initiative, which provides all 7th and 8th graders in the state with laptop computers, provides an additional resource for interfacing with PASCO-type sensors in module development.

Working with 2005 RET-Sensors participant (hereafter written 2005 RET) Jennifer Skala of BuMS 2004 RET John Mannelle of Bucksport High School and other teachers, fellow Aaron Clark has implemented hands-on modules such as introducing the concept of sensors, measuring

atmospheric pressure, making fruit batteries, sensing global warming, understanding wood composites. Using the middle school's climbing wall, he also helped start the Bucksport System Climbing Club in Fall 2005.

Janice Duy began her GK-12 Sensors! fellowship in February 2006. She has worked with fellow Lester French, who introduced her to program activities in three schools, CaMAs, HMS and HHS. Janice has focused her interactions at HMS, working with 2004 RET Alan Tweedie. She has introduced a variety of sensor concepts and hands-on exercises relating to aspects of her research.

Fellow Lester French interacts with teachers at three rural schools, primarily 2005 RET Richard Burger of CaMS, 2004 RET Alan Tweedie of HMS and 2005 Joanna Lisker of HHS. At the middle schools, Les has introduced modules involving drinking water quality sensors, Global Positioning Systems, how sensors allow internet data storage such as photos from the International Space Station, and others. At the high school, Les has introduced hands-on activities involving quartz crystal microbalances to help teach concepts such as Newtonian and spring forces. Les also coordinated UM advanced research facilities tours for Caravel Middle School eighth graders.

Working with 2005 RET Marc O'Clair and former GK-12 Sensors! fellow Danielle Donovan of HA and 2004 RET Georgiana Piete of RBMS, fellow Eeva Hedefine has motivated discussions about sensors through hands-on activities involving Geographic Positioning Systems, online interaction with the International Space Station, force and motion sensors, spectrometers and spectrometers, remote-sensing of black holes, and trips to the Challenger Learning Center (Bangor, ME). Eeva also works after-school with fellow Judith Walker, faculty and students at BHS on a GIS project for The City of Bangor.

Fellow Raymond Kennard has worked with 2005 RET Timothy Surette and 2004 RET Tracy Vassiliev at both CoMS and DMS, and the science faculty at John JBMHS, all located in Bangor, ME. He has introduced sensors into topics such as ink chromatography, spectrum analysis, the relation between the moon and the earth, monitoring solar activity. Sensors is the emphasis for the Spring 2006 DMS Student Invention Convention. Raymond is also working with staff at the Maine Discovery Museum (Bangor, ME) to develop permanent interactive exhibits relating to sensors, geared to ages 2-12.

Edwin Nagy began his GK-12 Sensors! fellowship in February 2006. Working with 2004 RET Arthur Libby and other faculty at BrHS and BrMs, Edwin has integrated sensing systems into hands-on exercises modeling human physiological systems, using these exercises as examples of the kinds of research he performs as a civil engineering graduate student. Edwin has also shared aspects of his research through presentations describing his work with the Peace Corps in Niger, West Africa, which he has used to motivate a sensor-based module consisting of a series of hands-on activities involving woodless construction.

Fellow Jesse Parks works with Physics teacher and 2005 RET Andrew Bouchard and Environmental Science teacher Theodore Taylor, also a 2005 RET, both of BHS. In physics classes, Jesse has incorporated sensor science and engineering into major modules in Energy and in Electronics. He has introduced sensors to Taylor's students through modules relating to plate tectonics, oceanography and meteorology.

Wade Pinkham engages 2005 RET Catherine Tilton-Davis's middle-school classrooms at CMS and 2005 RET Jane Stork's SVMS students. Starting from awareness exercises of human and everyday sensors, Wade has introduced students to sensors-related activities in techniques for biological sensing, velocity and acceleration, electricity, spectroscopy with diffraction gratings, hydro-fuel cells and Global Positioning Systems. Wade also coordinated a University of Maine advanced research facilities tour for Central Middle School eighth graders.

Ali Shareef began his GK-12 Sensors! fellowship in February 2006. He has worked with Jesse Parks to develop an electronics module for 2005 RET Andrew Bouchard's BHS physics classes. Ali works primarily with BHS participating teacher Don Erb, introducing students to both computing and electronics concepts through presentations and hands-on immersive exercises.

Judith Walker, who became a GK-12 Sensors! Fellow in July 2005, is engaged in a variety of sensor-related community-based projects with BHS students and faculty of the History Department. They have produced maps of both standard and hazardous-materials evacuation routes for Bangor; worked with Assistant Bangor Police Chief to use dispatch data in electronic format to geocode OUI data to alcohol providers; collaborated with the Bangor Historical Society to map the historical movement of area cemeteries, Jewish historical sites and Irish historical sites; used data provided by the Bangor Area Transport system to geocode Greater Bangor area public bus routes and census data. Walker also developed the classroom curriculum for a permanent BHS GIS course proposal that was adopted unanimously by the Bangor School Board in December 2005.

Contributions to Other Disciplines:

During the 2005-06 academic year, GK-12 Sensors! expanded its involvement in ninth and tenth grade Civics, History and World Geography classes; assisted in the curricular design of a new high-school level sensors-based course; engaged Social Studies classes at the sixth-eighth grade levels in participating middle schools.

Contributions to Human Resource Development:

The major goals of the project are achieved by using sensors as the vehicle to encourage students to pursue science and engineering careers. To this end the fellows act as role models as well as teachers. Emphasis toward encouraging underrepresented groups in science and technology, including females, minorities and disabled students is important to each teacher, faculty member and fellow working in the GK-12 Sensors! Program. It is anticipated that this program will significantly increase the number of high school students in Maine who will be choosing future careers in science and engineering.

Bangor School Committee adoption of a permanent course teaching Geographic Information Systems (GIS) at BHS has established a permanent footprint of GK-12, both in the school and the surrounding community. The knowledge of participating high school teachers and students has produced an ongoing working relationship between the Bangor school system and the police and fire departments of the City of Bangor. GIS-based community projects over the past three years have given GK-12 fellows the opportunity to introduce fire, police and other city officials to GIS technology, enhancing their understanding of the technology and showing them what GIS can do for the city, including improvements to emergency response and homeland security. Learning more about the power and capabilities of GIS has drawn them to large-scale implementation of these technologies for the improvement of the community. The high-school students working on projects are introduced to both GIS technology and civic engagement, encouraging some to continue involvement in community service. These projects gave students hands-on experience using GIS technology, providing them with new technical skills. Bangor city officials now view the civic contributions of participating students and teachers as an essential aspect of the City's ability to incorporate and maintain GIS technologies for security and other municipal purposes. Furthermore, the city is actively exploring ways to provide additional GIS-based resources to the high school in exchange for its ongoing efforts.

Teachings of Geographic Information Systems (GIS) at Bangor High School have increased the knowledge of participating high school teachers and helped to establish a working relationship between the Bangor school system and the police and fire departments of the City of Bangor.

In particular, through the Bangor, Maine Emergency Mapping GIS Project, GK-12 fellows introduced fire, police and other city officials to GIS technology, enhancing their understanding of the technology and showing them what GIS can do for the city, including improvements to emergency response and homeland security. Learning more about the power and capabilities of GIS has drawn them closer towards larger-scale implementation of these technologies for the improvement of the community. Working with high-school students on the project also helped introduce students to GIS technology and involved them in a community-based project. This may encourage them to continue involvement in community service. The project gave students hands-on experience using GIS technology, providing them with new technical skills.

Contributions to Resources for Research and Education:

Fellows, working with teachers at all schools we interact with, continue to develop portable sensor modules for dissemination to other schools.

GK-12 Sensors is collaborating with Gary Ybarra and Paul Klenk of Duke University to incorporate the GK-12 module library into their online engineering learning resource 'TeachEngineering.com.'

Sensor research is an interdisciplinary field with applications in all areas of science and mathematics. The students are introduced to the scientific approach to problem solving and invention.

Students in science and social studies courses to use laboratory sensors employing principles involved in the most advanced technology systems.

Development of community-based GIS projects with BHS students has encouraged the City to fund creation GIS lab at BHS.

Development of community-based GIS projects with BHS students prompted the Bangor School Board in December 2005 to unanimously adopt a proposal for a permanent BHS GIS course (the curriculum was co-designed by GK-12 fellow Judith Walker).

Fellow and participating teacher presentations of GK-12 Sensors!-related educational activities at the National Science Teachers Association Convention (March 31-April 3, Dallas, TX) provided opportunities to disseminate resources to educators from throughout the U.S., exhibiting concrete models for implementing sensors into middle- and high-school curricula.

The facilities at the Laboratory of Surface Science and Technology (LASST) are available for research opportunities. Group and individual visits to LASST have enhanced the GK-12 Sensors! classroom experience.

Contributions Beyond Science and Engineering:

Teachings about GIS and focus on community-based projects have provided the City of Bangor with emergency response-related spatial information, maps of both standard and hazardous-materials evacuation routes for Bangor, maps geocoding Greater Bangor area public bus routes and census data, geocoding OUI data to alcohol providers, maps of various historical geographies such as Jewish historical sites and Irish historical sites. These maps make possible unprecedented avenues for facilitating city planning, analysis of city resources and marketing.

GK-12 fellows have introduced fire, police and other city officials to GIS technology, enhancing their understanding of the technology and showing them what GIS can do for the city, especially improvements to emergency response and homeland security. Learning more about the power and capabilities of GIS has drawn Bangor closer towards large-scale implementation of these technologies for the improvement of the community. Working with high-school students on these projects also introduces students to GIS technology and involves them in a community-based project. This may encourage them to continue involvement in community service.

Recognizing the significance of these activities, the Bangor School Board in December 2005 unanimously adopted a permanent BHS GIS course into its high school curriculum.

GK-12 fellows involved themselves in a variety of extracurricular activities, including assisting organize an engineering technical society for BHS 11th graders, a TEAMS (Tests of Engineering Aptitude, Mathematics and Science) competition for BHS students, establishing a ham radio club at BHS, participation in BHS, DMS and CoMS science fairs as organizers and/or judges, serving as a mentor and organizer for a rock-wall climbing club at BuMS, assisting coaching the BuHS track team, co-organizing tours of university high-technology laboratories.

Categories for which nothing is reported:

Annual Report for Period:05/2002 - 05/2003

Submitted on: 12/20/2002

Principal Investigator: Vetelino, John F.

Award ID: 0139324

Organization: University of Maine

Title:

GK-12: Sensors!

Project Participants

Senior Personnel

Name: Vetelino, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Vetelino was born in Westerly R.I. He received the B.S., M.S., and Ph.D. in electrical engineering from the University of Rhode Island in 1964, 1966, and 1969, respectively. He was one of the founding members of the Laboratory for Surface Science and Technology at the University of Maine and is currently leader of the solid state research group. Three sensor companies û the BIODÉ Corp. in Westbrok, ME, Microsensor Conversion Technology in Brookings, SD, and Sensor Research and Development Corp. in Orono, ME û have been incubated from his research group.

Dr. Vetelino's research in acoustic wave and metal oxide sensors served as the motivation for the GK-12 Sensors program. He previously served on many NSF Science Education Review panels for NSF Undergraduate Research Participation (URP), NSF Local Course Improvement (LOCI), NSF Student Science Training (SST), NSF instructional Scientific Equipment Program (ISEP) and NSF Small Business Innovation Research grants (SBIR) proposals. He also served in many NSF workshops and various panels relating to research addressing national needs.

Name: Godsoe, Stephen

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephen Godsoe is from Bangor, Maine and has 36 years of high school teaching experience with at least one class of the most able students each year. Mr. Godsoe was the K-12 Mathematics Coordinator in Bangor from 1975-1983 and 1989-1991 and has served on several State committees to establish mathematics standards. He has taught all levels of high school mathematics, statistics, and computer science. His team of Bangor High students was twenty-third and thirty-sixth in the country in the Math League and the American High School Math exam. He was one of twenty-eight teachers in the US to receive the Edith May Sliffe award in 2001. Since 1994, Mr. Godsoe has taught Teaching K-8 Mathematics at the University of Maine also.

As Co-P.I. for GK-12 Sensors, Mr. Godsoe is an active a team member in the classroom helping GK-12 fellows, directs the program's collaboration with the state and city agencies, and works to support the program with new initiatives.

Name: Holden, Constance

Worked for more than 160 Hours: Yes

Contribution to Project:

Constance Holden is from Orono, Maine and has taught at Orono High School, University College of Bangor, and the University of Maine. She has supervised student teachers, helped to develop the curriculum on workshops for secondary school teachers, and authored publications for professional journals related to teaching science and engineering. She received an Ed D in Science Education in 1979 from the University of Maine.

As Co-P.I. for GK-12 Sensors, Dr. Holden brings her teaching experience to the task of supporting and training the GK-12 fellows. She teaches Spatial Science and Technology Information at the University of Maine, as well as meeting with the fellows on a one-to-one basis, interacting with civic leaders, developing GIS programs for BHS courses, and helping to administer the program.

Post-doc

Graduate Student

Undergraduate Student

Technician, Programmer**Other Participant****Research Experience for Undergraduates****Organizational Partners****Other Collaborators or Contacts**

COLLABORATORS

University of Maine Collaboration:

Dr. Peter Hoff, President of the University of Maine

Dr. Robert Ladd, Director of the Laboratory for Surface Science and Technology (LASST) and Professor of Physics

Dr. Brian Fredrick, Assistant Professor of Chemistry, LASST

Dr. Carl Tripp, Associate Professor of Chemistry, LASST

Dr. Mauricio DeCunha, Assistant Professor, Electrical and Computer Engineering, LASST

Dr. Bruce Segee, Associate Professor, Electrical and Computer Engineering

Dr. Paul Millard, Assistant Professor, LASST

Dr. Alfred Bushway, Professor of Food Science

Dr. Rodney Bushway, Chair and Professor of Food Science

Dr. William Desisto, Assistant Professor, Chemical Engineering, LASST

Dr. Mary Kate Bread-Tisdale, Chair and Professor of Spatial Science and Information Technology

Mr. Charles Morris, Senior Research Associate, Margaret Chase Smith Center for Public Policy, Evaluator for the GK-12 Sensors Program

GK-12 Sensors August 2002 Workshop Participants @ University of Maine

Brittelli, Mark Bangor H. S. Teacher Math

Craig, Patricia Bangor H. S. Teacher Math

Erb, Don Bangor H. S. Teacher Math

Grant, Elaine Bangor H. S. Teacher Math

Hamlin, Michael Bangor H. S. Teacher Math

Hedlund, Wes Bangor H. S. Teacher Biology

James, Cary Bangor H. S. Teacher Chem.

Koch, Helmut Bangor H. S. Teacher Chem.

Krupke, Irv Bangor H. S. Teacher Technology Edu.

Lord, Stevie Bangor H. S. Teacher Computer Sci.

O'Connell, M. Bangor H. S. Teacher Biology

Pratt, Ken Bangor H. S. Teacher Electronic, Mat. Sci.

Smith, Jim Bangor H. S. Teacher Math

Stubbs, John Bangor H. S. Teacher Math

Miller, Joanne Bangor H. S. Teacher Chemistry

Peterson, Mick Univ. Maine Faculty Mech. Eng.

Vetelino, John P.I. UMaine Faculty EECE

Godsoe, Stephen Dept. Head BHS, Co P.I. Math

Holden, Constance UMaine Faculty, Co P.I. Spatial Info Sci & Tech

Burgess, Scott John Bapst H.S., Teacher Science and Edu.

Berkenpass, Eric Grad Fellow EECE

Donovan, Danielle Grad Fellow Spatial Info Sci & Tech

French, Lester Grad Fellow EECE

Heddefine, Eeva Grad Fellow Spatial Info Sci & Tech

Krassikoff, John Grad Fellow Physics, Surface Sci & Tech

Martin, Andrea Grad Fellow Chemistry

Pitcher, Stephanie Grad Fellow EECE

Puckett, Anthony Grad Fellow Mech. Eng.
 Woodward, Becky Grad Fellow Mech. Eng.
 Hale, Sandra N. Project Coordinator Tech. Communications
 Thurlow, Jason Undergrad EECE
 Morris, Charles Evaluator Margaret Chase Smith Center for Public Policy

Community and State Collaboration:

Dr. Robert Ervin, Superintendent of Schools, Bangor
 Mr. Norris Nickerson, Principal, Bangor High School
 Peter Arno, Assistant Police Chief, Bangor
 Jeff Cammack, Fire Chief, Bangor
 Stan Moses, Community Development
 Paul Nichols, DEP for the state of Maine
 Mark Whiting, DEP (water quality),
 Bob Goodwin, Department of Marine Resources,
 Susan Morse, Bangor Area Comprehensive Transportation System (BACTS)
 Ken Beland, Atlantic Salmon Commission, state of Maine
 Dave Gould, Bangor Planning,
 John Murphy, City Engineering
 Rebecca Hupp, Bangor International Airport Director
 Jim Ring, City Engineer, Bangor
 Don Winslow, Police Chief, Bangor
 Rod McKay, Community Development, Bangor
 Rob Kenerson, Bangor Area Comprehensive Transportation System, BACTS
 Anne Hartmann, Discovery Museum, Bangor

Collaboration with Bangor High School and John Bapst Memorial High School includes the teachers who are listed in the Workshop Participants section above.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

GK-12 SENSORS! ACTIVITIES 2002

The GK-12 Sensors! Program is focused on bringing cutting-edge research in sensors to high school students in Maine in the anticipation of increasing the number of students pursuing a career in which science and engineering play a critical role. This project is a collaboration between the faculty of Bangor High School in Bangor, Maine and the University of Maine's interdisciplinary team of engineers and scientists working in sensors. The GK-12 Sensors! Program has also been extended to John Bapst Memorial High School in Bangor, as of December 2002. The goal is to use these high schools as models and to extend the program to other Maine high schools.

The key to implementing the program is cooperation at all levels of teaching. Currently one undergraduate and ten graduate fellows are teamed with Bangor High School faculty members to give the high school students opportunities to learn about sensors and their applications while studying math, biology, social science, electronics, computer science, chemistry, and electronics. The GK-12 Sensors! Program is a school-wide initiative at Bangor High School with all students encouraged to join in.

Accomplishments to date include: selection of eleven graduate fellows who have a strong interest in teaching; establishment of a link to the community and schools; fellows' completion of a comprehensive graduate course, Introduction of Sensors; a successful GK-12 Sensors Workshop for high school teachers, fellows, and university faculty; the development of 70 specific teaching modules created by teachers and fellows at the workshop; the creation of the teaching teams for Bangor High School; introduction of the fellows into the high school environment; and the implementation of teaching modules in high school courses.

Goals of Gk-12 Sensors! Program

 To use sensors as the vehicle to expose high school students to the areas of science and engineering.

 To encourage young people, particularly women, minorities and economically disadvantaged students in Maine, to pursue a career in science and engineering.

 To provide classroom teaching experience to graduate and undergraduate fellows in order to motivate them to choose an academic career.

 To improve the economic conditions in Maine and other states by increasing the number of people trained in science and engineering in order to satisfy the needs of present and future high technology industries.

The major goals of the project are achieved by using sensors as the vehicle to encourage students to pursue science and engineering careers. To this end the fellows act as role models, as well as teachers. Emphasis toward encouraging underrepresented groups in science and technology, including females, minorities and disabled students is important to each teacher, faculty member and fellow working in the GK-12 Sensors! Program. It is anticipated that this program will significantly increase the number of high school students in Maine who will be choosing future careers in science and engineering.

INTRODUCTION TO SENSORS

June 28 û August 19 2002

In the summer of 2002, 12 GK-12 fellows took a graduate-level 3-credit course entitled, Introduction to Sensors, ECE 465. The course, taught by Dr. John Vetelino, met each day for 8 weeks and covered theory and applications of sensors. The course gave the students a shared understanding of sensor technology in fields such as piezoelectric sensors, electrochemical sensors, and fiber optic sensors. At the end of the course, the students presented their ideas for teaching sensors in the high school.

OVERVIEW OF THE AUGUST WORKSHOP

August 12 û 15, 2002

The 2002 GK-12 Sensor Workshop at the University of Maine brought together 35 participants to create a plan to integrate the GK-12 fellows into the curriculum of Bangor High School. During the week-long workshop over 70 specific teaching modules were created in small groups.

Stephen Godsoe, Co-P.I. for the project, emphasized the interest within the city of Bangor to use the skills of the students to monitor noise, water quality, air, etc. The city is also interested in future help with security and logistical issues in the police department, fire department, airport and public works. In addition, state agencies such as Maine's Department of Environmental Protection and Maine Atlantic Salmon Commission are interested in the program.

One of the outcomes of the classroom discussions was that the fellows should be paired with one faculty member so they have someone on campus to go to for advice and information. The environment will be a team teaching environment with the fellows and teachers working together. The final day of the workshop included the formation of five BHS faculty-led groups to integrate the fellows into the school curricula for the coming year.

BANGOR HIGH SCHOOL INITIATIVE

September 4 û December 31, 2002

This fall, the teaching teams, formed during the August Workshop, took the program to the students, and GK-12 Sensors! became a school-wide initiative. The key to implementing the program has been cooperation at all levels of teaching and administration. GK-12 fellows with multidisciplinary experiences are now teamed with over twenty Bangor High School faculty members to give the high school students opportunities to learn about sensors while studying math, biology, social science, electronics, computer science, chemistry, and automotive technology.

Hands-on projects for high school students include using sensors to determine water and air quality, test security in transportation, test food and plant safety, analyze biological and wildlife data, and monitor sound and light pollution. Teaching modules are also designed to create school-wide debates on public issues, such as sensor technology versus privacy. Bangor High School is the pilot school for the program providing on-site teaching for new sensor modules. The objective is to use this 3-year project as a model to create similar programs in high

schools throughout the state.

JOHN BAPST MEMORIAL HIGH SCHOOL INITIATIVE December 2002

GK-12 Sensors! has been extended to John Bapst Memorial High School in Bangor, as of December 2002. John Krassikoff, a GK-12 fellow is working with Scott Burgess, physics teacher. Mr. Burgess attended the course, 'Introduction to Sensors' with the fellows this summer, developed a series of teaching modules based on sensors, and participated in the GK-12 August Workshop. This led to the implementation of GK-12 Sensors! at John Bapst Memorial High School.

Findings: (See PDF version submitted by PI at the end of the report)

FINDINGS FOR GK-12 SENSORS! 2002

The GK-12 Sensors! Program is on target. We have reached all the major Benchmarks established at the beginning of the year. They are listed below:

BENCHMARKS 2002

September 2001 Submission of the GK-12 Sensors! Proposal to NSF

February 2002 The GK-12 Sensors Program is funded by NSF.
Applications of GK-12 Fellows were solicited.

May 2002 Twelve GK-12 Fellows were accepted into the program.

June - August 2002 'Introduction to Sensors,' an 8-week graduate course is given to all GK-12 fellows.

August 12 - 15, 2002 GK-12 Sensors! August Workshop held at University of Maine's Orono campus.

August 15, 2002 Teaching teams were created at the workshop comprised of fellows and teachers with similar interests in sensors.

September 2002 GK-12 Sensors! Fellows begin team-teaching with faculty members at Bangor High School.

October 31-

November 1, 2002 Dr. John Vetelino (P.I.), Dr. Constance Holden (Co P.I.), Mr. Stephen Godsoe (Co P.I.), and Ms. Andrea Martin, (GK-12 fellow) attend the NSF GK-12 Workshop in Arlington, VA.

December 2002 GK-12 Sensors! is introduced into John Bapst Memorial High School.

New Course Proposal

As a result of the work accomplished by the fellows working at both Bangor High School and John Bapst Memorial High School, a new course has been proposed for the year 2002-2003 at Bangor High School.

'Introduction to Sensors' Bangor High School, proposed for Fall 2003

This course is designed to introduce students to sensors and their applications. The course will be taught by a team of BHS faculty members and GK-12 fellows from the University of Maine. The focus is on sensor theory, design, fabrication and applications in areas such as medicine, environmental monitoring, the automotive industry, the chemical industry, manufacturing, construction, global positioning, and the food industry. How sensors impact our communities and society will be discussed throughout the course.

Field trips on the Maine coast, within the Bangor region, and on the campus of the University of Maine will relate to sensor applications. Environmental applications that will be researched through field trips include remote sensing of whales, testing water quality in Maine's rivers and streams, and measuring sound and light pollution within our community.

Training and Development:

This summer, Dr. Vetelino, P.I. designed a course for all of the GK-12 fellows that put them on the same track relating to sensor technology. The course used both a lecture format and a seminar approach, offering the fellows an opportunity to present their research to an audience and receive feedback.

Outreach Activities:

Stephen Godsoe, Co-P.I. for the GK-12 Sensors project, made connections with Bangor Regional officials and Maine's Department of Environmental Protection; Bangor's Fire, Police, Engineering, Planning, Community Development Departments; and Bangor International Airport. A meeting was led on December 6, 2002 with representatives from these agencies and the GK-12 P.I.s and fellows. They discussed interests and needs for collaboration efforts.

Journal Publications**Books or Other One-time Publications**

John Vetelino, Stephen Godsoe, Constance Holden, "Report on GK-12 August Workshop Report, the University of Maine", (). Report, Submitted
Bibliography: August 2002

Web/Internet Site**Other Specific Products**

Product Type: Visual Presentation

Product Description:

Introducing Sensors into the Classroom, 12 PowerPoint Presentations, by GK-12 Sensors! Fellows, August 2002.

Sharing Information:

They were presented at the GK-12 Sensors August 2002 Workshop.

Product Type: Poster Presentation

Product Description:

Poster Presentation for GK-12 National Meeting Oct. 2002, presented by John Vetelino, Stephen Godsoe, and Constance Holden.

Sharing Information:

The poster is being used to inform people at the University of Maine about our program.

It will be used in the Bangor High School to inform students about our program.

Contributions**Contributions within Discipline:****CONTRIBUTIONS OF THE GK-12 SENSORS! PROGRAM**

This summer, Dr. Vetelino, P.I. designed a course for all of the GK-12 fellows that put them on the same track relating to sensor technology. The course used both a lecture format and a seminar approach, offering the fellows an opportunity to present their research to an audience and receive feedback.

Although the program has just begun, all of the GK-12 fellows have made valuable contributions to the schools they are serving. They have broken new ground with their ability to reach the students using their enthusiasm, flexibility and creativity. At BHS the students are thinking 'outside the box' by learning what's in the box.

FELLOWS 2002 -2003

The fellows have made contributions to all the students they have helped this semester.

John Allen was born in Flint, Michigan, and grew up in Maine. He received his Bachelor of Science degree in Electrical Engineering at Worcester Polytechnic Institute in Worcester, Massachusetts. He is currently working towards his Master of Science in Electrical Engineering under the direction of Dr. John Vetelino, and his thesis project relates to acoustic wave sensors. His primary place of research is at LASST (Laboratory of Surface Science and Technology) in the Sawyer Research Center. As a GK-12 Fellow, he will be working with students to assist in web design. He currently assists with two HTML classes at Bangor High school. His other responsibility is the design of the GK-12 Sensors! Web site.

Eric Berkenpas grew up Northwest Iowa. He attended South Dakota State University where he received his undergraduate degree in Electrical Engineering with a Computer Science minor. He is starting out in the masters program in the Electrical and Computer Engineering department. Eric is currently working on a research project involving the development of a new kind of sensor for detecting bio-terrorism pathogens with his advisor Dr. Mauricio DaCunha. Eric is currently working with electronics classes at BHS.

Danielle Donovan is from Presque Isle, Maine. She received her Bachelors Degree from the University of Maine in Spatial Information Science and Engineering. She is currently working on her Masters degree in Spatial Information Science and Engineering at the University of Maine. She is specializing in remote sensing and geographic information systems (GIS). Danielle is working at Bangor High School with Mr. Smith in his two senior seminars, with Mr. Krupke, in his advanced drafting class, and in geography.

Lester French is pursuing a Ph.D. in electrical engineering. Lester's research is focused on acoustic wave sensors for use as liquid-phase chemical sensors. Lester received the BSEE with a minor in optical and illumination engineering from the University of New Hampshire in 1993. Lester worked as a commercial engineer for Duro-Test Corporation and as a research engineer for BIODE, Inc. on the modeling, testing, and packaging of acoustic wave devices as liquid-phase chemical sensors. He received his MSEE from the University of Maine in 2002. Lester is primarily working with the Chemistry department at Bangor High School for the NSF GK-12: Sensors! Project. He has also interacted with Mr. Smith's Senior Seminar courses at Bangor High School.

Eeva Hedefine is in the first year of her Masters Degree in the Department of Spatial Information Science and Engineering at the University of Maine. Eeva is researching privacy issues relating to sensors. She received a Bachelors Degree in Spatial Information Engineering from the University of Maine and an Associate Degree in Legal Technology from the University of Maine at Augusta. Eeva grew up in Maine for the most part. Eeva is working with the Senior Seminar, Civics, Geography, and Advanced Drafting classes at Bangor High School.

John Krassikoff is pursuing a Ph.D. in Physics. He is a research assistant at the Laboratory for Surface Science and Technology where he performs research tasks related to sensor development for monitoring high temperature oxidation of SiAlON fracture resistant thin films. John served, in various capacities, during ten years in the United States Air Force. He subsequently worked as an electronics technician for Hipotronics, a high-voltage test equipment company and was an engineering technician for the United Parcel Service at their R&D facility working on voice recognition systems. Finally, John worked as a staff engineer at Lorex Industries working on the design of optical and acoustic measurement systems for the telecom and semiconductor industries. He left industry to attend graduate school after completing his second bachelor's degree, this one in Physics, at the State University of New York at New Paltz.

John is currently working with the science department at John Bapst Memorial High School as a NSF GK-12 Fellow. He has given an introduction to sensors seminar to each of five physics classes (AP, Honors, three Standard) at the school. He has also assisted with and taught laboratory sections for the two physics teachers at John Bapst M.H.S.

Andrea Martin is from Indiana and received her degree in forensic chemistry from Ohio State University. She is currently pursuing her PhD in chemistry at the University of Maine and works on the development of a nitric oxide gas sensor in the Laboratory for Surface Science and Technology. At Bangor High School, Andrea is working with the students in the chemistry classes.

Stephanie Pitcher is currently pursuing a master's degree in Electrical engineering and may continue her research for a Ph.D. Stephanie's research is focused on developing an impedance based metal oxide gas sensor for ethylene detection and fruit ripening. Stephanie grew up in Washington State during elementary and high school, and studied at the University of Colorado at Colorado Springs for her undergraduate BS degree in Electrical Engineering. She is working with the biology department (Biology level 1, AP Biology, and Marine Biology) at Bangor High School.

Anthony Puckett is pursuing a PhD in mechanical engineering. His research is focused on ultrasonic methods for material characterization using solid cylindrical waveguides. Anthony was born and raised in New Mexico. He received his BS and MS in Mechanical Engineering from Colorado State University. Anthony is working mainly with the pre-calculus classes at Bangor High School.

Jason Thurlow is an undergraduate student in Computer Engineering. Jason also works at LASST developing new Gas Delivery Systems for testing sensors. Jason grew up in Cannan, ME, and graduated from Skowhegan High School in 1998. Jason is currently working with the Electronics classes at Bangor High School.

Becky Woodward is a Ph.D. Student, with an Individualized Program. Becky is conducting a cross-species comparison of the morphologies and performance abilities of four baleen whale species. Her work involves the use of suction-cup attached, multi-sensor data logging tags to monitor the underwater movements of large whales at sea. Data recorded by the tags include depth, roll, pitch, and heading as well as acoustical information which will be used to analyze the animals' diving performance and swimming biomechanics.

Several examples of team-teaching activities are presented here.

Becky Woodward, a graduate fellow and Dr. Wes Hedlund, biology teacher at BHS, designed a module that the biology students will never forget. The module consisted of 16 weeks of lectures/labs as well as a full day field trip on a whale watching cruise out of Bar Harbor, Maine. According to Becky, 'The goal of the unit was to give the students a basic working knowledge of whales including their biology, evolution, special adaptations to the sea, species identification, and typical behaviors.' The whale watching field trip gave the students first hand experiences with the animals and exposure to difficult sighting conditions and limited surface intervals. Students explored research techniques for studying these unique animals, including a look at how sensors can be used to help answer biological questions.

One student commented: 'Throughout this unit [on whales] I gained an appreciation for the work of Becky and other [researchers], not only for being able to brave the harsh working conditions on a regular basis, but also for the intense observations they must make.'

Stephanie Pitcher, graduate fellow is also working with Dr. Wes Hedlund in biology. She recently gave a presentation on 'What is a Sensor?' in Biology classes. The students experimented with mapping their taste buds on their tongues to learn about change relating to sensors. Stephanie is planning more presentations including a demonstration on her university research related to the use of sensors to detect ripening fruit gases.

John Allen is the newest member of GK-12 sensors, and he has already made unique contributions to the program. He designed three tutorials for the computer language classes at BHS to assist Mr. Erb and Mr. Godsoe at BHS. The tutorials are web-based visuals with written information into an html format. They are easy to use and made a big impression on the students. He also is designing an extended project on robotics and C++ programming that will benefit computer programming and electronics students next semester.

MAJOR REPORTS, PRESENTATIONS, COURSE DEVELOPMENT 2002 GK-12 SENSORS!

'Introduction to Sensors,' Graduate Course, John Vetelino, Professor of Electrical and Computer Engineering, the University of Maine, June 2002.

GK-12 August Workshop Report, August 2002.

GK-12 Sensors Report on Teaching Modules, August 2002

Annual Report to the National Science Foundation, December 2002

'Communiqu' Article Introducing the GK-12 Sensors! Program at Bangor High School, June 2002, published by Bangor Schools.

'Communiqu' Article on GK-12 Sensors! Progress at Bangor High School, December 2002, published by Bangor Schools.

Poster Presentation for GK-12 National Meeting Oct. 2002, presented by John Vetelino, Stephen Godsoe, and Constance Holden.

'Introducing Sensors into the Classroom,' 12 PowerPoint Presentations, by GK-12 Sensors! Fellows, August 2002.

Contributions to Other Disciplines:

Contributions in History, Civics, Public Policy

Danielle Donovan and Eeva Hedefine, Gk-12 fellows, are working with Mr. James Smith in his Senior Seminar at BHS to give the students knowledge of how sensors affect our communities and our personal lives. In November, the fellows arranged for Dr. George Bernhardt, Scientist at the laboratory for Surface Science and Technology, to speak on chemical and biological sensors. The seminars included presentations by GK-12 fellows: John Allen on computer hacking, Stephanie Pitcher on airport security, Danielle Donovan on satellites, and Eeva Hedefine on privacy issues. Danielle and Eeva also arranged for the director of Bangor International Airport to come and speak on airport security after 9/11.

Contributions to Human Resource Development:

The major goals of the project are achieved by using sensors as the vehicle to encourage students to pursue science and engineering careers. To this end the fellows act as role models, as well as teachers. Emphasis toward encouraging underrepresented groups in science and technology, including females, minorities and disabled students is important to each teacher, faculty member and fellow working in the GK-12 Sensors! Program. It is anticipated that this program will significantly increase the number of high school students in Maine who will be choosing future careers in science and engineering.

Contributions to Resources for Research and Education:

ð BHS teachers currently are working with The GK-12 Sensors fellows to develop sensor modules that work for their classrooms and these will be integrated into the course in Fall 2003.

ð Sensor research is an interdisciplinary field with applications in all areas of science and mathematics. The students are introduced to the scientific approach to problem solving and invention.

ð In the future, The students will be using math, physics, chemistry, biology, electrical circuitry and drafting knowledge to create laboratory sensors that employ the principles of the most advanced technology systems.

ð The facilities at the Laboratory of Surface Science and Technology are available for research opportunities. Group and individual visits to LASST will enhance the classroom experience.

Contributions Beyond Science and Engineering:

The project leaders are working with the city of Bangor, Maine. Stephen Godsoe, Co-P.I. for the project, made connections with area and city officials and Maine's Department of Environmental Protection so that students could collaborate with these representatives, Fellows, and teachers to monitor noise, water quality, air quality, etc. Students can help with Geographic Information System (GIS) mapping to benefit the Fire, Police, Engineering, Planning, Community Development Departments and Bangor International Airport.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Organizational Partners

Any Journal

Any Web/Internet Site

GK-12 SENSORS! ACTIVITIES 2002

The GK-12 Sensors! Program is focused on bringing cutting-edge research in sensors to high school students in Maine in the anticipation of increasing the number of students pursuing a career in which science and engineering play a critical role. This project is a collaboration between the faculty of Bangor High School in Bangor, Maine and the University of Maine's interdisciplinary team of engineers and scientists working in sensors. The GK-12 Sensors! Program has also been extended to John Bapst Memorial High School in Bangor, as of December 2002. The goal is to use these high schools as models and to extend the program to other Maine high schools.

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- To provide classroom teaching experience to graduate and undergraduate fellows in order to motivate them to choose an academic career.
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to each teacher, faculty member and fellow working in the *GK-12 Sensors!* Program. It is anticipated that this program will significantly increase the number of high school students in Maine who will be choosing future careers in science and engineering.

INTRODUCTION TO SENSORS

June 28 – August 19 2002

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OVERVIEW OF THE AUGUST WORKSHOP

August 12 – 15, 2002

The 2002 GK-12 Sensor Workshop at the University of Maine brought together 35 participants to create a plan to integrate the GK-12 fellows into the curriculum of Bangor High School. During the week-long workshop over 70 specific teaching modules were created in small groups.

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BANGOR HIGH SCHOOL INITIATIVE

September 4 – December 31, 2002

This fall, the teaching teams, formed during the August Workshop, took the program to the students, and *GK-12 Sensors!* became a school-wide initiative. The key to implementing the program has been cooperation at all levels of teaching and administration. GK-12 fellows with multidisciplinary experiences are now teamed with

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JOHN BAPST MEMORIAL HIGH SCHOOL INITIATIVE
December 2002

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FINDINGS FOR GK-12 SENSORS! 2002

The GK-12 Sensors! Program is on target. We have reached all the major Benchmarks established at the beginning of the year. They are listed below:

BENCHMARKS 2002

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February 2002	The GK-12 Sensors Program is funded by NSF. Applications of GK-12 Fellows were solicited.
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August 12 – 15, 2002	GK-12 Sensors! August Workshop held at University of Maine’s Orono campus. Teaching teams were created at the workshop comprised of fellows and teachers with similar interests in sensors.
September 2002	GK-12 Sensors! Fellows begin team-teaching with faculty members at Bangor High School.
October 31- November 1, 2002	Dr. John Vetelino (P.I.), Dr. Constance Holden (Co P.I.), Mr. Stephen Godsoe (Co P.I.), and Ms. Andrea Martin, (GK-12 fellow) attend the NSF GK-12 Workshop in Arlington, VA.
December 2002	<i>GK-12 Sensors!</i> is introduced into John Bapst Memorial High School.

New Course Proposal

As a result of the work accomplished by the fellows working at both Bangor High School and John Bapst Memorial High School, a new course has been proposed for the year 2002-2003 at Bangor High School.

“Introduction to Sensors” Bangor High School, proposed for Fall 2003

This course is designed to introduce students to sensors and their applications. The course will be taught by a team of BHS faculty members and GK-12 fellows from the University of Maine. The focus is on sensor theory, design, fabrication and applications in areas

such as medicine, environmental monitoring, the automotive industry, the chemical industry, manufacturing, construction, global positioning, and the food industry. How sensors impact our communities and society will be discussed throughout the course.

Field trips on the Maine coast, within the Bangor region, and on the campus of the University of Maine will relate to sensor applications. Environmental applications that will be researched through field trips include remote sensing of whales, testing water quality in Maine's rivers and streams, and measuring sound and light pollution within our community.

Annual Report for Period:05/2003 - 05/2004

Submitted on: 05/11/2004

Principal Investigator: Vetelino, John F.

Award ID: 0139324

Organization: University of Maine

Title:

GK-12: Sensors!

Project Participants

Senior Personnel

Name: Vetelino, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Vetelino was born in Westerly R.I. He received the B.S., M.S., and Ph.D. in electrical engineering from the University of Rhode Island in 1964, 1966, and 1969, respectively. He was one of the founding members of the Laboratory for Surface Science and Technology at the University of Maine and is currently leader of the solid state research group. Three sensor companies û the BIODÉ Corp. in Westbrook, ME, Microsensor Conversion Technology in Brookings, SD, and Sensor Research and Development Corp. in Orono, ME û have been incubated from his research group.

Dr. Vetelino's research in acoustic wave and metal oxide sensors served as the motivation for the GK-12 Sensors program. He previously served on many NSF Science Education Review panels for NSF Undergraduate Research Participation (URP), NSF Local Course Improvement (LOCI), NSF Student Science Training (SST), NSF instructional Scientific Equipment Program (ISEP) and NSF Small Business Innovation Research grants (SBIR) proposals. He also served in many NSF workshops and various panels relating to research addressing national needs.

Name: Godsoe, Stephen

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephen Godsoe is from Bangor, Maine and has 36 years of high school teaching experience with at least one class of the most able students each year. Mr. Godsoe was the K-12 Mathematics Coordinator in Bangor from 1975-1983 and 1989-1991 and has served on several State committees to establish mathematics standards. He has taught all levels of high school mathematics, statistics, and computer science. His team of Bangor High students was twenty-third and thirty-sixth in the country in the Math League and the American High School Math exam. He was one of twenty-eight teachers in the US to receive the Edith May Sliffe award in 2001. Since 1994, Mr. Godsoe has taught Teaching K-8 Mathematics at the University of Maine also.

As Co-P.I. for GK-12 Sensors, Mr. Godsoe is an active a team member in the classroom helping GK-12 fellows, directs the program's collaboration with the state and city agencies, and works to support the program with new initiatives.

Name: Holden, Constance

Worked for more than 160 Hours: Yes

Contribution to Project:

Constance Holden is from Orono, Maine and has taught at Orono High School, University College of Bangor, and the University of Maine. She has supervised student teachers, helped to develop the curriculum on workshops for secondary school teachers, and authored publications for professional journals related to teaching science and engineering. She received an Ed D in Science Education in 1979 from the University of Maine.

As Co-P.I. for GK-12 Sensors, Dr. Holden brings her teaching experience to the task of supporting and training the GK-12 fellows. She teaches Spatial Science and Technology Information at the University of Maine, as well as meeting with the fellows on a one-to-one basis, interacting with civic leaders, developing GIS programs for BHS courses, and helping to administer the program.

Name: Crowley, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

Adam Crowley is from Caribou, Maine and has taught at The University of Maine and Beal College. As the program manager, Mr. Crowley has coordinated all GK-12 activities, set-up meetings, promoted the program to the public, prepared reports, maintained the website, designed PowerPoint presentations on GK-12 Sensors, and assisted in the development of modules.

Name: Boyle, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Boyle is the Program Evaluator. As the Program Evaluator, he gathers information on all fellow classroom activities and meets frequently with the GK-12 teachers to discuss the impact of fellows on classroom activities. Dr. Boyle has established a system to chart the impact of our program on high school students, and his conclusions will play a central role in the development of the program. Dr. Boyle also serves as the advisor to the GK-12 Sensors! Social Science fellow Brad Neumann.

Post-doc

Graduate Student

Name: Berkenpas, Eric

Worked for more than 160 Hours: Yes

Contribution to Project:

Eric Berkenpas from Northwest Iowa attended South Dakota State University where he received his undergraduate degree in Electrical Engineering with a Computer Science minor. Eric is an MS student in Electrical Engineering working on a research project involving the development of a new kind of sensor for detecting bio-terrorism pathogens.. Eric is currently working with electronics classes at BHS and JBMHS. Erik has designed and implemented an 'electronic rooster' module at JBMHS which senses light. He has also designed a number of modules students can perform in their own homes to sense heating efficiency.

Name: Carr, Crystal

Worked for more than 160 Hours: Yes

Contribution to Project:

Crystal Carr from China, Maine received her Bachelors Degrees from the University of Maine in Engineering Physics and Computer Engineering. She is an MS student at the University of Maine in Electrical Engineering working on magnetic sensors in hearing aid applications. This year, Crystal has developed and implemented a number of Lego Mindstorm related modules at Bangor High School. These modules help students sense light and sound and include a programming component. She has subsequently taken these modules to our rural schools.

Name: Donovan, Danielle

Worked for more than 160 Hours: Yes

Contribution to Project:

Danielle Donovan from Presque Isle, Maine. She received her Bachelors Degree from the University of Maine in Spatial Information Science and Engineering. She is currently working on her Ph.D in Spatial Information Science and Engineering at the University of Maine specializing in remote sensing and geographic information systems (GIS). Danielle is working at Bangor High School with Mr. Smith in his freshman level civics classrooms and in freshman level health classrooms. Danielle is one of two fellows who have worked with NASA to develop EarthKam modules for our classrooms. Furthermore, Danielle has been instrumental in the development of the Sensor Sensitive program at BHS, detailed in a later portion of this report.

Name: French, Lester

Worked for more than 160 Hours: Yes

Contribution to Project:

Lester French is pursuing a Ph.D in electrical engineering where he is focused on acoustic wave sensors for use as liquid-phase chemical sensors. Lester received the BSEE with a minor in optical and illumination engineering from the University of New Hampshire in 1993. Lester worked as a commercial engineer for Duro-Test Corporation and as a research engineer for BIODE, Inc. on the modeling, testing, and packaging of acoustic wave devices as liquid-phase chemical sensors. He received his MSEE from the University of Maine in 2002. Lester is primarily working with the Chemistry department at Bangor High School for the NSF GK-12: Sensors! project. In particular, Lester has been working closely with BHS Chemistry teacher Helmut Koch, designing and implementing sensor modules that detect acidity and viscosity in various substances. In the spring of 2003, Lester traveled to Magdeburg, Germany to take part in a program related research experience at the Otto-von-Guericke University.

Name: Hedefine, Eeva

Worked for more than 160 Hours: Yes

Contribution to Project:

Eeva Hedefine, a Maine native, is a MS student in the Department of Spatial Information Science and Engineering at the University of Maine. Eeva is researching privacy issues relating to sensors. She received a Bachelors Degree in Spatial Information Engineering from the University of Maine and an Associate Degree in Legal Technology from the University of Maine at Augusta. Eeva is working with the Senior Seminar, Civics, Geography, and Advanced Drafting classes at Bangor High School. This year, Eeva has been central to the development of the Bangor, Maine GIS Emergency Mapping Project, detailed in a later portion of this paper.

Name: Kennard, Raymond

Worked for more than 160 Hours: Yes

Contribution to Project:

Raymond Kennard is from South Paris Maine. He graduated from Ithaca College in '99 with a B.S. in Chemistry and a minor in Physics. The next four years Raymond Kennard taught physical sciences at Fryeburg Academy. In the fall of '02, he decided to return to school to pursue a Ph.D in Chemical Engineering. Raymond is currently researching mesoporous thin films and their application to Sensor as a molecular prefilter. As a fellow, he has been working with Alyson Saunders at Dexter High School, developing portable modules and an extracurricular science and sensor focused group.

Name: Krassikoff, John

Worked for more than 160 Hours: Yes

Contribution to Project:

John Krassikoff, a Ph.D student in Physics, is a research assistant at the Laboratory for Surface Science and Technology where he performs research tasks related to sensor development for monitoring high temperature oxidation of SiAlON fracture resistant thin films. John served, in various capacities, during ten years in the United States Air Force. He subsequently worked as an electronics technician for Hipotronics, a high-voltage test equipment company and was an engineering technician for the United Parcel Service at their R&D facility working on voice recognition systems. Finally, John worked as a staff engineer at Lorex Industries working on the design of optical and acoustic measurement systems for the telecom and semiconductor industries. He left industry to attend graduate school after completing his second bachelor's degree, this one in Physics, at the State University of New York at New Paltz. At John Bapst High School, John worked closely with students from general physics classes to help them produce sensor-oriented projects for annual physics project competition. Furthermore, John introduced electricity into the curriculum of ninth grade science classes. John Krassikoff left the GK-12 Sensors! program in October of 2003.

Name: Lampron, Kenna

Worked for more than 160 Hours: Yes

Contribution to Project:

Kenna Lampron from Standish, Maine received her Bachelors degree from the University of Maine in Electrical Engineering this past August and is currently working on her MS at the University of Maine in the same field as her undergraduate study. Her research involves semiconducting metal-oxide (SMO's) sensors. More specifically, she is working on fabricating, and testing a hydrogen sensor to detect leaks from fuel cells for an automotive applications. Kenna has been working with Wes Hedlund's Biology class at Bangor High School. She has developed portable modules for biology classes that focus on PH sensing. These modules have been performed at both our suburban and rural schools.

Name: Lewark, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Michael Lewark from Jonesport, Maine, is a candidate for a PhD in Electrical Engineering at the University of Maine. He received his undergraduate degree in Electrical Engineering from the University of Maine in May of 2003. Michael's area of research is in material characterization for microwave acoustic applications. He is working with the science and math classes Jonesport-Beals High School (JBHS). At JBHS, Mike has introduced electricity into the curriculum of freshmen physics classrooms. His has designed and implemented a number of Lego Mindstorm-based modules at JBHS. These modules are designed to help students detect light, sound and rotation. They also have a basic programming element.

Name: Martin, Andrea

Worked for more than 160 Hours: Yes

Contribution to Project:

Andrea Martin from Indiana and received her degree in forensic chemistry from Ohio University. She is currently pursuing her PhD in chemistry at the University of Maine and works on the development of a nitric oxide gas sensor in the Laboratory for Surface Science and Technology. At Bangor High School, Andrea is working with the students in the chemistry classes. As a fellow, Andrea has developed one of only two air quality monitoring stations in the state of Maine. This station is located at Bangor High School. She has designed a number of modules around the station and has developed a system for the dissemination

of this information to our satellite schools. In the summer of 2003, Andrea traveled to Brescia, Italy to take part in a program related research experience at the University of Brescia.

Name: McCarthy, Erik

Worked for more than 160 Hours: Yes

Contribution to Project:

Erik McCarthy, originally from Greene, ME, is a graduate of Leavitt Area High School in Turner. He received a B.S. degree in Electrical Engineering from the University of Maine in May, 2003 and currently is working on a Master's degree in Biological Engineering. His graduate research focuses on biosensors that may be used to detect pathogens in water supplies. Erik joined the GK-12 program in February, 2004. Most of his classroom time has been spent in Computer Programming at Bangor High School, where he has taught C++ programming language fundamentals and worked with Lego Mindstorms. He is also learning some of the modules now in place in the Math Department. At Sumner High School, Erik assisted teachers in presenting a unit on Mars rovers.

Name: Neumann, Brad

Worked for more than 160 Hours: Yes

Contribution to Project:

Brad Neumann is a Master of Science candidate in the Department of Resource Economics and Policy, and joins the GK-12 Sensors team from Northern Michigan. He received his Bachelor of Science degree from Northern Michigan University where he dual-majored in Economics and Land Use Planning, and studied Geographic Information Systems (GIS) as a minor concentration. Brad has worked as a GIS intern for Environmental Systems Research Institute, Inc., and has also worked as an independent consultant on GIS and land use planning projects. His research at the University of Maine primarily deals with evaluating the effects that preserved land has on neighboring property values. Brad was brought into the program in 2003 as a social science fellow. This was done to expand our program into the social sciences. Brad is working at Bangor High School in the Social Studies Department and is primarily involved in Mr. Smith's civics classes. Along with fellow Eeva Hedefine, Brad has developed the Bangor, Maine GIS Emergency Mapping Module, which is detailed in a later section of this report.

Name: Pitcher, Stephanie

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephanie Pitcher is currently a MS degree candidate in Electrical Engineering and may continue her research for a Ph.D. Stephanie's research is focused on developing an impedance based metal oxide gas sensor for ethylene detection and fruit ripening. Stephanie grew up in Washington State during elementary and high school, and studied at the University of Colorado at Colorado Springs for her undergraduate BS degree in Electrical Engineering. She is working with the biology department (Biology level 1, AP Biology, and Marine Biology) at Bangor High School. Stephanie is one of two fellows who have worked with NASA to develop modules for our classrooms. Along with fellow Danielle Donovan, Stephanie has been central in the development of the Sensor Sensitive program, detailed in later section of this report.

Name: Puckett, Anthony

Worked for more than 160 Hours: Yes

Contribution to Project:

Anthony Puckett just completed his PhD in mechanical engineering. His research focused on ultrasonic methods for material characterization using solid cylindrical waveguide used in non destructive sensing. Anthony was born and raised in New Mexico. He received his BS and MS in Mechanical Engineering from Colorado State University. Anthony worked mainly with the pre-calculus classes at Bangor High School. He developed a number of motion detector-based modules which were implemented at BHS and have subsequently been disseminated to our satellite schools. Anthony Puckett left the GK-12 Program in April of 2004.

Name: Woodward, Becky

Worked for more than 160 Hours: Yes

Contribution to Project:

Becky Woodward, a Ph.D Student, is conducting a cross-species comparison of the morphologies and performance abilities of four baleen whale species. Her work involves the use of suction-cup attached, multi-sensor data logging tags to monitor the underwater movements of large whales at sea. Data recorded by the tags include depth, roll, pitch, and heading as well as acoustical information which will be used to analyze the animals' diving performance and swimming biomechanics. Becky designed a whale watching module that brought students from several schools to the coast of Maine to observe and classify the habits of humpback whales. Becky Woodward left the Gk-12 Sensors! program at the end of 2003.

Name: Reed, Allison

Worked for more than 160 Hours: Yes

Contribution to Project:

Allison Reed has been assisting Dr. Boyle in his evaluation of the GK-12 Sensors! program.

Name: Ozdemir, Smera

Worked for more than 160 Hours: Yes

Contribution to Project:

Smera Ozdemir has been assisting Dr. Boyle in his evaluation of the GK-12 Sensors! program.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Bangor High School

Bangor High School:

Number of Fellows: 11

Number of teachers effected: 20

Number of classes effected: 45

Type of School: urban

% of free or reduced price Lunch: 51%

% minority: 1%

Academic Standing: Exceeds state averages in math, reading, and writing.

Bangor High School Teachers:

Mark Brittelli Math

Patrici Craig Math

Don Erb Math

Elaine Grant Math

Wes Hedlund Biology

Cary James Chemistry

Helhmt Koch Chemistry

Irv Krupke Technology Education

Joanne Miller Chemistry

Martin O'Connel Biology

Ken Pratt Electronics and Math

Jim Smith Civics

Stephen Godsoe Math

Michael Hamlin Math

Stevie Lord Computer Science

John Stubbs Math

Margaret Chenosky Geography

Kevin Birkel Math

Kim Stone History

Geoffrey Wingard History

John Bapst Memorial High School

John Bapst Memorial High School:

Number of Fellows: 2

Number of teachers effected: 2

Number of classes effected: 5

Type pf School: urban

% of free or reduced price Lunch: This school does not have a lunch program.

% minority: 4%

Academic Standing: Exceeds national averages in math, reading, and writing

John Bapst Memorial High School Teachers

Scott Burgess Physics

John Allshouse Earth Science

Dexter Reginal High School**Dexter Reginal High School:**

Number of Fellows: 1

Number of teachers effected: 1.

Number of Classes effected: 3

Type of School: Rural

% of free or reduced price Lunch: 51%

% minority: 1%

Academic Standing: Exceeds state averages in writing and reading, but fails to meet state average for math.

Dexter Reginal High School Teacher:

Alyson Saunders Chemistry

Sumner Memorial High School**Sumner Memorial High School:**

Number of Fellows: 12

Number of Teachers Effected: 2

Number of classes effected: 5

Type of School: Rural

% of free or reduced price Lunch: 21%

% minority: 1%

Academic Standing: Fails to meet state average in reading, writing, and math.

Sumner Memorial High School Teachers:

Henri Gignoux Physics

Mike Benjamine Physical Science

Lee Academy**Lee Academy:**

Number of Fellows: 12

Number of Teachers effected: 1
 Number of classes effected: 4
 Type of School: Rural
 % of free or reduced price lunch: 53%
 % minority: 23%
 Academic Standing: Fails to meet state average in reading,
 writing, and math

Lee Academy Teacher:

John Simone Chemistry

Jonesport-Beals High School

Jonesport-Beals High School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected: 3
 Type of School: Rural
 % of free or reduced price lunch: 44%
 % minority: 0%
 Academic Standing: meets state average in writing, reading,
 and math.

Jonesport-Beals High School Teacher:

Lynn Alley All Science Classes

Bangor, Maine City Council

The council has taken a role in the development of the Bangor, Maine GIS Emergency Mapping Project, developed by GK-12 Sensors! fellows in collaboration with faculty at Bangor High School.

Bangor Maine Fire Department

By loaning materials and training time, the Bangor Fire Department has assisted the development of the Bangor, Maine GIS Emergency Mapping Project.

Bangor, Maine Police Department

By assisting with the locating of emergency supplies, the Bangor Police Department has assisted the development of the Bangor, Maine GIS Emergency Mapping Project.

NASA

Two of our fellows have developed a number of modules using information they have received at Maine Teachers of Earth and Space Science Workshop 2003 in Washington, DC. This workshop was sponsored by NASA.

Other Collaborators or Contacts

Other University of Maine Collaboration:

Dr. Peter Hoff, President of the University of Maine
 Dr. Robert Lad, Director of the Laboratory for Surface
 Science and Technology (LASST) and Professor of Physics
 Dr. Carl Tripp, Associate Professor of Chemistry, LASST
 Dr. Bruce Segee, Associate Professor, Electrical and
 Computer Engineering
 Dr. Paul Millard, Assistant Professor, LASST

Dr. Alfred Bushway, Professor of Food Science
 Dr. Rodney Bushway, Chair and Professor of Food Science

Other Community and State Collaboration:

Dr. Robert Ervin, Superintendent of Schools, Bangor
 Mr. Norris Nickerson, Principal, Bangor High School
 Peter Arno, Assistant Police Chief, Bangor
 Jeff Cammack, Fire Chief, Bangor
 Stan Moses, Community Development
 Paul Nichols, DEP for the state of Maine
 Mark Whiting, DEP (water quality),
 Bob Goodwin, Department of Marine Resources,
 Susan Morse, Bangor Area Comprehensive Transportation System
 (BACTS)
 Ken Beland, Atlantic Salmon Commission, state of Maine
 Dave Gould, Bangor Planning,
 John Murphy, City Engineering
 Rebecca Hupp, Bangor International Airport Director
 Jim Ring, City Engineer, Bangor
 Don Winslow, Police Chief, Bangor
 Rod McKay, Community Development, Bangor
 Rob Kenerson, Bangor Area Comprehensive Transportation
 System, BACTS
 Anne Hartmann, Discovery Museum, Bangor

Fellow Advisors:

Dr. Peggy Agouris, Assistant Professor of Spatial Information Science and Engineering, University of Maine: Dr. Agouris serves as the advisor to GK-12 fellow Danielle Donovan.

Dr. Mauricio DaCunha, Assistant Professor of Electrical and Computer Engineering, University of Maine: Dr. DaCunha serves as the advisor to GK-12 fellows Eric Berkenpas, Michael Lewark, and Jeremy Thiele.

Dr. William J. Desisto, Assistant Professor of Chemical Engineering, University of Maine: Dr. Desisto serves as the advisor for GK-12 fellow Raymond Kennard.

Dr. Brian Frederick, Assistant Professor for Chemistry Department, University of Maine: Dr. Frederick serves as the advisor for GK-12 fellow Andrea Martin.

Dr. David Kotecki, Assistant Professor of Electrical and Computer Engineering, University of Maine: Dr. Kotecki serves as the advisor to GK-12 fellow Crystal Carr.

Dr. Paul Millard, Assistant Professor of Biological Engineering, University of Maine: Dr. Millard serves as the advisor for GK-12 fellow Erik McCarthy

Dr. Harlan Onsrud, Professor of Spatial Information Science and Engineering, University of Maine: Dr. Onsrud serves as the advisor to GK-12 fellow Eeva Hedefine .

Dr. Mick Peterson, Assistant Professor of Mechanical Engineering and Graduate Coordinator: Dr. Peterson serves as the advisor to GK-12 fellows Anthony Puckett and Becky Woodward.

Activities and Findings

Research and Education Activities:

Executive Summary:

Since its inception in 2002, the GK-12 Sensors! Program has been focused on bringing cutting-edge research in sensors to high school students in Maine in the anticipation of increasing the number of students pursuing a career in which science and engineering play a critical role. Currently, this project is a collaboration between an interdisciplinary team of University of Maine (UM) engineers and scientists working in sensors and six Maine high schools: Bangor High School (BHS), John Bapst Memorial High School (JBMHS), Dexter Regional High School (DRHS), Jonesport-Beals High School (JBHS), Sumner Memorial High School (SMHS), and Lee Academy (LA). The goal is to use these high schools as models and to extend the program to other Maine high schools.

During our second year, the program has undergone a significant transformation. Fourteen graduate fellows have teamed with rural and urban high school faculty members at schools with vastly different socioeconomic resources. In order to establish a technological equilibrium at these schools, GK-12 Sensors! fellows and teachers have developed and implemented a catalog of portable modules designed to give all collaborating high schools equal exposure to new sensor-based technology and curriculum. In addition, fellows working at BHS have developed and implemented a community-based GIS Mapping Project in Bangor, Maine which has enormous potential to educate students at all our schools on how classroom activities can have a direct impact on the health and well being of their respective communities.

Other major second year accomplishments include: research experience for a fellow and teacher at the Otto-von-Guericke University in Magdeburg, Germany and at the University of Brescia in Brescia, Italy; the addition of a new program evaluator, Dr. Kevin Boyle, Professor of Economics at UM; acquired funding through a supplemental proposal to support social science fellow Brad Neumann; secured supplemental funding to increase socioeconomic scope and impact of program by expanding into four rural Maine schools; established initial contacts with rural schools through a Research Experience for Teachers (RET) grant; funding of an NSF RET site grant that will fund the research participation of thirty Maine high school teachers at the University of Maine over the next three years; establishment of links between collaborating schools and the University of Maine via guided tours of research laboratories; fellows' and RETs' completion of a comprehensive graduate course, ECE 465: Introduction of Sensors; introduction of INT 570, a preplanned experience requiring regular school visits to selected K-12 school(s) throughout the semester, during which fellows share their knowledge of emerging science and technology with K-12 school teachers and students; a successful GK-12 Sensors! summer workshop for all GK-12 Sensors! participants; the further refinement of seventy specific teaching modules created by teachers and fellows during year one; the creation of twenty-five portable modules; the development of two pilot programs, the Bangor, Maine GIS Emergency Mapping Project and Sensors Sensitive, at BHS that have the potential to be recreated at our satellite schools; greater emphasis on ninth grade classroom activities resulting in the generation of thirty-five ninth grade sensor-based module concepts.

Benchmarks 2003-2004:

Spring 2003:

INT 570, Emerging Science and Technology Integration Into K-12 Classrooms, established for fellows. Course Description: A preplanned experience requiring regular school visits to selected K-12 school(s) throughout the semester, during which undergraduate and graduate science and engineering students share their knowledge of emerging science and technology with K-12 school teachers and students.

GK-12 Sensors! program is reviewed by Dr. Harriet Taylor. Her review of our program has been appended to this report.

Program PI, John Vetelino, becomes aware of research activities at the Otto-van-Guericke University in Magdeburg, Germany and at the University of Brescia in Brescia, Italy that could benefit GK-12 Sensors. A proposal for supplemental funding to send two fellows and two teachers to visit these Universities was submitted to NSF and subsequently funded.

Supplemental proposals to add a socioeconomic dimension to the program and to support a summer Research Experience For Teachers (RET) program submitted and subsequently funded.

April 2003:

All Maine High Schools were notified of a Research Experience for Teachers (RET) program that would be held at the University of Maine (UM) during the summer of 2003. Four schools responded with particularly strong applicants: Dexter Regional High School (DRHS),

Jonesport-Beals High School (JBHS), Lee Academy (LA), and Sumner Memorial High School (SMHS).

June 2003:

RET participants and new GK-12 fellows begin ECE 465, Introduction to Sensors. RET participants begin working closely with University of Maine Research Scientists on cutting-edge sensor technology.

August 2003:

A workshop as held for all GK-12 Sensors! participants at UM. At this workshop, Dr. Taylor's review of the program was discussed, and strategies were discussed for addressing areas of concern. As a direct result, over 35 module concepts were created for ninth grade classrooms.

Fellows Danielle Donovan and Stephanie Pitcher attend the Maine Teachers of Earth and Space Science Workshop 2003 in Washington, DC.

September 2003:

GK-12 Sensors! expands from two schools to six. New schools represent some of the poorest in Maine and include Dexter Regional High School (DRHS), Jonesport-Beals High School (JBHS), Sumner Memorial High School (SMHS), and Lee Academy (LA).

October û November 2003:

Fellows and teachers begin to develop a catalogue of portable modules to share between the six schools.

December 2003:

Fellows and teachers begin to collaborate on journal articles that detail their GK-12 Sensors! activities.

Article on GK-12 Sensors! published in the Bangor High School Communiqu .

January 2004:

Implementation of alternative rotation schedule designed to alleviate transportation issues for Fellows traveling to distant schools.

Paper on the GK-12 Sensors! program submitted to the 2004 Frontiers in Education conference. This conference will be held in Savannah, Georgia.

March 2004:

Fellows, PI, Co-PI, and Project Manager attend the GK-12 Annual meeting in Washington DC. Poster presentation on past and current program activities presented.

NSF RET site proposal is funded. Thirty teachers from primarily rural high schools will be coming to UM over the next three years to interact with GK-12 fellows and plan strategies for integrating sensors into rural middle and high schools.

April 2004:

Paper on GK-12 Sensors! presented at the 2004 American Society of Engineering Education in Dedham, Massachusetts.

Paper submitted to 2004 Frontiers in Education Conference accepted.

Fellows meet to compile portable modules. Modules are readied for publication on the web.

May 2004:

The Bangor, Maine GIS Emergency Mapping Project is presented to the Bangor, Maine city council by fellows Brad Neumann and Eeva Hedefine.

Fellows, in collaboration with mentor teachers, complete journal articles and conference papers. Papers are submitted to a number of publications and conferences detailed in a later portion of this report.

2003 summer activities, Europe trip:

In the spring of 2003, the GK-12 Sensors! PI John Vetelino became aware of a number of activities taking place at both the Otto-von-Guericke University in Magdeburg, Germany and at the University of Brescia in Brescia, Italy that could benefit GK-12 Sensors! These activities included research relating to air quality, water quality, landfill and food monitoring. As a result supplemental funding from NSF was obtained to send two fellows and two teachers to Europe.

One fellow and one teacher from Bangor High School spent two weeks at the Otto-von-Guericke University in Magdeburg, Germany. They interacted with graduate students and researchers and developed several different modules. One module relates to the development of a biofilm sensor to monitor the growth of biological cultures. A quartz crystal monitor (QCM) sensor can be placed in a beaker in which a biological culture is added with some nutrient. The students are then able to see that the culture growth can be measured by a frequency shift in the QCM. Another example relates to the determination of the fluid's physical properties. Using a QCM sensor in a beaker with distilled water a liquid of density different than that of water can be added. The students can then see that a change in density causes a change in the frequency of the QCM. A third example relates to a module which has also been recently adapted to measure oil viscosity in motor vehicles.

Another teacher and fellow from Bangor High School spent two weeks at the University of Brescia in Italy. They interacted with graduate students and faculty working on the development of metal oxide sensors to detect gases emitted from foods, liquids, landfills and environmental pollutants in the atmosphere and workplace. As a result of these interactions, a number of modules involving the determination of the quality of coffee, olive oil, and wine, gases emitted from landfills in Bangor, Maine and ozone monitoring in the atmosphere have been developed. Monitoring for landfill gases is currently being performed at nearby landfills and an ozone monitoring station has been implemented. Bangor High School students publish a weekly ozone report, which is available to all students and teachers in the Bangor School System and the public.

On both of these trips, fellows and teachers interacted with university science and math administrators to gain a better understanding and appreciation for each nation's educational system. In particular, fellows and teachers learned about alternative methods for integrating science and mathematics into the high school curriculum. As a direct result, interactions have begun regarding how our schools can become competitive with our European contacts in the areas of science and mathematics education. Michael Meissner, a student from the Otto-von-Guericke University, has come to the University of Maine to work with research scientists at the Laboratory for Surface Science and Technology. During the 2004-2005 school year, he will have interactions with some of the high school students in the GK-12 Sensors! program.

Portable Modules:

To ensure that our program is capable of demonstrating similar technologies at schools with different resources, our fellows have created 25 portable modules that can be easily transported, either in their entirety or partially, from school to school. As a direct result of the portable modules, new technology has been introduced into the fellows' classrooms. For example, fellow Andrea Martin has designed a portable ozone monitoring model that has been implemented at Bangor High School (BHS) which is now producing valuable data available to other high schools. This module utilizes an Ultraviolet photometer which, under the direction of BHS students, now serves as one of only two ozone monitoring stations in the state of Maine. In another BHS classroom, fellows Danielle Donovan and Stephanie Pitcher have introduced technology and data they have gathered through the EarthKam project, which is funded by NASA. As a directly result of their work, the student Danielle and Stephanie interact with in both suburban and rural settings have access to a network of research and geographic data they would otherwise not have. At Jonesport-Beals High School (JBHS), fellow Mike Lewark has introduced Lego Mindstorms materials into the physics classrooms. Without Mike's presence and University support, JBHS would simply not have been able to afford these incredibly useful materials for its students. Mike regularly interacts with fellows at different schools utilizing mindstorm technology to improve his classroom activities.

Bangor, Maine GIS Emergency Mapping Project:

In addition to portable modules, Fellows have been organizing community outreach programs, such as the Bangor, Maine GIS Emergency Response Mapping Project, which enable students to produce valuable maps for local police and fire departments, detailing the location of fire hydrants, shelters, and other emergency resources. Because Bangor is willing to share its GIS equipment with our fellows, this project can be reproduced in other towns at little or no cost. The fellows have presented this program to the Bangor School Department, and they are scheduled to present it to the Bangor City Council in mid-May.

Sensor Sensitive:

At BHS, civics teacher Jim Smith has been working with fellows to create a pilot program called Sensors Sensitive. This two-day event targets all freshmen at BHS. During day one, all students take an interest survey with CHOICES software. The survey is designed to make students aware of how they can pursue science and engineering related occupations. During the second day of the program, students construct a poster presentation around a science and engineering occupation they might consider pursuing after graduation.

Findings:

The trips that our fellows and teachers took to Europe have proven invaluable for the program. In particular, we have found that the air quality experiments fellow Andrea Martin learned how to perform in Italy have proved useful for our students. Students in both rural and suburban schools have found ozone monitoring to be a practical and fun activity that illustrates one of the many uses of sensor technology. The sensor modules that assimilate real world data: i.e., air, water and food monitoring, and also those modules focused on mapping town recourses, appear to be the most successful in helping students make the connection between sensor technology and the world they live in. These findings are based on student comments gathered through student surveys.

The portable module initiative has been very successful. GK-12 Sensors! works in school with vastly different economic resources. By tailoring our modules to quickly and efficiently introduce particular technologies, we have brought all of our schools together 'on the same page'. For example, Students at Bangor High School, which is relatively affluent, have access to the same ozone monitoring data as students at Jonesport-Beals High School, our least economically stable institution.

As a result of our growth, we have had to develop a rotation schedule for our fellows. Four of our six schools are at least one hour away from the University of Maine. Two fellows, Raymond Kennard and Michael Lewark are permanently stationed at Dexter High School and Jonesport-Beals High School respectively. However, we have had to set up a rotating schedule at Sumner High School and Lee Academy. This year, we rotated the fellows though for fifteen school days each. This method made it difficult to maintain a sense of continuity at these schools. During the 2004 summer workshop, we will bring teachers and fellows together to design a rotation schedule that will better suit all parties.

2003 Review of GK-12 Sensors Program:

In the spring of 2003, Dr. Harriet Taylor reviewed GK-12 Sensors for the National Science Foundation. What follows is a list of Dr. Taylor's concerns and our specific responses to those concerns.

Concern One:

Undergraduate engineering students have problems committing time. They are not paid well and have too many courses with little flexibility in scheduling in their final year. The project will limit the use of undergraduates or not use them in future years.

Response:

We agree that undergraduate engineering students have very little flexibility in scheduling, especially seniors who must write a research paper. Undergraduate students no longer serve as fellows.

Concern Two:

Participation in the project involves an initial steep learning curve that is time consuming for fellows; many are spending more time than required. This should even out over time. A small number of the Fellows are not engaging the students in meaningful ways, relying on lecture and demos and no hands on activities. These Fellows need significant attention if they are to be in classrooms next year. We will be attempting to increase hands-on activities and closely monitor the fellows not engaging in hands-on activities.

Response:

To ensure that our fellows enter the classroom ready to engage students, we have developed a 'buddy' system, in which new fellows are paired with experienced fellows and older sites for at least the first month of their time in the classroom. This allows the fellow time to get comfortable in the classroom environment before they begin to begin implementing their own curriculum.

Concern Three:

The project took an interesting approach of trying to reach every mainstream ninth grader through a civics class. The results were enjoyable, but not hands-on and not science. Fellows need to be working in or near their scientific discipline and working with a master teacher who

mentors them in science education and their discipline. Some way must be found to achieve similar goals but through science teaching experiences û hands-on, as well. The ninth graders also commented on the lack of hands-on work. It is clear that the teachers involved in this part of the project are very enthusiastic. It would be good if some way were found to include them in a meaningful and appropriate way, but not with three Fellows who are not doing science.

Response:

To address this specific issue, we have developed the Bangor, Maine GIS Emergency Mapping Project. This project, administered through our civics classrooms, provides the students with hands-on experiences with GIS technology and cartography. The project utilizes a number of technologies, such as GPS equipment, that have never been used in Bangor High civics classrooms before.

Concern Four:

The evaluation consultant does not appear to have a good plan or commitment to the project. He has not visited any classrooms during the year and has made only token efforts. No reports have been generated and there is little baseline data collected. The teachers see some impact and want to be involved in measuring it. Evaluation must be re-designed, with an outside group taking the lead in the design and administration of instruments. Baseline data must be established and realistic ways to measure project goals established.

Response:

The project team has dismissed the initial evaluator. A new evaluator, Dr. Kevin Boyle, Professor of Economics at the University of Maine, has been taken into the project. Dr. Boyle has devised and implemented a system for gathering baseline data for every GK-12 Sensors! school and is closely monitoring every actively that every fellow performs. This data will be used to determine whether or not we are successfully pursuing our goals. Dr. Boyle is being assisted by two graduate students, Allison Reed and Semra Ozdemir, as well as by Dr. Mark Anderson, UM Senior Instructor of Resource Economics and Policy.

Concern Five:

Communications between project participants is a major problem. The Fellows are not meeting regularly û the last meeting of them as a group was in January. There are no planned meetings with the high school teachers, who feel somewhat abandoned by the university faculty. University faculty must be in schools and meet with the teachers at the school sites regularly. The teachers could also find the opportunity for continuing education units tied to quarterly meetings a very positive reward for their participation.

Response:

The fellows have been called together a number of different times over the past year to exchange information about what they are doing in their various classrooms. These meetings have been both formal and informal gatherings. Teachers and other members of the project team have been invited and attended these meetings. As a direct result, communication between the program participants has improved, and a greater sense of community has been established.

Concern Six:

Co-PI Holden has been charged with overseeing the Fellows and their work in the schools. She has a significant teaching load and is unable to commit large amounts of time to this effort. Some relief must be found, either through graduate student support for Holden, release time, or another person to share in these responsibilities, particularly when the project expands to more remote sites.

Response:

Bi-monthly meetings with teachers have reduced the amount of time required for Co-PI's to visit with the teacher's individually. Also, teachers are communicating more frequently with the project's new Program Manager, Adam Crowley, who was hired in August of 2003.

Concern Seven:

Dissemination is a major problem. More communications and dissemination is needed. The Web site needs to serve for both public outreach as well as participant support. Some consideration might be given to contracting this function out, at least a model for an exemplary site that covers all aspects of the project.

Response:

We have used public relations materials, press releases to news media and conference participation as a system for dissemination. Furthermore, we have established a website that lists all of our classroom modules. At the national level, we are submitting to various journals detailed in a later portion of this document and presenting our findings at conferences such as the 'IEEE Transactions in Education', the 'Frontiers in Education' Conference, and the 'American Society for Engineering Education'

Dissemination issues were specifically addressed at our August 2003 summer workshop, during which all participants had an opportunity to voice alternatives to the current dissemination system. As a direct result, we established teams between fellows and teachers to help information about our program between the departments of our schools

Concern Eight:

One graduate student's research on whales takes her away at critical times. They have been able to juggle her classroom responsibilities, but it is difficult to coordinate training and other events. Availability at key times may need to be a consideration in selecting Fellows.

Response:

We agree and now screen candidates much more carefully in regard to their availability and teamwork capabilities. Only fellows who can fully commit to the requirements of their position are considered for funding.

Concern Nine:

Replacement of project coordinator and a smooth transition may be a major concern for the summer.

Response:

A replacement coordinator was found. Adam Crowley joined GK-12 Sensors! in August of 2003. In the month prior to his activation, he worked closely with Sandra Hale, the program's initial manager.

Concern Ten:

Keeping the project manageable is difficult with the many enticements to branch out in many directions. A current strength is the clear focus and manageable level; the PIs must keep this and do controlled expansion; maintaining a good balance between more fellows in the same school and outreach to new schools will be critical in the next year.

Response:

Four new teachers: Lynn Alley, (JBHS); Henry Gignoux, (SHS); Alyson Saunders, (DHS) and John Simone, (LA), from rural Maine high schools are now on board and interacting with the GK-12 fellows. Each teacher had an RET experience in the summer of 2003 and interacted extensively with new and existing GK-12 fellows before and during the 2003 summer workshop. Six new fellows have been added to the program. Because we only move into schools that have teachers who have successfully undergone an RET experience, these teachers are very familiar with our fellows. As a result, our current rate of expansion has been manageable.

Concern Eleven:

Currently there is no participation at all by the College of Education. It seems that they could be some useful collaboration, possibly with graduate students serving as consultants in preparing meaningful classroom activities as well as in evaluation efforts.

Response:

An education specialist was brought on board for the 2003 August Workshop to present teaching methodology and classroom management skills to the fellows. Also, all new GK-12 Teachers undergo an RET experience at UM the summer prior to their interdiction into the GK-12 program. This system has worked well for us. It ensures that our fellows have an opportunity to discuss classroom activities and evaluation practices prior to their introduction at the schools.

Concern Twelve:

Preparation of Fellows for entry into the classroom is problem. The Fellows and their mentor teachers all felt that the Fellows were ill prepared for the school environment. Many had difficult starts and experienced problems adjusting to the high school culture and the diverse learning styles of high school students. Bangor High has a complex daily schedule of 8 periods with 40-minute class sessions. There is little time to waste or to mentor during class meetings. More needs to be done upfront to plan a reasonable transition period for the Fellows and prepare them for the classroom.

Response:

As previously noted, our fellows now have extensive interactions with other fellows and GK-12 teachers before they enter the classroom. As a result, fellows are never initially charged with running a classroom activity. They begin by assisting experienced fellows until they are comfortable enough in the environment to effectively manage classroom activities.

Training and Development:

2003 summer workshop:

In August of 2003, GK-12 Fellows, teachers from BHS, JBMHS, DRHS, LA, JBHS, and SMHS high schools, and faculty members from the UM met at UM to formalize GK-12 Sensors! activities for 2003-2004 academic year. The workshop began with a review of Dr. Harriet Taylor's spring 2003 review of the program. Problem areas were identified, and a discussion was begun on how these areas might be best addressed. In particular, Dr. Vetelino suggested that teachers and fellows begin to think of more portable modules that would be appropriate for ninth grade students.

Fellows and teachers were divided into a number of interest groups focused on subjects like air quality, water quality, sound and light, and transportation. Each group developed at least one portable module that would be appropriate for ninth grade students. The creation of modules like these has been the primary focus of the second year of GK-12 Sensors! During the 2003-2004 academic year, 25 portable modules have been developed. Their creation ensures that our program is capable of demonstrating similar technologies at schools with vastly different resources. In addition to portable modules, the Fellows have been organizing community outreach programs in Bangor, Maine, such as the GIS Emergency Response Mapping Project, which enable students to produce valuable maps for local police and fire departments. This project has been designed to be reproducible in other towns at little to no cost.

Future Training:

In the spring of 2004, Dr. John Vetelino and Dr. Constance Holden received an RET site grant from the National Science Foundation. As a result, during the summer of 2004 and for the next three summers, ten teachers will be brought to UM by the RET program each summer. As was the case with the RET's during the summer of 2003, these teachers will be paired with UM faculty members and work closely with current participants in the GK-12 Program. By bringing these teachers to UM, we hope to significantly increase the number of schools we can influence in Central and Northern Maine

During the summer of 2004, program participants, including high school students, will identify 'best practices' from GK-12 Sensors! for dissemination across Maine and the nation. GK-12 teams will identify the best modules and develop a 'lending library' of materials and curricula to be sent to teachers at local high schools. The work will culminate with the implementation of a hands-on, inquiry-based honors class founded on the theme of sensors at Bangor High School. This class will serve as a model for other high schools to adopt and become part of their permanent curriculum.

Outreach Activities:

Conferences:

Fellows Brad Neumann and Eeve Hedefine have collaborated on a paper with BHS teacher Jim Smith on their GK-12 Sensors! activities entitled 'The Bangor, Maine GIS Emergency Mapping Project' and have submitted it to The National Science Teacher Convention

Fellows Brad Neumann, Mike Lewark and program manager Adam Crowley presented a poster presentation entitled 'GK-12 Sensors! Program' at the 2004 GK-12 National Meeting in Washington, DC.

Fellows Stephanie Pitcher and Danielle Donovan have collaborated with BHS teacher Margaret Chenosky on their GK-12 activities and have submitted an abstract of their paper entitled 'Using Satellite Remote Sensing to Investigate the 5 Themes of Geography' to The National Science Teacher Convention.

Program Manager Adam Crowley presented paper 'GK-12 Sensors! Program at The University of Maine' at the 2004 ASEE National Conference in Dedham, Massachusetts.

PI John Vetelino will present a paper on the GK-12 Sensors! program entitled 'Introduction of Sensors in High School Classrooms' at the 2004 Frontiers in Education conference in Savannah, Georgia.

Journal Publications

Carr, Crystal; Grant, Elaine; Puckett, Anthony, "Matrices and Digital Pictures", The Mathematics Teacher, p. , vol. , (). Submitted

French, Lester; Koch, Helmut, "A Sensor Design Project For High School Chemistry Classes", The Journal of Science Education, p. , vol. , (). Submitted

Lampron, Kenna; Hedlund, Wes, "The pH Sensor Lab", The Science Teacher, p. , vol. , (). Submitted

James, Cary; Martin, Andrea, "Air Quality Projects In a High School Chemistry Curriculum", The Journal of Chemical Education, p. , vol. , (). Submitted

Heddefine, Eeve; Neumann, Brad; Smith, Jim, "The Bangor, Maine GIS Emergency Mapping Project", The Science Teacher, p. , vol. , (). Submitted

Chenosky, Margaret; Donovan, Danielle; Pitcher, Stephanie, "Using Satellite Remote Sensing to Investigate the 5 Themes of Geography", The Journal of Geography, p. , vol. , (). Submitted

Burgess, Scott; Burkenpass, Eric; Lewark, Michael; Thiele, Jeremy, "Electronics Applied: The Light Sensor", The Physics Teacher, p. , vol. , (). Submitted

Crowley, Adam, "It's All About CHOICES", Communique, p. 7, vol. , (2004). Published

Hale, Sandra, "GK-12 Sensors! Partnership Opens Doors", Communique, p. 1, vol. , (2002). Published

Godsoe, Stephen, "GK-12 Sensors! Grant", Communique, p. 4, vol. , (2004). Published

Hale, Sandra, "Do You Want To Be An Engineer?", Communique, p. 14, vol. , (2003). Published

Books or Other One-time Publications

Crowley, Adam, "GK-12 August Workshop Report, August 2003", (2003). Report, Published
Bibliography: Crowley, Adam. "GK-12 August Workshop Report, August 2003."

Crowley, Adam, "GK-12 Sensors! Portable Module Catalog: April 2004", (2004). web page, Published
Bibliography: Crowley, Adam. "GK-12 Sensors! Portable Module Catalog: April 2004."

Crowley, Adam; Godose, Stephen; Holden, Constance; Vetelino, John, "GK-12 Sensors: Annual Report, May 2003- May 2004", (2004). Report, Submitted
Bibliography: Crowley, Adam. "GK-12 Sensors: Annual Report, May 2003- May 2004"

Web/Internet Site

URL(s):

<http://www.eece.maine.edu/~vet/gk12/>

Description:

This side contains information on our current activities, our fellows, our modules, and upcoming GK-12 Sensors! events.

Other Specific Products

Product Type: Web page

Product Description:

A catalogue of our current portable modules can be found at the following address:

<http://www.eece.maine.edu/~vet/gk12/portablemodule.htm>

Sharing Information:

This product will be shared over the internet.

Contributions

Contributions within Discipline:

The principal disciplinary field of the project is sensor education. GK-12 Sensors! has developed and extended this field in the high school environment through the extension of twenty-five portable modules, available on our web site. Our fellows have documented the success they have had with these modules in a series of journal articles detailed in another section of this report.

One fellow, Andrea Martin, has used her GK-12 Sensors! experience as the foundation for her thesis work:

Andrea Martin GK-12 Sensors! Related Research:

Implementing a project based atmospheric chemistry unit in a high school honors chemistry classroom helps students learn and apply science concepts that relate to environmental policy and health. At Bangor High School, in Mr. Cary James's classroom, an ozone monitoring station acquired from the Maine Department of Environmental Protection, sparked the development and integration of a series of air quality projects. The monitoring equipment detected ground level ozone concentrations outside the high school 24 hours a day, enabling students to analyze and interpret the data. The effectiveness of the air quality projects in meeting the following three goals: helping students obtain a better understanding of 1) atmospheric chemistry, 2) the environmental and health risks associated with different types of air pollution, and 3) the analytical methods for detecting various gases in the atmosphere, were evaluated using qualitative and quantitative data from 57 honors students who participated in the study. A comparison between the students' pre and post scores on an air quality questionnaire was used to assess how well the projects met the above three goals. Also, grading rubrics were provided to evaluate the students' performance on individual projects. The results verify the overall success- improved student scores on the questionnaire, successful completion of projects, including a service outreach component of students sharing learning with younger students, and positive comments about increased motivation, especially from four students who were given responsibility for setting up and maintaining the equipment.

GK-12 Fellows Disciplines and other Contribution:

Eric Berkenpas from Northwest Iowa attended South Dakota State University where he received his undergraduate degree in Electrical Engineering with a Computer Science minor. Eric is an MS student in Electrical Engineering working on a research project involving the development of a new kind of sensor for detecting bio-terrorism pathogens.. Eric is currently working with electronics classes at BHS and JBMHS. Erik has designed and implemented an 'electronic rooster' module at JBMHS which senses light. He has also designed a number of modules students can perform in their own homes to sense heating efficiency.

Crystal Carr from China, Maine received her Bachelors Degrees from the University of Maine in Engineering Physics and Computer Engineering. She is an MS student at the University of Maine in Electrical Engineering working on magnetic sensors in hearing aid applications. This year, Crystal has developed and implemented a number of Lego Mindstorm related modules at Bangor High School. These modules help students sense light and sound and include a programming component. She has subsequently taken these modules to our rural schools.

Danielle Donovan from Presque Isle, Maine. She received her Bachelors Degree from the University of Maine in Spatial Information Science and Engineering. She is currently working on her Ph.D in Spatial Information Science and Engineering at the University of Maine specializing in remote sensing and geographic information systems (GIS). Danielle is working at Bangor High School with Mr. Smith in his freshman level civics classrooms and in freshman level health classrooms. Danielle is one of two fellows who have worked with NASA to develop EarthKam

modules for our classrooms. Furthermore, Danielle has been instrumental in the development of the Sensor Sensitive program at BHS, detailed in a later portion of this report.

Lester French is pursuing a Ph.D in electrical engineering where he is focused on acoustic wave sensors for use as liquid-phase chemical sensors. Lester received the BSEE with a minor in optical and illumination engineering from the University of New Hampshire in 1993. Lester worked as a commercial engineer for Duro-Test Corporation and as a research engineer for BIODE, Inc. on the modeling, testing, and packaging of acoustic wave devices as liquid-phase chemical sensors. He received his MSEE from the University of Maine in 2002. Lester is primarily working with the Chemistry department at Bangor High School for the NSF GK-12: Sensors! project. In particular, Lester has been working closely with BHS Chemistry teacher Helmut Koch, designing and implementing sensor modules that detect acidity and viscosity in various substances. In the spring of 2003, Lester traveled to Magdeburg, Germany to take part in a program related research experience at the Otto-von-Guericke University.

Eeva Hedefine, a Maine native, is a MS student in the Department of Spatial Information Science and Engineering at the University of Maine. Eeva is researching privacy issues relating to sensors. She received a Bachelors Degree in Spatial Information Engineering from the University of Maine and an Associate Degree in Legal Technology from the University of Maine at Augusta. Eeva is working with the Senior Seminar, Civics, Geography, and Advanced Drafting classes at Bangor High School. This year, Eeva has been central to the development of the Bangor, Maine GIS Emergency Mapping Project, detailed in a later portion of this paper.

Raymond Kennard is from South Paris Maine. He graduated from Ithaca College in '99 with a B.S. in Chemistry and a minor in Physics. The next four years Raymond Kennard taught physical sciences at Fryeburg Academy. In the fall of '02, he decided to return to school to pursue a Ph.D in Chemical Engineering. Raymond is currently researching mesoporous thin films and their application to Sensor as a molecular prefilter. As a fellow, he has been working with Alyson Saunders at Dexter High School, developing portable modules and an extracurricular science and sensor focused group.

John Krassikoff, a Ph.D student in Physics, is a research assistant at the Laboratory for Surface Science and Technology where he performs research tasks related to sensor development for monitoring high temperature oxidation of SiAlON fracture resistant thin films. John served, in various capacities, during ten years in the United States Air Force. He subsequently worked as an electronics technician for Hipotronics, a high-voltage test equipment company and was an engineering technician for the United Parcel Service at their R&D facility working on voice recognition systems. Finally, John worked as a staff engineer at Lorex Industries working on the design of optical and acoustic measurement systems for the telecom and semiconductor industries. He left industry to attend graduate school after completing his second bachelor's degree, this one in Physics, at the State University of New York at New Paltz. At John Bapst High School, John worked closely with students from general physics classes to help them produce sensor-oriented projects for annual physics project competition. Furthermore, John introduced electricity into the curriculum of ninth grade science classes. John Krassikoff left the GK-12 Sensors! program in October of 2003.

Kenna Lampron from Standish, Maine received her Bachelors degree from the University of Maine in Electrical Engineering this past August and is currently working on her MS at the University of Maine in the same field as her undergraduate study. Her research involves semiconducting metal-oxide (SMO's) sensors. More specifically, she is working on fabricating, and testing a hydrogen sensor to detect leaks from fuel cells for an automotive applications. Kenna has been working with Wes Hedlund's Biology class at Bangor High School. She has developed portable modules for biology classes that focus on PH sensing. These modules have been performed at both our suburban and rural schools.

Michael Lewark from Jonesport, Maine, is a candidate for a PhD in Electrical Engineering at the University of Maine. He received his undergraduate degree in Electrical Engineering from the University of Maine in May of 2003. Michael's area of research is in material characterization for microwave acoustic applications. He is working with the science and math classes Jonesport-Beals High School (JBHS). At JBHS, Mike has introduced electricity into the curriculum of freshmen physics classrooms. He has designed and implemented a number of Lego Mindstorm-based modules at JBHS. These modules are designed to help students detect light, sound and rotation. They also have a basic programming element.

Andrea Martin from Indiana and received her degree in forensic chemistry from Ohio University. She is currently pursuing her PhD in chemistry at the University of Maine and works on the development of a nitric oxide gas sensor in the Laboratory for Surface Science and Technology. At Bangor High School, Andrea is working with the students in the chemistry classes. As a fellow, Andrea has developed one of only two air quality monitoring stations in the state of Maine. This station is located at Bangor High School. She has designed a number of modules around the station and has developed a system for the dissemination of this information to our satellite schools. In the summer of 2003, Andrea traveled to Brescia, Italy to take part in a program related research experience at the University of Brescia.

Erik McCarthy, originally from Greene, ME, is a graduate of Leavitt Area High School in Turner. He received a B.S. degree in Electrical Engineering from the University of Maine in May, 2003 and currently is working on a Master's degree in Biological Engineering. His graduate

research focuses on biosensors that may be used to detect pathogens in water supplies. Erik joined the GK-12 program in February, 2004. Most of his classroom time has been spent in Computer Programming at Bangor High School, where he has taught C++ programming language fundamentals and worked with Lego Mindstorms. He is also learning some of the modules now in place in the Math Department. At Sumner High School, Erik assisted teachers in presenting a unit on Mars rovers.

Brad Neumann is a Master of Science candidate in the Department of Resource Economics and Policy, and joins the GK-12 Sensors team from Northern Michigan. He received his Bachelor of Science degree from Northern Michigan University where he dual-majored in Economics and Land Use Planning, and studied Geographic Information Systems (GIS) as a minor concentration. Brad has worked as a GIS intern for Environmental Systems Research Institute, Inc., and has also worked as an independent consultant on GIS and land use planning projects. His research at the University of Maine primarily deals with evaluating the effects that preserved land has on neighboring property values. Brad was brought into the program in 2003 as a social science fellow. This was done to expand our program into the social sciences. Brad is working at Bangor High School in the Social Studies Department and is primarily involved in Mr. Smith's civics classes. Along with fellow Eeva Hedefine, Brad has developed the Bangor, Maine GIS Emergency Mapping Module, which is detailed in a later section of this report.

Stephanie Pitcher is currently a MS degree candidate in Electrical Engineering and may continue her research for a Ph.D Stephanie's research is focused on developing an impedance based metal oxide gas sensor for ethylene detection and fruit ripening. Stephanie grew up in Washington State during elementary and high school, and studied at the University of Colorado at Colorado Springs for her undergraduate BS degree in Electrical Engineering. She is working with the biology department (Biology level 1, AP Biology, and Marine Biology) at Bangor High School. Stephanie is one of two fellows who have worked with NASA to develop modules for our classrooms. Along with fellow Danielle Donovan, Stephanie has been central in the development of the Sensor Sensitive program, detailed in later section of this report.

Anthony Puckett just completed his PhD in mechanical engineering. His research focused on ultrasonic methods for material characterization using solid cylindrical waveguide used in non destructive sensing. Anthony was born and raised in New Mexico. He received his BS and MS in Mechanical Engineering from Colorado State University. Anthony worked mainly with the pre-calculus classes at Bangor High School. He developed a number of motion detector-based modules which were implemented at BHS and have subsequently been disseminated to our satellite schools. Anthony Puckett left the GK-12 Program in April of 2004.

Becky Woodward, a Ph.D Student, is conducting a cross-species comparison of the morphologies and performance abilities of four baleen whale species. Her work involves the use of suction-cup attached, multi-sensor data logging tags to monitor the underwater movements of large whales at sea. Data recorded by the tags include depth, roll, pitch, and heading as well as acoustical information which will be used to analyze the animals' diving performance and swimming biomechanics. Becky designed a whale watching module that brought students from several schools to the coast of Maine to observe and classify the habits of humpback whales. Becky Woodward left the Gk-12 Sensors! program at the end of 2003.

Contributions to Other Disciplines:

During the 2003-2004 academic year, GK-12 Sensors! made significant inroads into ninth grade Civics and Health classrooms, disciplines not commonly engaged by GK-12 programs. At Bangor High School, four fellows have been working closely with Civics teacher Jim Smith on two pilot programs. The first program, The Bangor, Maine GIS Emergency Mapping Project, is a Homeland Security program that incorporates GIS technology to map the emergency resources of Bangor, Maine. The maps the project produces will be dotanted to the Bangor Fire and Police Departments, which currently do not have maps containg this information.

The second project is the Sensor Sensative project, which utlizies CHOICES Interest Survey software to educate ninth grade health students on a number of math and science related fields. This project is designed to have a direct impact on students actively pursuing disciplines outside of math and science.

Contributions to Human Resource Development:

The major goals of the project are achieved by using sensors as the vehicle to encourage students to pursue science and engineering careers. To this end the fellows act as role models, as well as teachers. Emphasis toward encouraging underrepresented groups in science and technology, including females, minorities and disabled students is important to each teacher, faculty member and fellow working in the GK-12 Sensors! Program. It is anticipated that this program will significantly increase the number of high school students in Maine who will be choosing future careers in science and engineering.

Contributions to Resources for Research and Education:

Teachers at all six of the schools we interact with contine to develop portable sensor modules for dissemination to other schools in the fall of 2004.

Sensor research is an interdisciplinary field with applications in all areas of science and mathematics. The students are introduced to the scientific approach to problem solving and invention.

The students are using math, physics, chemistry, biology, electrical circuitry and drafting knowledge to create laboratory sensors that employ the principles of the most advanced technology systems.

The facilities at the Laboratory of Surface Science and Technology are available for research opportunities. Group and individual visits to LASST have enhanced the GK-12 Sensors! classroom experience.

Contributions Beyond Science and Engineering:

The project leaders are working with the city of Bangor, Maine. Stephen Godsoe, Co-P.I. for the project, made connections with area and city officials and Maine's Department of Environmental Protection so that students could collaborate with these representatives, Fellows, and teachers to monitor noise, water quality, air quality, etc. Students can help with Geographic Information System (GIS) mapping to benefit the Fire, Police, Engineering, Planning, Community Development Departments and Bangor International Airport.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Site Visit ñ University of Maine GK-12 Projects
Harriet Taylor
May 18-21, 2003

Overview

A site visit was conducted to the University of Maine at Orono. The primary purpose of the trip was to visit the Sensor Technology GK-12 project headed by Dr. John Vetelino. The project uses applications of sensors to expose secondary students to science and engineering. This project has just completed its first year, with activity in many classes at Bangor High School (BHS) as well as extension to John Bapst Memorial High School in the spring. The project has completed a very successful first year, exceeding the expectations of the PI and others involved. The sensor technology emphasis is an unusual specialty for high school. The fellows and the teachers they work with have found many ways to fit this into the curriculum naturally and productively, engaging the students in unusual ways. The project has received a good deal of public awareness and is helping the school to branch out to other community involvement projects. Taylor spent two days visiting this project, including meetings with the fellows, the university faculty and administrators, the teachers, and the secondary students.

The other component of the site visit was an informal dialogue with the environmental science GK-12 project headed by Dr. Susan Brawley. The Brawley project has just completed its initial funding and is beginning a second funding cycle to spread to four more rural schools. The project is part of the AIR evaluation study and thus was not subject to intense study itself as part of this site visit. The focus of the dialogue with Dr. Brawley and then Drs. Brawley and Vetelino centered on how NSF can manage multiple sites at the same institution and how they may cooperate, collaborate, and benefit each other.

The first part of this report will deal solely with the Velelino project. It will include positive elements, challenges and recommendations as well as an account of the various meetings. The second part of this report will deal with the meetings to discuss issues around multiple projects at the same site.

Report on the Vetelino Project

Current Status

The project is just finishing its first year. They have recruited two new Fellows for next year, but will keep most of their core group from this past year. They are preparing for the summer workshop with the Fellows and the participating teachers. They plan to expand the project next year to include four more teachers from more remote areas. These sites were picked to provide diversity and to provide resources in areas of need, thus impacting the state. The four new teachers will participate in RET experiences, real research projects, not simply preparing classroom materials, during the coming summer. One possible major change is that the project coordinator may be leaving at the end of the summer and a new coordinator must be found and transitioned during the summer.

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Strengths of Project

There are many excellent components of the project evident at the end of the first year. These include:

1. The PI has built an excellent team, including outstanding teacher leaders within the high schools.
2. The project is built solidly on leveraging RET experiences. The project emerged from a summer RET group experience. PI Vetelino wanted to do something with high schools and worked with Co-PI Godsoe (a RET teacher) to bring the project together.
3. There was a good initial group of fellows who started off in the project. They all took an intense (but elementary) sensor class in the summer to familiarize them with simple uses of sensors that they might adapt for the high school.
4. The field sites are carefully planned to benefit the state. The choice of Bangor High for the first year was wise. Bangor High is an excellent school, honored for its excellence. The teachers at Bangor high are outstanding and have been exemplary role models for the Fellows as well as each participants in the new classroom experiments. The project currently enjoys an excellent rapport with the school district and the teachers as well as outstanding leadership in the two schools. They expanded this spring to John Bapst High School, again to connect with one of their prior RET teachers. It will be interesting to see if they can manage this level of trusting relationship with other schools as they expand to new sites.
5. The project has carved out a unique niche ñ curricular units based on sensors. There was considerable skepticism among all participants about this approach when the project started. All seem to value it highly now! Thus the niche is firmly established.
6. The project has generated a great deal of enthusiasm on which to build. The decision to use a team approach during the summer workshops and pair Fellows and teachers was a wise one. It has resulted in enthusiastic teachers and Fellows as well as high school students. Many students have been able to do special projects and explorations as the Fellows have taken on special projects in addition to their assigned classroom duties.
7. Everyone noticed a significant personal and professional growth in the Fellows during the year. They seemed to gain in responsibility, time management, communications skills, and general confidence.
8. International Extension. This summer two fellows and two faculty members will conduct research with universities in Germany and Italy. Perhaps this can bridge cooperative projects between classes in these countries. This is an exciting and rewarding professional experience for both Fellows and the high school teachers.

Positive Results

There are many positive results. Those most frequently cited included:

1. Enthusiasm for project from all participants and stakeholders
2. Community outreach and impact

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3. Revitalized teachers
4. Grad student formed support clusters which may influence degree completion
5. Fellows have a positive teaching experience; one Fellow changes career to be high school teacher, university faculty feel that other Fellows may make excellent faculty members

Problem Areas

As with any project, the focus on the first year was getting off to a good start. There have been some problems, but the overall feeling is that the positives greatly outweigh the negatives. However, the PIs now need to focus on refinements to address the problem areas before starting another school year. Among the concerns were the following:

1. Undergraduate engineering students have problems committing time. They are not paid well and have too many courses with little flexibility in scheduling in their final year. The project will limit the use of undergraduates or not use them in future years.
2. Participation in the project involves an initial steep learning curve that is time consuming for fellows; many are spending more time than required. This should even out over time. A small number of the Fellows are not engaging the students in meaningful ways, relying on lecture and demos and no hands on activities. These Fellows need significant attention if they are to be in classrooms next year.
3. The project took an interesting approach of trying to reach every mainstream ninth grader ñ through a civics class. The results were enjoyable, but not hands-on and not science. Fellows need to be working in or near their scientific discipline and working with a master teacher who mentors them in science education and their discipline. Some way must be found to achieve similar goals but through science teaching experiences ñ hands-on, as well. The ninth graders also commented on the lack of hands-on work. It is clear that the teachers involved in this part of the project are very enthusiastic. It would be good if some way were found to include them in a meaningful and appropriate way, but not with three Fellows who are not doing science.
4. The evaluation consultant does not appear to have a good plan or commitment to the project. He has not visited any classrooms during the year and has made only token efforts. No reports have been generated and there is little baseline data collected. The teachers see some impact and want to be involved in measuring it. Evaluation must be re-designed, hopefully with an outside group taking the lead in the design and administration of instruments. Baseline data must be established and realistic ways to measure project goals established.
5. Communications between project participants is a major problem. The Fellows are not meeting regularly ñ the last meeting of them as a group was in January. There are no planned meetings with the high school teachers, who feel somewhat abandoned by the university faculty. University faculty must be in schools and meet with the teachers at the school sites regularly. The teachers could also find the opportunity for continuing education units tied to quarterly meetings a very positive reward for their participation.

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6. Co-PI Holden has been charged with overseeing the Fellows and their work in the schools. She has a significant teaching load and is unable to commit large amounts of time to this effort. Some relief must be found, either through graduate student support for Holden, release time, or another person to share in these responsibilities, particularly when the project expands to more remote sites.
7. Dissemination is a major problem. More communications and dissemination is needed. The Web site needs to serve for both public outreach as well as participant support. Some consideration might be given to contracting this function out, at least a model for an exemplary site that covers all aspects of the project.
8. One graduate student's research on whales takes her away at critical times. They have been able to juggle her classroom responsibilities, but it is difficult to coordinate training and other events. Availability at key times may need to be a consideration in selecting Fellows.
9. Replacement of project coordinator and a smooth transition may be a major concern for the summer.
10. Keeping the project manageable is difficult with the many enticements to branch out in many directions. A current strength is the clear focus and manageable level; the PIs must keep this and do controlled expansion; maintaining a good balance between more fellows in the same school and outreach to new schools will be critical in the next year.
11. Currently there is no participation at all by the College of Education. It seems that they could be some useful collaboration, possibly with graduate students serving as consultants in preparing meaningful classroom activities as well as in evaluation efforts.
12. Preparation of Fellows for entry into the classroom is problem. The Fellows and their mentor teachers all felt that the Fellows were ill prepared for the school environment. Many had difficult starts and experienced problems adjusting to the high school culture and the diverse learning styles of high school students. Bangor High has a complex daily schedule of 8 periods with 40-minute class sessions. There is little time to waste or to mentor during class meetings. More needs to be done upfront to plan a reasonable transition period for the Fellows and prepare them for the classroom.

Recommendations

1. **Keep under control** ñ plan new initiatives, sites carefully - Practice controlled growth
2. **Evaluation** ñ PIs must take a more active role in evaluation planning; a new evaluation team needs to be found; the PI must meet regularly with evaluators and help develop a work schedule and list of deliverables, including regular reports which are monitored; the PI might consider models that have Fellows collecting baseline data in the fall as a way of getting the Fellows acclimated to the school environments. The project is well positioned to compete for future funding in several areas, but will need data to support

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claims of success. Try to measure impact on learning as well as impact on college entrance.

3. **Coordination and communication with all stakeholders**

The PI and project staff need to hold regular meetings with Fellows. They also need to have periodic debriefing sessions with the high school faculty and involve the high school faculty in planning for summer workshops. The Web site needs to be modified to serve as a meaningful coordination tool for participants and a way to spotlight success. The teachers suggested that they would also like to see a regular newsletter to keep them involved in the project and up-to-date on what is going on.

4. **Maintain a focus on science.**

Fellows should focus on hands-on science and work in a science discipline closely related to their own fields, or at least in areas relevant to them. This will require revisiting the 9th grade civics model and involvement of those Fellows in more meaningful ways.

5. **Better preparation for the classroom.**

Fellows need to be better prepared for the classroom during the summer and phased into directing classroom activities. They need to be placed in disciplines and environments where they are comfortable. Students must have more help in preparing for the classroom and in the principles of inquiry-based learning. Fellows might try out modules on each other and practice, to get a degree of suitability for the classroom and to test the equipment and set up before the classroom experience is to take place.

6. **Classroom visits by project staff.** Fellows and mentor teachers need to be visited regularly by project staff. It is important that a visit fairly early in the experience is held to intercept and address problems and that an ongoing dialogue with the mentor teachers (without the fellows) is established.

7. **Plan summer activities carefully with input from practicing teachers.**

Focus on the fit of sensors into curriculum and keeping models that are most effective. Develop ways to help fellows who are having difficulties and ease Fellows into the classroom environment gradually. The project may need some support from a consultant, perhaps from the College of Education or the other local GK-12 project who is in school setting frequently and regularly early in project.

8. **Refine the policy towards sensors**

Allow Fellows to show expertise in general and sensors where they logically fit. There is not enough time to force sensors into every learning situation. Forty minute class periods are challenging, with little time to waste or re-teach. Identify best modules, disseminate and reuse. A Web site that disseminates these modules could be fundamental to establishing the sensor approach as a viable pedagogy in high schools across the nation.

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Visit Log

Sunday, May 18, 2003

Taylor arrived in Orono on Sunday afternoon and checked into the Big Bear Inn. PI Vetelino picked her up for dinner at the Chocolate Grill. They met Co-PIs Dr. Constance Holden of the University of Maine and Stephen Godsoe of Bangor High School. The group generally discussed the project including the events of the past year, the impact, and the plans for the coming year. All agreed that the project had run very smoothly and had far exceeded their expectations. They saw tremendous growth in the Fellows as well as in the high school teachers and students. There was a clear thriving partnership that was driving the project.

PI Vetelino recounted the origins of the project. Vetelino is a successful researcher with significant research funding. He has been at the university for several decades. He felt a need to do some outreach in the high school as a way of increasing engineering enrollments. He started by obtaining some funding for a group of RET teachers. Co-PI Godsoe was among the first RET group. The proposal and this project was an outgrowth of the summer RET experience. Vetelino had little prior experience with secondary schools and teachers prior to this project. He is an excellent leader and has carefully formed his leadership team so that he can lead and still continue his many research projects. Much of the day-to-day operation has been placed in the capable hands of project coordinator Sandra Hale. Co-PI Holden has been an excellent liaison between the fellows, the university faculty and the schools. Co-PI Godsoe has done an outstanding job of overseeing the implementation at the school level and helping develop the vision for the activities and outreach.

Co-PI Godsoe has taught 36 years. He says that this year there was more collaborative activity at his school that he had ever seen before. Prior to the project he was considering retirement. He no longer is considering retiring; he wants the project to go on for 6 years so he can be a part of it. Godsoe is chair of the math department and thus is involved with the teachers at several levels. He related that this project was changing teachers and students. The Fellows spend their days with many teachers and the project was developed so that every mainstream ninth grader was part of a project class this year. They are now making plans for next year with a focus on how to continue to reach new student groups but to reinforce the experiences for the ninth graders. Evaluation of the impact on this group of students for long term educational and career impact in the future could be beneficial. Godsoe and Holden recently collaborated on a proposal to restore a watershed stream to benefit wild Atlantic salmon and other native fish. The project involves local, state and federal partners as well as secondary students, teachers, and Fellows. Funding is requested from NOAA; they anxiously expect word on the funding any day. Godsoe reports that the project has created excitement at the school. He could easily get many more teachers to participate; his biggest challenge seems to be to resist spreading out in too many directions.

Co-PI Holden spoke of the impact on the secondary students and the Fellows. She has spent a good deal of her time in the schools observing the classroom interactions as well as working with the Fellows. Holden reports an excitement among the high school teachers over the real applications and uses of the sensors but also a new awareness of privacy issues and responsible use of technology. She reported that prior to the project, the Fellows had limited experience in secondary schools and that they were a bit nervous about the challenges facing them. She has seen them evolve into a very confident, able group that has worked well within the classroom

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structures. Fellows engage the secondary students and interact with them on a personal and professional level. They provide technical and discipline expertise well beyond that of most of the teachers. They are serving as role models for the high school students and thus encouraging interest in science and higher education. She has also seen a marked change in the ability of the Fellows to speak to group and make oral presentations, particularly about their work and discipline. Like the others, time management is a major challenge as she acquired significant new responsibilities with this project but no release time.

The group talked about all facets of the project including: training of Fellows and teachers; different models of placement of Fellows in schools and with various teachers; problem areas and challenges; successes and surprises; possible outreach and modifications; and selection and recruitment of the Fellows. The group discussed the long range goals of the project, such as increasing interest and enrollment in science, encouraging graduate students to pursue academic careers, and increasing numbers of underrepresented groups in science courses. Since the project is just in its first year, it is far too early to measure success on these goals. An external evaluator is following Fellows and interviews participants to track long range impact. There are signs that the project is having positive impact, but hard numbers are not yet available. They have been careful to select a reasonable number of female Fellows so that there are good female scientist role models in the schools. They also reported that one Fellow had already declared her intention to change careers ñ to become a high school teacher.

At the end of the evening, PI Vetelino drove Taylor back to the hotel. They discussed the plans for the two days of visits specific to the sensor project and planned for the exit interview dedicated to the sensor project to take place during dinner on Tuesday evening.

Monday, May 19

Project coordinator Sandra Hale picked up Taylor for a breakfast meeting with two Fellows, Andrea Martin and Stephanie Pitcher

Project coordinator Hale said she was lucky to be the person watching things evolve during the year. She described the transition from the time when they selected Fellows and were still very uncertain about what would happen to the current time. She felt that the August workshop with the faculty mentors was a pivotal point in the project.

Fellow Pitcher first visited the Orono campus as a participant in a summer Vetelino REU site program and decided to pursue a graduate degree at the university as a result. Fellow Martin reported that she had absolutely been against applying to participate in the project but was encouraged by her faculty advisor. Her experience had been so profound that she has decided to make a career change and become a high school teacher. Both of the Fellows had participated in undergraduate research experiences in some way prior to entering graduate school.

Both Fellows reported that the first days in the classroom were traumatic. They felt overwhelmed as if they had been thrown to the wolves. As the year progressed, so did their comfort level in the schools and their enjoyment of the project. Fellow Martin has gotten particularly involved in the school, taking on two senior independent study students.

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Both Fellows plan to concentrate on their research this summer. They felt that the project enhanced their graduate student research. Before, they quickly got bored with the routine of simply doing research in an isolated lab environment every day. The GK-12 school component provided a break and chance to be around others doing science. They felt they used the time in the lab more productively as a result.

They reported that their time in the schools had increased over time. As they got more proficient, the students got more excited and were eager to have the Fellows in their classes. At the same time, one Fellow reported that she understood her own research better from having to break things down to fundamental components and explain them to the high school students.

9:00 am ñ 12:30 pm ñ Fellows presentations

The morning was dedicated to a meeting with the project staff and the Fellows. PI Velelino provided an overview to the project. Each Fellow gave a brief overview of his/her role in the project. Taylor asked each Fellow to address three items:

1. What has been the impact of the project on the Fellow, the teachers, and students
2. What has been the most difficult part of the project?
3. What is the most exciting or unusual thing that has happened to you in the classroom?

Comments of the Fellows are summarized below:

Eric Berkenpas is pursuing a masters degree in Electrical and Computer Engineering. He is working with electronics classes at BHS.

UM research - developing a sensor for detection of bioterrorism linked pathogens in the liquid phase (NSF ñ SGER project). At BHS, electronics, manufacturing, CAD 3. Used Play-Doh to teach electronics students about current flow. Students created resistors out of Play-Doh and measured how current flow was affected by shape. Photolithography process, CAD students each designed a photomask and some of the mask designs were used in research at LASST. (would be good for students to see circuit board they designed that was made put to use.) Intro to transistors (lecture and demo), enough info to be dangerous. Student tried to rev up his stereo. Earthquake tower sensing, annual project to build tower, sensors measured forces during simulated earthquake. Hands-on activity on ac voltage and oscilloscopes. (clear that he had a good time, mostly passive student engagement, needs to include students more). This week will build crude eco-location system, raided lab for equipment.

Impact ñ All students really into electronics. Students all want to be technicians, trying to get them to be engineers.

Difficulty ñ Start with concept and then must do math background that is needed to support it. Getting them started.

Unusual event ñ Teacher left room and student tried to glue classmate to chair. First time had to take disciplinary action. One female in electronics class ñ dropped out. Some of kids go to UTC.

Danielle Donovan is pursuing a masters degree in Spatial Information Science and Engineering. She works with the senior seminar students at BHS as wells as with advanced drafting classes and geography classes. Voting machine unit, guns and war including sensors. All fellows helped them put together leadership module, sensor sensitive (Leadership traits, student interest in leadership, UMaine hockey captain came to talk to class). Touched about 400 freshmen with it ñ

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career. (Hard to see science here, use of sensors). Advanced drafting lab, GPS lab, students draw routes and digital maps using ArcView GIS labs, will do mapping for Kenduskeag Stream project next year. Geography (tropical deforestation, desertification, students researched possible solutions and presented to class). She is also helping coach track.

Impact ñ Has given her confidence to speak in public, students have learned a lot from their experiences. In end of year career choices, a few mentioned engineering and sensors.

Difficulty ñ How time consuming it is to be a teacher and prepare presentations.

Unusual event ñ Field trip to lecture series, during end, some guy swearing about war, kids scared.

Lester French is pursuing a Ph.D in electrical engineering. He worked with the senior seminar classes, but focused primarily on chemistry classes at BHS.

Worked for lighting manufacturer prior to grad study. He did some tech training for industry and some university teaching prior to this. Integration into chemistry curriculum has been smooth.

Extensive work in implementing Vernier sensors into labs ñ Vernier sensors particularly geared to high school. Examples: ozone sensors, sensor journal (small research paper reviewing articles on chemical sensors, focus on environmental monitoring), water purification, Union River sampling, photoelectric effect, HoltraChem plan presentation to social studies, x-ray diffraction and electrochemistry. Would modify journal assignment in future. Assistance of faculty has been invaluable (enthusiastic and helpful, answered all questions, not afraid to let Fellows make their own mistakes). Students more interested in lab uses of sensors than in research papers. Has interacted with chemistry classes at all levels. Definite interest in using sensors developed at LASST in the chemistry classes. What has he learned: preparation is key to good classroom activity, for highest efficacy the classroom activities must fit with the curriculum, and high school students don't know everything that he knows (what is basic knowledge for him is not for a 16 year old ñ took him 6 months to get into his head).

Recommendation ñ Germany trip, look into collaborative efforts between students and teachers in Germany and BHS, collaborative projects, dialogue, exchange programs. (He and a teacher will go to Germany to participate in a research project this summer.)

Impact ñ had a good idea that he wanted to go into academia and teaching before, has strengthened it (if success with hs, can do good job at college). Thinks he did good job. A lot of fun working with hs students.

Difficulty ñ high school students difficult from college students, goal oriented (get good grade, graduate, etc) and not necessarily learning. Explored areas where no 'correct answer' ñ gray areas, students have difficulty dealing with gray, no correct answer.

Unusual event ñ Great student in honors class doing lab on telling how materials metal or not, basic conductivity meter, students always try to get reaction, Adam made it go off. 10 minutes after school kid back to see why it is working. As year progressed you could see him getting more and more interested in science. Will develop more of interest in future. Will help get student into sciences.

Eeva Hedefine is pursuing a masters degree in Spatial Information Science and Engineering. She works with the senior seminar class, as well as civics, geography, and advanced drafting classes at BHS.

Eeva studying SIS and Eng, research on privacy issues related to sensor use. UM BS in Spatial Information Engineering, Maine HS grad.

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Worked with large group of teachers, senior seminar, geography, drafting, etc.

Sensors in Our World, sensor-related articles (GPS, electronic noses, Shaws card, SARS, car rental companies use GPS). How to use sensors to deal with SARS ñ thermal detectors at airports to see if individual has unusually elevated temperature. Privacy unit team taught (identity theft, smart badge, etc) Casino unit ñ upcoming vote in Maine on casinos.

Impact Great to see students get excited about sensors, able to demonstrate sensor use in everyday life and deal with social impact. Never contemplated teaching before, now seriously contemplating it.

Difficulty Trying to feel at ease speaking in front of people (initial), now how to make presentations more interesting and how to do hands on.

Unusual Event ñ Freshman at beginning of year very immature, no confidence, at beginning of year wanted to be pet shop owner, end of year wants to be computer programmer.

John Krassikoff is pursuing a Ph. D. in physics. He is working with the physics classes at John Bapst Memorial High School.

Specialization in surface sciences. Research in manufacture of SiAlON thin film coatings useful as high temp fracture resistant coatings; Air Force interested in research. Only fellow to work in 2 different schools ñ first with Godsoe at BHS in math dept. At BHS, demos using sensors to illustrate concepts. Dec 2002 moved to John Bapst to work with Scott Burgess and one other physics teachers. Five classes, one AP, one honors, three regular physics all college prep.

Teaching physics curriculum, preparing lab sessions, instructional support and tech assistance to students as they complete their sensors-based senior physics projects. 75 students in team projects, 3-4 students each using six step engineering design process. Examples of projects: using temp sensor on a remote control vehicle to identify a flame source and automatically discharge a water spray to extinguish the flame, building a simple mobile robot that uses terrain avoidance techniques to traverse a room, a microprocessor based VF computer input device, using optical velocity sensor to measure the sweet spot of a baseball bat, using a magnetic sensor measure to force amplitude of an inelastic collision of a ball and a pendulum, and optical sensor to detect DNA strands in an electrophoresis experiment. Problem ñ amount of time students have had to do work, doing amazingly well despite limitation. Will try to be ready for science fair next October. Many ideas for next year. Need to integrate sensor activity with Maine Learning Results and national standards. Move down to freshman class Intro to science next year.

Impact ñ Positive experience. Part of the class not an outsider. Enjoyed working with the students.

Difficulty ñ Surprised with lack of fundamental skills (in putting things together, building things) that kids do not have. Next year, work parallel to teachers on projects to teach hand tools and soldering.

Unusual Event ñ Kids very quickly accepted him in classes (gone on trip, missed regular day). Kids upset he was not there on regular day.

Andrea Martin is pursuing a Ph. D. in chemistry. She works with the chemistry classes at BHS. Is changing career to be high school teacher. Research at LASST ñ nitric oxide gas sensor using silver/gold modified tungsten trioxide. Worked with Lester French on chemistry, Cary James (honors and AP chem.). Photochemical smog independent study with 2 female seniors. Paired with Cary James in August ñ he was interested in air quality. Good presenter. Talks about students in informed way, connected to students. Maine DEP person spoke, brought Maine DEP

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ozone detector. Let BHS keep for rest of year. Students monitor ozone daily, have since Feb, now a state site. Can keep thru summer. Quarter three interfaced ozone detector with computer to simplify data collections. Last quarter, gas unit ñ individuals designed their own experiments, ozone in Maine, ozone in Bangor, turned into lesson in using Excel. Quarter 4 ñ Thursday are Demo days, small portable test unit designed and built at UM and taken into class. Electronic nose demo. Sensors not nearly as selective as nose. Took independent study students to Cadillac Mountain to study ozone (high, influenced by air from Portland) ñ visited scientist there. Will participate in summer research with teacher in Italy.

Impact ñ has made career change decision

Difficulty ñ staying creative with making all assignments related to sensors.

Unusual Event ñ water quality lab with level 2, 1, and honors ñ what a difference. Level 2 (lowest level) performed better than honors students (maybe more practical and not as book-oriented, more task oriented, more collaborative, independent. Honors class horrible).

Stephanie Pitcher is pursuing a masters degree in electrical engineering. She works with the biology classes at BHS.

Came to UM to do masters (result of work her in REU site project). Her research - Fruit Ripening sensor to improve quality and freshness of fruit.

Worked in senior seminar and civics on Homeland Security (ABC weapons, bring in Bernhardt LAAST ñformerly at Pentagon, airport security brought in Director of Bangor International, Privacy Issues, Satellites). Environmental Issues ñ connected to nearby environmentally challenged sites. In presentation, only mentioned lecturing. Senior seminar ñ college survival tips, they are the role models. (not enthusiastic presenter, only mentioned lecturing as a mode of instruction)

Also, biology classes ñ what is a sensor, fruit ripening sensor (tongue as sensor, fruit ripening sensor).

Impact ñ Enjoyable experience. Interaction with students and teachers beneficial and enhanced presentation skills.

Difficulty ñ Freshman too test oriented want to know what they need to know for test. Spoon fed, what is required.

Unusual event ñ Student bit into fruit ñ awful, ready for sensor to help. Student wrote resume (during career module) and actually got job.

Limited view, narrow view of learning, engagement.

Anthony Puckett is pursuing a Ph. D. in mechanical engineering. He is working with pre-calculus classes at BHS.

Showed picture of his child that was born in January ñ the last time the Fellows got together. Research at UM on ultrasonics and cylindrical waveguides. BHS with math dept. Lectures on given day illustrating applications of math in daily life. Math labs where sensors are used to illustrate math concepts or where math is used with sensors. Wave propagation, sequences and sums of bouncing bodies, distance sensor triangulation, and conic sections. Interesting conic section activity using flashlights ñ got from Internet. Nice hand on ellipse device. Started (with teacher) JETS (Junior Engineering Technical Society) national organization to promote interest in math, science, and engineering. Regular JETS meeting, he brings interesting sensor apps to each meeting. Good hands on teacher ñ very student oriented. Participated in JETS competition,

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first in state, 21st in nation, only a few weeks to prepare. Ex ñ tower with index cards (in half an hour) that will hold a brick, catapult.

Impact- Students excited on days he is coming, ask questions that are not related to topic.

Realized that he should consider possibility of teaching. Scared of tenure proposal writing.

Difficulty - Not knowing the student's knowledge base (ex, presented matrices example and student not familiar with background math). In college, if no questions, keep going. In high school, if blank stares, go back over it. Small classes more interactive than large.

Unusual event ñ Doing bullet plots with calculus class, student asks for equations to use for computer science assignment. Lot of students never seen spirographs before.

Problem. Most of math teachers do not have science background, harder for them to do.

Becky Woodward is a Ph. D. student with an individualized program

Studying swimming biomechanics of large whales using electronic tags, interdisciplinary program, individualized doctoral program

Showed students in bio classes ways to incorporate engineering in biology. Interaction with marine biology class (1 semester course, new group this spring).

Unit on whales and dolphins. Field trip ñ whale watch tour in Bar Harbor (funded by NSF).

How hard is it to find a whale? Commercial whale watch adventure, no use of sensors. In class

brought in tags from whales. Process of putting tags on, getting off, recovering data. Spring,

included all marine mammals. Learned in falls that students needed more hands on experiences,

tried to incorporate in spring. Blubber Glove experiment, Comparative functional anatomy lab

(no whales in spring ñ different hands on activities) whale skeletons and other mammal skeletons

and how adapted to environment of animal (horse, etc), 10 varieties of skulls, assembling the

Minke Whale (borrowed skeleton from College of Atlantic), photo id lab to identify whales and

chart their locations (used her photos and research from British Columbia). What students have

said

Quotes from students

ì Education and boring are not longer synonymous in my vocabularyî

I think the whale watching trip put things into perspective for me. It's never quite the same hearing about something Ö .

Next year ñ has buried dolphin body in horse manure, will dig up, reassemble.

Impact ñ has nice student quotes, get copies of slides

Difficulty ñ Used to college where everything lecture, found out that did not work so well with high school students, needs more hands on. Had to develop resources herself.

Unusual event ñ Managing all the students on the boat for whale watch, getting them to do experiments, student sick, others on boat. Grant paid for whale watch ñ other ways to do, to get exclusive use of boat and naturalists.

Tim Johnson ñ only current undergrad, new to program, started in February

Graduated past Saturday. Big time commitment, doing senior project, graduating, etc. Had reduced time commitment. Also musician, excels in Math and Science.

Worked with music kids and materials class and seniors at BHS. Musical Instrument project for independent study music students. Student gifted in math as well as music. Branched out to

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materials and electronics class. Characteristics - optical sensors type of instrument, laser beam sensors, musical signal created ñ make harp. Play strings by breaking light. Just got PIC microcontroller (theory before). Now into structure design (working with materials class). Idea ñ use engine, each cylinder holds laser, break light to play. Space program unit based on his experience hearing astronaut.

Impact ñ On him, had previously considered teaching, going into program was test. Realized that he does want to teach, will get some experience in field before pursuing a teaching career.

Difficulty - Time commitment. Wanted to put a lot of time and could not. Unfortunate ñ went in Monday and got them excited, not until Friday until went back. Project passed on, sophomores returning and can continue, Anthony may pick up.

Unusual Event ñ he is BHS grad was in rock group, gets recognized as former band member, students surprised that he is engineer and not rock musician.

Lunch 12:24 ñ 2:00 pm

PI Vetelino, Dr. Robert Ladd, Kim Amato, Sandy Hale, Charles Morris (evaluator)

Taylor had a quick lunch and discussed the project briefly with the above group. Main conversations were with Charles Morris, the evaluator, as this was the only opportunity to speak with him. Morris reported little progress with evaluation. He had not been in the schools yet, but was considering going soon.

Ladd talked about one Fellow who was his advisee. The Fellow was having a hard time balancing coursework with the school commitments. The Fellow was doing his research, however, and recently returned from a conference in San Francisco, having won a travel fellowship to present his paper. Ladd reported that many of the Fellows have gone to conferences to present papers.

Evaluator Morris reported plans to capture data on the Fellows expectations and perceptions. It was unclear if anyone was planning on collecting data to measure fulfillment of project goals. He had no plans for annual reports.

The group spoke of an unusual phenomenon in Maine ñ that its greatest export seems to be the students. Maine has one of the highest high school completion rates in the United States (89%) ñ but one of the lowest percentages going to college, particularly within the state of Maine. Most of the students who do attend college, go out of state. The economy is a problem as well. Graduates must go out of state for employment. Many students simply plan to go into the lumber or lobster industry as their parents and thus feel no need for higher education.

Meeting with Vetelino and Holden ñ 2 pm

Taylor talked over the project once more with PI Velelino and Co-PI Holden

They felt things were working well. They had had a generally positive first year and had worked hard to keep the project manageable.

What could you be doing better?

1. More involvement in 9th grade ñ now civics, no sensors

Good interactions at junior/senior need more at freshman

Need to hit them with good science

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2. Some teachers gung ho, Fellows gravitated to them
Good start, got trust, now tweak
 3. Extension to more rural schools
Targeted due to low number of students going on to college ed (Summer less than 15% - become fisherman or lumberjacks or farmers)
Females wait on tables ñ Quite a challenge (accepted at BHS thru internal connection, prior collaboration) oversight difficult
 4. Down the line, look sub 9th grade, middle school
 5. Broader outreach to include more teachers, pd on modules, not necessarily Fellow support ñ broaden RET ñ RET site ñ lot of support for this
 6. Evaluator ñ not much interaction with process so far, want to see evaluator look at from objective sense
Input about modifications to summer activities
No plan for reports, need to formally connect with project, connect to project goals, define reporting structure
Claimed IRB problems but talking about going into schools later this month
Guidance counselor ready to participate, clear that this is a project area
 7. Fellows met as a group in January ñ should they meet more often?
Have them meet
Online discussion, ones at HS meet at HS
Important when get geographically dispersed ñ need same supportive environment
 8. Will this experience make them better researchers? Any collaborative experience contributes, hard to nail down. Will definitely make them better teachers.
 9. Had to modify budget to include project coordinator ñ Holden couldnít do it all. Clear division of labor and works to the strengths of each.
Concerns of Holden next year when move into more distant regions. Hired specifically to teach ñ hard to get release. Needs grad student to do labs. Pay grad student for some sections.
- Recommendations from this meeting
1. 2 fellows that were weakest ñ mentor more, get them actively engaged
 2. Release time or other assistance for Holden
 3. Work with evaluator, get deliverables tied down, or go to outside evaluator, evaluator must be in schools ñ very little done here, many opportunities lost
- + Very supportive environment, caring faculty

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Meeting with Fellows Faculty Advisors ñ 3 pm

Present: Mick Peterson, M. DaCunha, Brian Frederick, Robert Ladd, Harlan Onsrud, John Vetelino

Impact on Fellows?

- Strength of program ñ forcing time management early on, having to balance research, teaching, etc
- One faculty member had to ask student to put less time into teaching, being asked to work too many hours. Compromising ability to be duties as a student.

Is it a good thing for first year grad students or not, two steep learning curves at beginning?

- More like a TA ñ will focus on research this summer. During year teaching plus coursework, research in summer. Teaching module student did good groundwork for research. Now time to get moving.
- Coming out with better multi-tasking skills.

Problems with difference in stipend amount? Some, trying to get stipend improved. \$19K now.

Major advantage of project ñ gets high school kids interested in science.

- Chemistry prep in state so low, math background low, needs help.
- Two high school students working with GK-12 students in lab this summer. ìPorous borderî between high school and university
- Losing top 50% to out of state colleges, private schools ñ will keep higher percentage of top students here
- Have benefits with educational emphases ñ pair with discipline faculty at educational meetings of professional societies in their discipline

Will completion rate of Fellows be higher than non-fellows? Masters versus doctoral, etc

Student positive experience, good speaker. Like groups support as research groups.

- Limit grad students ñ funding dependent, completion rate tied to ongoing research
- To make students more successful. Continuity on this. Looking forward to next year. Model set. Many challenges this year.
- Long range project, need more time to see results
- Another job for Fellows, learned time management
- May pay dividends with increased science enrollment and community connections in future
- May see more students entering and doing undergrad research and going into grad school ñ summer jobs for high school students

Questions about young scholars program, how to include high school students in research, use it as recruiting tool?

- Positive ñ something different;
- Best thing ñ positive feedback, excitement among students
- Communications aspect, about own discipline, putting discipline in laymanís terms
- Good marketing to have students talking about their own research, positive
- Like behind the scenes role ñ more with time

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- Bring in JETS students

Dinner with Fellows at Patís Restaurant

Taylor dined with 9 of the Fellows and Sandy Hale. Fellows talked about challenges of entering the classroom, possible long-term benefits of the project, their career aspirations, and project preparations in an informal setting. The Fellows shared that they have had three group meetings in informal settings with the Fellows from the Brawley project to share experiences and learn from each other. They also said that their opportunities to meet as a group had been limited by schedules - but they were clearly together as a group and supportive of each other. Although U. Maine classes have ended, the fellows will remain in the high school classrooms until the end of the school term on June 11. Most said that they had not been able to be as productive in research as they wished during the school year and that they were planning to focus on research during the summer.

Tuesday, May 20, 2002

Kim Amato picked up Taylor at 7:30 to head to Bangor High School.

8:00 ñ 8:40 Meeting with BHS faculty and students

Taylor meet with a group of BHS faculty and students including Cary James, Jim Smith, Wes Hedlund, Paula Tingly (dean of students) and four high school students (Lucy Gross, David Kleinschmidt, Jue Wang, and Mark Gonyar).

The students described their experiences. Chemistry students talked about research using the ozone monitor. Each student took data from a particular day and made a PowerPoint presentation explaining how the weather that day influenced the ozone level. A senior talked about her independent research project with a Chemistry fellow. Two students discussed their special project building a harp based on sensors.

One student said that things were as different from night and day. He could recite the scientific method backwards and forwards prior to this project but he did not understand what science was. He did not really know what it meant to conduct experiments and test and evaluate them. Now it was ingrained and ì under his skin.î

The Dean of Students said that the Fellows have been excellent role models. She told a story of a young ninth grader who had serious problems acclimating to high school early in the year, crying daily and generally miserable. The studentís career aspiration was to own a pet store. The Fellows worked with the student. Now he is happy and an active part of the school. His current career goal is to go to college and major in computer science.

The teachers all agreed that it had been an enthusiastic first year. They had seen big changes from the Fellows who arrived on campus ill-prepared to deal with students and talking in front of groups. They now see a cadre of very effective teachers (the Fellows) who have very effectively become part of the school community and environment. There was early skepticism about the fit

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of sensors into the curriculum but this had been shown to be realistic. They felt that the coming summer should more fundamentally find ways to fit the sensor units into the curriculum.

8:40 ñ 8:45 BHS Principal Norris Nickerson and Superintendent Robert Ervin joined Taylor and Amato to tour the school. The Superintendent spoke eloquently about the project and its many benefits to the school. BHS is itself an award-winning school with a student body of over 1500 students. 90 percent of the students go to college; there is a standard of success there. There were many banners marking excellence in both sports and mathematics competition. The school had outstanding facilities and was able to offer a wide range of elective courses including architecture, drafting, electronics, multi-media, photography, specialized music and chorus, as well as others.

Superintendent Ervin showed several exceptional facilities, unique for most high schools. The school has built its own observatory with a high powered telescope that can be manipulated remotely through the web. They hope to add astronomy classes soon and to spread these across the state through distance education. They also showed a theater style classroom, wired for laptop use at each seat. They showed well-equipped music, electronics, drafting, and science classrooms.

8:45 ñ 10:40 Classroom visits

The group visited classrooms where the Fellows were working. First was a pre-calculus class where Anthony Puckett demonstrated an imaginative device using a distance sensor to plot time versus distance. This generated sin and cos waves in various magnitudes depending on how the moving object was manipulated. The room the demonstration was held in is slated to be a designated math lab where teachers can bring groups for specialize labs.

The next stop was at the math teachers' work room, a dedicated office room for the 16 math teachers where they can all prepare lessons and meet to work on plans and collaborative activities.

The next stop was the ATM room supporting real time video broadcast. BHS hopes to be actively online soon and use the facility for curriculum enrichment, perhaps to pilot an astronomy class using the new observatory.

The next stop was to Jim Smith's senior seminar class. Three Fellows were talking about smart cards and privacy issues related to technology.

Next was Cary James' chemistry classroom. Senior Lucy Gross (independent study with a Fellow) explained the ozone monitor device left by the state at the school. The chemistry students had plots of data from the ozone detector using hourly averages and exploring various ways to display data.

Next was the observatory and then the large lecture hall. At this point the Superintendent and Principal left the tour.

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Taylor, Amato, and Godsoe went to the CAD Lab and talked with students working with Fellow Eeva Hedefine using ArcView software. They moved onto the electronics and manufacturing lab and talked with faculty member Ken Pratt. They saw projects led by Fellow Eric Berkenpass, who had done several engaging hands-on labs with the students.

They then went to the Chorus room, where undergrad Fellow Tim Johnson was working with the students designing the sensor-based harp. Johnson had just introduced the students to assembly language programming and was helping them debug and develop simple programs. Fellow Johnson was a graduate of BHS, so he had a special relationship with the school and both the music and science faculty ñ he excelled in both at BHS.

Finally, the group visited another Chemistry class where Fellow Lester French had students conducting experiments using pressure sensors to illustrate Boyleís Law.

After a very full morning, Taylor and Amato headed back to Orono to the university for a meeting with the Provost.

11:00 ñ 11:45 Meeting with Provost Robert Kennedy

Taylor met with Provost Robert Kennedy. Provost Kennedy shared the new strategic plan for the university. The first three points were priority areas ñ and they meshed wholly with the project. These included excellence in undergraduate education, supporting further development of university-wide, cross-disciplinary Information Science initiative, and strengthening graduate education as a vital component of the universityís research and outreach endeavors. Provost Kennedy was pleased with U. Maineís funding success, particularly two recent IGERT awards.

The Provost felt that the GK-12 project was outstanding, particularly the focus on sensors. Taylor and Kennedy talked of ways to institutionalize the project, including possible funding of Fellowships in the future. Provost Kennedy saw an excellent fit between the project, the mission of the university, and seemed committed to helping find resources to support the effective elements of the program in the future.

Lunch 11:50 ñ 12:30

The group broke for a quick lunch at the Student Union.

12:35 ñ 1:00 Travel to John Bapst HS

Taylor and Amato met and traveled from U. Maine to John Bapst HS in Bangor. The physics classes at John Bapst were brought into the project in the spring. This extension was selected based on the participation of physics teacher Scott Burgess in a summer RET project.

1:00 ñ 1:45 Visit to John Bapst

Taylor, Amato, and Burgess met briefly with Head of School Allen Adriance. Headmaster Adriance said that the project had been good for the school, despite the late start in the school year.

The group visited Burgessís physics class where students were working in groups on projects with Fellow John Krassikoff. These were fairly major design projects using sensors, such as a car

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that sensed smoke and squirted water and sensors to measure stress on bridges. Taylor talked with four groups about their projects as they demonstrated them.

Taylor and Amato left at the end of the class period and traveled to Bangor High School.

2:00 ñ 3:15 Meeting with BHS Faculty

Taylor met with 6 faculty members to discuss the first year of the project. Teachers were generally positive about the first year of the project. They had several concerns:

1. One expected more help from the university dealing with technical problems with CAD software
2. Others remarked on how ill-prepared the Fellows were when they arrived ñ versus how competent they are now
3. The high school faculty had not had much support from the University, there were no meetings with the university staff after the summer, they were not part of decision making or selection of the new fellows
4. There was praise for Fellow Eric B and all the special hands-on activities he did with the kids. The students in the civics class enjoyed the 3 Fellows but complained that there were no hands-on activities.

The teachers had several suggestions:

1. A regular newsletter or informational update about the project. Perhaps an online discussion board where they could share and discuss problems
2. Much more visible presence of UM staff in the school ñ some way to address problems in a timely manner
3. Better communications between UM and BHS, regular debriefing meetings between the teachers and the UM staff (without fellows present)
4. Involve the College of Education in the project, particularly in helping the Fellows with the initial transition into the classroom

One faculty member related his own success story. Of 50 students in his classes, 5 now want to be engineers ñ a marked increase, including 2 females.

3:30 ñ 4:00 pm Drive back to the hotel

Amato drove Taylor back to the hotel. They discussed the project and other potential funding issues. Taylor spent some time preparing her report. She drove herself to the restaurant for dinner with the PIs and the exit interview on the sensor project.

7:00 - Dinner with PIs

Taylor met PIs Vetelino, Holden, Godsoe and Project Manager Hale for dinner at Captain Nick's restaurant. The group generally discussed the project. Taylor went over her findings ñ strengths, concerns and recommendations. Taylor will send her report to the PI, first to check for factual problems. Then the PI may respond or indicate changes to be made to respond to recommendations.

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People Interviewed

Sensor Project

Vetelino, John ñ U. Maine, PI
Holden, Constance ñ U. Maine, Co-PI
Godsoe, Stephen ñ BHS math teacher, Co-PI
Hale, Sandra ñ U. Maine, Project Coordinator
Morris, Charles ñ U. Maine, Margaret Chase Center, Evaluator
Ladd, Robert ñ U. Maine, Dir. Of LASST, Faculty Advisor
Amato, Kim ñ U. Maine Grants Officer
Peterson, Mick ñ U. Maine, Fellows Faculty Advisor
DaCunha, M. - U. Maine, Fellows Faculty Advisor
Frederick, Brian - U. Maine, Fellows Faculty Advisor
Onsrud, Harlan - U. Maine, Fellows Faculty Advisor
Kennedy, Robert ñ U. Maine Executive Vice-President and Provost
Ervin, Robert - Superintendent, Bangor schools
Nickerson, Norris - Principal, BHS
James, Cary ñ BHS teacher
Smith, Jim - BHS teacher
Krupke, Irv - BHS teacher
Cherniosky, Margaret ñ BHS teacher
Hedlund, Wes - BHS teacher
Grant, Eliaine ñ BHS teacher
Miller, JoAnn - BHS teacher
Pratt, Ken - BHS teacher
Tingly, Paula ñ BHS Counselor
Koch, Helmut - BHS teacher
Burgess, Scott ñ John Bapst teacher
Adriance, Allen ñ John Bapst Head of School

Fellows:

Berkenpass, Eric
Donovan, Danielle
French, Lester
Hedefine, Eeva
Krassikoff, John
Martin, Andrea
Pitcher, Stephanie
Puckett, Anthony
Woodward, Becky
Johnson, Timothy (undergrad)

High school students in multiple classes at BHS and in physics class at John Bapst

High school students in special meetings
Lucy Gross, David Kleinschmidt, Jue Wang, Mark Gonyar

Annual Report for Period:05/2004 - 04/2005

Submitted on: 05/18/2005

Principal Investigator: Vetelino, John F.

Award ID: 0139324

Organization: University of Maine

Title:

GK-12: Sensors!

Project Participants

Senior Personnel

Name: Vetelino, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Vetelino was born in Westerly R.I. He received the B.S., M.S., and Ph.D. in electrical engineering from the University of Rhode Island in 1964, 1966, and 1969, respectively. He was one of the founding members of the Laboratory for Surface Science and Technology at the University of Maine and is currently leader of the solid state research group. Four sensor companies û the BIODE Corp. in Westbrook, ME, Microsensor Conversion Technology in Brookings, SD, Sensor Research and Development Corp. in Orono, ME and Mainely Sensors, also in Orono, ME û have been incubated from his research group.

Dr. Vetelino's research in acoustic wave and metal oxide sensors served as the motivation for the GK-12 Sensors program. He previously served on many NSF Science Education Review panels for NSF Undergraduate Research Participation (URP), NSF Local Course Improvement (LOCI), NSF Student Science Training (SST), NSF instructional Scientific Equipment Program (ISEP) and NSF Small Business Innovation Research grants (SBIR) proposals. He also served in many NSF workshops and various panels relating to research addressing national needs.

As Principal Investigator, Dr. Vetelino makes the final decision on fellow selection, directs fellow activities, sets guidelines for module development, facilitates communication between the six GK-12 Sensors! schools and UM faculty, writes and submits supplemental and related grants for the program, establishes guidelines for fellow journal articles on the GK-12 program, and attends GK-12-related conferences.

Dr. Vetelino also serves as the advisor for GK-12 Sensors! fellows Lester French, Jesse Parks, Wade Pinkham and Chris York.

Name: Godsoe, Stephen

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephen Godsoe is from Bangor, Maine and has 37 years of high school teaching experience. Mr. Godsoe was the K-12 Mathematics Coordinator in Bangor from 1975-1983 and 1989-1991 and has served on several state committees to establish mathematics standards. He has taught all levels of high school mathematics, statistics, and computer science. He was one of twenty-eight teachers in the US to receive the Edith May Sliffe award in 2001. Since 1994, Mr. Godsoe has also taught 'Teaching K-8 Mathematics' at the University of Maine.

As Co-P.I. for GK-12 Sensors, Mr. Godsoe is an active team member in the classroom, helping GK-12 fellows. He directs the program's collaboration with the state and city agencies, and works to support the program with new initiatives. Mr. Godsoe organizes GK-12 activities at our largest site, Bangor High School. In this capacity, he pairs fellows with appropriate teachers, produces GK-12 press releases for the school paper, and regularly communicates with GK-12 satellite schools on issues relating to technology in the classroom.

Name: Holden, Constance

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Constance Holden has significant teaching experience at the local high school, University College of Bangor and the University of Maine. She has supervised student teachers, helped to develop the curriculum on workshops for secondary school teachers, and authored publications for professional journals related to teaching science and engineering.

As Co-P.I. for GK-12 Sensors, Dr. Holden brings her teaching experience to the task of supporting and training the GK-12 fellows. She teaches Spatial Science and Technology Information at the University of Maine, as well as meeting with the fellows on a

one-to-one basis, interacting with civic leaders, developing GIS programs for BHS courses, and helping to administer the program.

Name: Crowley, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

Adam Crowley is from Caribou, Maine and has taught at The University of Maine and Beal College. As the program manager, Mr. Crowley has coordinated all GK-12 activities, set-up meetings, promoted the program to the public, prepared reports, maintained the website, designed PowerPoint presentations on GK-12 Sensors, and assisted in the development of modules.

Name: Boyle, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

As program evaluator, Dr. Boyle gathered information on fellow classroom activities and surveyed GK-12 teachers to assess the impact of fellows on classroom activities. Dr. Boyle left the program February 2005.

Name: Arsenault, Jr., Joseph

Worked for more than 160 Hours: Yes

Contribution to Project:

Joe Arsenault has taught at The New School for Social and Behavioral Research (NYC) and at The University of Maine. As program manager, Mr. Arsenault has coordinated all GK-12 Sensors activities and meetings; acted as a liaison between Co-PIs, fellows and teachers; prepared articles, reports and informational presentations on GK-12 Sensors!; assisted fellows in the development of modules and conference presentations; represented the program at national conferences; advocated for establishing ongoing State financial support for GK-12-type programs; worked with fellows to establish auxiliary support for GK-12 related activities.

Name: Hart, Suzanne

Worked for more than 160 Hours: Yes

Contribution to Project:

Suzanne Hart, Research Associate/Policy Analyst, College of Education & Human Development, University of Maine, is the current GK-12 Sensors! program evaluator. As such, Hart has reviewed past and current evaluation efforts and instruments and is performing additional analyses on prior evaluation reports. She will be administering and analyzing 2004-2005 evaluation data and is developing an evaluation plan for the GK-12 Sensors! Track II proposal being submitted June 2005.

Name: Parks, Jesse

Worked for more than 160 Hours: Yes

Contribution to Project:

Jesse Michael Parks was born in Calais, ME and is currently pursuing a Ph.D. in Electrical Engineering at UM. He received his BS in Electrical Engineering from UM in 1999 and worked at Sensor Research & Development in Orono, ME and Edwards Systems Technology in Pittsfield, ME before returning to UM in 2004. Jesse's research interests include sensor design and modeling and sensor response analysis. He is a first-year fellow with the NSF GK-12 Sensors! program working with both Wes Hedlund at BHS and Tracy Vasiliev at Bangor's CMS and DMS.

Name: York, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

Chris York was born in Levittown Pennsylvania and attended high school in Belfast Maine. Chris earned his undergraduate degree in Electrical Engineering at the University of Maine and is currently working on an MS in Electrical Engineering. Supported by Dr. John Vetelino, Chris is part of a group developing the lateral field excited (LFE) acoustic wave sensor, a new sensor platform. In particular, he is examining the LFE for use in biosensor applications such as detecting E. coli in water supplies. In his first year with the NSF GK-12 Sensors! program, Chris has worked primarily with Jim Tyson at MCI, a high school located in the town of Pittsfield.

Post-doc

Graduate Student

Name: Berkenpas, Eric

Worked for more than 160 Hours: Yes

Contribution to Project:

Eric Berkenpas from Northwest Iowa attended South Dakota State University where he received his undergraduate degree in Electrical Engineering with a Computer Science minor. Eric is an MS student in Electrical Engineering working on a research project involving the development of a new kind of sensor for detecting bio-terrorism pathogens.. Eric is currently working with electronics classes at BHS and JBMHS. Erik has designed and implemented an 'electronic rooster' module at JBMHS which senses light. He has also designed a number of modules students can perform in their own homes to sense heating efficiency.

Name: Kenney, Crystal

Worked for more than 160 Hours: Yes

Contribution to Project:

Crystal Kenny is from China, ME. She received Bachelors Degree from UM in Engineering Physics and Computer Engineering. She is currently completing her Masters degree at UM in Electrical Engineering. Her research is with magnetic flux sensors in hearing aid applications, with advisor David E. Kotecki. She is currently working with physics teachers at JBHS.

Name: Donovan, Danielle

Worked for more than 160 Hours: Yes

Contribution to Project:

Danielle Donovan from Presque Isle, Maine. She received her Bachelors Degree from the University of Maine in Spatial Information Science and Engineering. She is currently working on her Masters degree in Spatial Information Science and Engineering at the University of Maine, specializing in remote sensing and geographic information systems (GIS). Danielle is working at Reeds Brook Middle School with Robert O'Leary in his life science classes. Danielle is one of two fellows who have worked with NASA to develop EarthKam modules for our classrooms. Furthermore, Danielle has been instrumental in the development of the Sensor Sensitive program at BHS, detailed in a later portion of this report.

Name: French, Lester

Worked for more than 160 Hours: Yes

Contribution to Project:

Lester French is pursuing a Ph.D in electrical engineering where he is focused on acoustic wave sensors for use as liquid-phase chemical sensors. Lester received the BSEE with a minor in optical and illumination engineering from the University of New Hampshire in 1993. Lester worked as a commercial engineer for Duro-Test Corporation and as a research engineer for BIODE, Inc. on the modeling, testing, and packaging of acoustic wave devices as liquid-phase chemical sensors. He received his MSEE from the University of Maine in 2002. Lester is primarily working with the Chemistry department at Bangor High School for the NSF GK-12: Sensors! project. In particular, Lester has been working closely with BHS Chemistry teacher Helmut Koch, designing and implementing sensor modules that detect acidity and viscosity in various substances. In the spring of 2003, Lester traveled to Magdeburg, Germany to take part in a program related research experience at the Otto-von-Guericke University.

Name: Hedefine, Eeva

Worked for more than 160 Hours: Yes

Contribution to Project:

Eeva Hedefine, a Maine native, is a MS student in the Department of Spatial Information Science and Engineering at the University of Maine. Eeva is researching privacy issues relating to sensors. She received a Bachelors Degree in Spatial Information Engineering from the University of Maine and an Associate Degree in Legal Technology from the University of Maine at Augusta. Eeva is working with the Senior Seminar, Civics, Geography, and Advanced Drafting classes at Bangor High School. This year, Eeva has been central to the development of the Bangor, Maine GIS Emergency Mapping Project, detailed in a later portion of this paper.

Name: Kennard, Raymond

Worked for more than 160 Hours: Yes

Contribution to Project:

Raymond Kennard is from South Paris Maine. He graduated from Ithaca College in '99 with a B.S. in Chemistry and a minor in Physics. The next four years Raymond Kennard taught physical sciences at Fryeburg Academy. In the fall of '02, he decided to return to school to pursue a Ph.D in Chemical Engineering. Raymond is currently researching mesoporous thin films and their application to Sensor as a molecular prefilter. As a fellow, he has been working with chemistry faculty at BHS.

Name: Krassikoff, John

Worked for more than 160 Hours: Yes

Contribution to Project:

John Krassikoff, a Ph.D student in Physics, is a research assistant at the Laboratory for Surface Science and Technology where he performs research tasks related to sensor development for monitoring high temperature oxidation of SiAlON fracture resistant thin films. John served, in various capacities, during ten years in the United States Air Force. He subsequently worked as an electronics technician for Hipotronics, a high-voltage test equipment company and was an engineering technician for the United Parcel Service at their R&D facility working on voice recognition systems. Finally, John worked as a staff engineer at Lorex Industries working on the design of optical and acoustic measurement systems for the telecom and semiconductor industries. He left industry to attend graduate school after completing his second bachelor's degree, this one in Physics, at the State University of New York at New Paltz. At John Bapst High School, John worked closely with students from general physics classes to help them produce sensor-oriented projects for annual physics project competition. Furthermore, John introduced electricity into the curriculum of ninth grade science classes. John Krassikoff left the GK-12 Sensors! program in October of 2003.

Name: Lampron, Kenna

Worked for more than 160 Hours: Yes

Contribution to Project:

Kenna Lampron from Standish, Maine received her Bachelors degree from the University of Maine in Electrical Engineering this past August and is currently working on her MS at the University of Maine in the same field as her undergraduate study. Her research involves semiconducting metal-oxide (SMO's) sensors. More specifically, she is working on fabricating, and testing a hydrogen sensor to detect leaks from fuel cells for an automotive applications. Kenna has been working with Wes Hedlund's Biology class at Bangor High School. She has developed portable modules for biology classes that focus on PH sensing. These modules have been performed at both our suburban and rural schools.

Name: Lewark, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Michael Lewark from Jonesport, Maine, is a candidate for a PhD in Electrical Engineering at the University of Maine. He received his undergraduate degree in Electrical Engineering from the University of Maine in May of 2003. Michael's area of research is in material characterization for microwave acoustic applications. Worked with science classes at Jonesport-Beals High School (JBHS). At JBHS, Mike introduced electricity into the curriculum of freshmen physics classrooms. He has designed and implemented a number of Lego Mindstorm-based modules at JBHS involving detection of light, sound and rotation. In the fall of 2004, Mike was also instrumental in reviving the school's Electric Car Club.

Name: Martin, Andrea

Worked for more than 160 Hours: Yes

Contribution to Project:

Andrea Martin from Indiana and received her degree in forensic chemistry from Ohio University. She is currently pursuing her PhD in chemistry at the University of Maine and works on the development of a nitric oxide gas sensor in the Laboratory for Surface Science and Technology. At Bangor High School, Andrea is working with the students in the chemistry classes. As a fellow, Andrea has developed one of only two air quality monitoring stations in the state of Maine. This station is located at Bangor High School. She has designed a number of modules around the station and has developed a system for the dissemination of this information to our satellite schools. In the summer of 2003, Andrea traveled to Brescia, Italy to take part in a program related research experience at the University of Brescia.

Name: McCarthy, Erik

Worked for more than 160 Hours: Yes

Contribution to Project:

Erik McCarthy, originally from Greene, ME, is a graduate of Leavitt Area High School in Turner. He received a B.S. degree in Electrical Engineering from the University of Maine in May, 2003 and currently is working on a Master's degree in Biological Engineering. His graduate research is focused on attaching selective biomolecular layers to sensors that may be used to detect pathogens in aqueous environments. Erik joined the GK-12 program in February, 2004 and spent time at BHS Lee Academy and SHS. He has worked in a variety of subject areas, including calculus, physical science, chemistry and computer programming. Erik has been at BrHS since September 2004, collaborating with teachers to design and implement an electronics unit for 9th-grade physical science classes. The unit is aimed at building student interest in engineering early on, with an emphasis on hands-on activities.

Name: Neumann, Brad

Worked for more than 160 Hours: Yes

Contribution to Project:

Brad Neumann is a Master of Science candidate in the Department of Resource Economics and Policy, and joins the GK-12 Sensors team from Northern Michigan. He received his Bachelor of Science degree from Northern Michigan University, where he dual-majored in Economics and Land Use Planning, and studied Geographic Information Systems (GIS) as a minor concentration. Brad has worked as a GIS intern for Environmental Systems Research Institute, Inc., and has also worked as an independent consultant on GIS and land use planning projects. His research at the University of Maine primarily deals with evaluating the effects that preserved land has on neighboring property values. Brad was brought into the program in 2003 as a social science fellow. He is working at Bangor High School in the Social Studies Department and is involved in Senior Seminar, Civics, and World Geography classes. Along with fellow Eeva Hedefine, Brad has developed the Bangor, Maine Emergency Response GIS Project and several related projects, which are detailed in a later section of this report.

Name: Pitcher, Stephanie

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephanie Pitcher is currently a MS degree candidate in Electrical Engineering and may continue her research for a Ph.D. Stephanie's research is focused on developing an impedance based metal oxide gas sensor for ethylene detection and fruit ripening. Stephanie grew up in Washington State during elementary and high school, and studied at the University of Colorado at Colorado Springs for her undergraduate BS degree in Electrical Engineering. She is working with the biology department (Biology level 1, AP Biology, and Marine Biology) at Bangor High School. Stephanie is one of two fellows who have worked with NASA to develop modules for our classrooms. Along with fellow Danielle Donovan, Stephanie has been central in the development of the Sensor Sensitive program, detailed in later section of this report.

Name: Puckett, Anthony

Worked for more than 160 Hours: Yes

Contribution to Project:

Anthony Puckett just completed his PhD in mechanical engineering. His research focused on ultrasonic methods for material characterization using solid cylindrical waveguide used in non destructive sensing. Anthony was born and raised in New Mexico. He received his BS and MS in Mechanical Engineering from Colorado State University. Anthony worked mainly with the pre-calculus classes at Bangor High School. He developed a number of motion detector-based modules which were implemented at BHS and have subsequently been disseminated to our satellite schools. Anthony Puckett left the GK-12 Program in April of 2004.

Name: Woodward, Becky

Worked for more than 160 Hours: Yes

Contribution to Project:

Becky Woodward, a Ph.D Student, is conducting a cross-species comparison of the morphologies and performance abilities of four baleen whale species. Her work involves the use of suction-cup attached, multi-sensor data logging tags to monitor the underwater movements of large whales at sea. Data recorded by the tags include depth, roll, pitch, and heading as well as acoustical information which will be used to analyze the animals' diving performance and swimming biomechanics. Becky designed a whale watching module that brought students from several schools to the coast of Maine to observe and classify the habits of humpback whales. Becky Woodward left the Gk-12 Sensors! program at the end of 2003.

Name: Reed, Allison

Worked for more than 160 Hours: Yes

Contribution to Project:

Allison Reed has been assisting Dr. Boyle in his evaluation of the GK-12 Sensors! program.

Name: Ozdemir, Smera

Worked for more than 160 Hours: Yes

Contribution to Project:

Smera Ozdemir has been assisting Dr. Boyle in his evaluation of the GK-12 Sensors! program.

Name: Clark, Aaron

Worked for more than 160 Hours: Yes

Contribution to Project:

Aaron Clark is from Hermon, Maine. He is currently working on his Ph.D. in Chemical Engineering at the University of Maine. His research involves the development of metal-oxide chemical microsensors for gas sensing applications. He received his

Bachelors Degrees from the University of Maine in Chemical Engineering and Mathematics in 2002, and a Masters Degree in Chemical Engineering in 2004. Aaron is a first-year fellow with the NSF GK-12: Sensors! Program; he works primarily with John Mannette at Bucksport High School.

Name: Gallimore, Dana

Worked for more than 160 Hours: Yes

Contribution to Project:

Dana Gallimore attended UM and received an undergraduate degree in Electrical Engineering, with a minor in mathematics. Dana is currently a Ph.D. student in Electrical Engineering, working on a research project to determine the elastic properties of biofilms on surface acoustic wave sensors. Dana is working with the BHS mathematics department. Student activities include building Lego robots, heart rate monitors and motion detectors.

Name: Isenberg, Douglas

Worked for more than 160 Hours: Yes

Contribution to Project:

Douglas Isenberg is a new Masters student in Electrical Engineering at UM. He received his BS in Electrical Engineering at the University of North Carolina at Charlotte. Douglas is working with Mr. Tweedie's computer classes at Hermon Middle School, introducing the students to computer programming and robots. His research interest is in the area of mobile robotics and control.

Name: Pinkham, Wade

Worked for more than 160 Hours: Yes

Contribution to Project:

Wade Pinkham is from Damariscotta, Maine. He received his BS in Electrical Engineering from UM in 2004 and is currently working on a MS degree in Electrical Engineering at UM. He is specializing in bulk acoustic wave sensors, to be used for pesticide detection. Wade is working with Bob Littlefield's physics classes at CHS in Corinth, ME.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Bangor High School

Bangor High School:

Number of Fellows: 8

Number of teachers effected: 13

Number of classes effected: 38

Type of School: urban

% of free or reduced price Lunch: 20%

% minority: 8%

Academic Standing: Exceeds state averages in math, reading, and writing.

Bangor High School Teachers:

Kevin Birkel Math

Mark Britelli Math

Margaret Chernosky Geography

Jaime Cooke Civics
 Patricia Craig Math
 Don Erb Math
 Stephen Godsoe Math
 Wes Hedlund Biology
 Cary James Chemistry
 Helhut Koch Chemistry
 Bruce Morse Health
 Jim Smith Civics
 Geoffrey Wingard History

John Bapst Memorial High School

John Bapst Memorial High School:

Number of Fellows: 1
 Number of teachers effected: 2
 Number of classes effected: 4
 Type of School: urban
 % of free or reduced price Lunch: This school does not have a lunch program.
 % minority: 6%
 Academic Standing: Exceeds state average for reading, writing and math.

John Bapst Memorial High School Teachers:

Scott Burgess Physics
 Kurt Klappenbach Physics

Bucksport High School

Bucksport High School:

Number of Fellows: 1
 Number of Teachers effected: 3
 Number of classes effected: 13
 Type of School: Urban
 % of free or reduced price lunch: 25.28%
 % minority: 2%
 Academic Standing: Fails to meet state average in reading, writing and math.

Bucksport High School Teachers:

John Mannede Physics, Physical Science, Earth Science
 Denise Smith Biology, Earth Science
 Virginia White Chemistry

Sumner Memorial High School

Sumner Memorial High School:

Number of Fellows: 1
 Number of Teachers Effected: 2
 Number of classes effected: 5
 Type of School: Rural
 % of free or reduced price Lunch: 31.89%
 % minority: 2%

Academic Standing: Fails to meet state average in reading, writing and math.

Sumner High School Teachers:

Henri Gignoux Physics

Mike Benjamine Physical Science

Lee Academy

Lee Academy:

Number of Fellows: 12

Number of Teachers effected: 1

Number of classes effected: 4

Type of School: Rural

% of free or reduced price lunch: 53%

% minority: 23%

Academic Standing: Fails to meet state average in reading, writing, and math

Lee Academy Teacher:

John Simone Chemistry

Jonesport-Beals High School

Jonesport-Beals High School:

Number of Fellows: 1

Number of Teachers effected: 1

Number of classes effected: 3

Type of School: Rural

% of free or reduced price lunch: 41%

% minority: 0%

Academic Standing: Fails to meet state average in writing, reading and math.

Jonesport-Beals High School Teacher:

Lynn Alley All Science Classes

Bangor, Maine City Council

The council has taken a role in the development of the Bangor, Maine GIS Emergency Mapping Project, developed by GK-12 Sensors! fellows in collaboration with faculty at Bangor High School.

Bangor Maine Fire Department

By loaning materials and training time, the Bangor Fire Department has assisted the development of the Bangor, Maine GIS Emergency Mapping Project.

Bangor, Maine Police Department

By assisting with the locating of emergency supplies, the Bangor Police Department has assisted the development of the Bangor, Maine GIS Emergency Mapping Project.

NASA

Two of our fellows have developed a number of modules using information they have received at Maine Teachers of Earth and Space Science Workshop 2003 in Washington, DC. This workshop was sponsored by NASA.

Brewer High School

Brewer High School

Number of Fellows: 1

Number of teachers effected: 3

Number of Classes effected: 10

Type of School: Urban

% of free or reduced price Lunch: 19.05%

% minority: 3%

Academic Standing: Fails to meet state average in reading and writing; exceeds state average in math.

Brewer High School Teachers:

Arthur Libby Physical Science

Todd Hillier Physical Science

Darrell King Physical Science, Physics

Caravel Middle School

Caravel Middle School:

Number of Fellows: 1

Number of Teachers effected: 4

Number of classes effected: 4

Type of School: Rural

% of free or reduced price lunch: 42.32%

% minority: 1%

Academic Standing: Exceeds state average in reading, writing and math.

Caravel Middle School Teachers:

Jason Burgess Social Studies

Paula Hubbard Social Studies

Kim Nadeau (Lane) Social Studies

Georgiana Piete Social Studies

Central High School

Central High School:

Number of Fellows: 1

Number of Teachers effected: 2

Number of classes effected: 3

Type of School: Rural

% of free or reduced price lunch: 38%

% minority: 2 %

Academic Standing: Meets state average in reading; fails state average in writing and math.

Central High School Teachers:

Robert Littlefield Physics

Ed Lindsey Earth Science

Central Middle School

Central Middle School:

Number of Fellows: 1
Number of Teachers effected: 1
Number of classes effected: 5
Type of School: Rural
% of free or reduced price lunch: 53.07%
% minority: 2%
Academic Standing: Meets state average in reading, fails state average in writing and exceeds state average in math.

Central Middle School Teacher:

Kathy Tilton Science

William S. Cohen School

William S. Cohen [Middle] School:

Number of Fellows: 2
Number of Teachers effected: 1
Number of classes effected: 2
Type of School: Urban
% of free or reduced price lunch: 23.08%
% minority: 8%
Academic Standing: Exceeds state average in reading, writing and math.

William S. Cohen [Middle] School Teacher:

Tracy Vassiliev Applied Science

James F. Doughty School

James F. Doughty [Middle] School:

Number of Fellows: 2
Number of Teachers effected: 2
Number of classes effected: 7
Type of School: Urban
% of free or reduced price lunch: 46.06%
% minority: 8%
Academic Standing: Exceeds state average in reading and math, fails state average in writing.

James F. Doughty [Middle] School Teachers:

Patricia Bernhardt Life Science
Tracy Vassiliev Applied Science

Hampden Academy

Hampden Academy:

Number of Fellows: 1
Number of Teachers effected: 1
Number of classes effected: 2
Type of School: Rural
% of free or reduced price lunch: 9.86%
% minority: 2%
Academic Standing: Exceeds state average in reading, writing and math.

Hampden Academy Teacher:

Lauralee Lynch Math

Hermon Middle School

Hermon Middle School:

Number of Fellows: 1

Number of Teachers effected: 1

Number of classes effected: 9

Type of School: Rural

% of free or reduced price lunch: 19.79%

% minority: 3%

Academic Standing: Fails state average for reading and writing, meets state average for math.

Hermon Middle School Teacher:

Alan Tweedie Computer Science

Maine Central Institute

Maine Central Institute:

Number of Fellows: 1

Number of Teachers effected: 3

Number of classes effected: 7

Type of School: Rural

% of free or reduced price lunch: 12.92%

% minority: 6%

Academic Standing: Exceeds state average in reading, writing and math.

Maine Central Institute Teachers:

Linda Amsden Statistics

Irma Cushing Algebra

Jim Tyson Physics, Integrated Science

Reeds Brook Middle School

Reeds Brook Middle School:

Number of Fellows: 2

Number of Teachers effected: 5

Number of classes effected: 10

Type of School: Rural

% of free or reduced price lunch: 13.35%

% minority: 2%

Academic Standing: Exceeds state average in reading, writing and math.

Reeds Brook Middle School Teachers:

Jen Bowman-Mckay Social Studies

Kim Haggan Social Studies

Robert O'Leary Life Science

Georgiana Piete Science, Social Studies

Deb Sykes Social Studies

Other Collaborators or Contacts

Other University of Maine Collaboration:

Dr. Robert Kennedy, President of the University of Maine
 Dr. Peter Hoff, Former President of the University of Maine
 Dr. Robert Lad, Director of the Laboratory for Surface
 Science and Technology (LASST) and Professor of Physics
 Dr. Carl Tripp, Associate Professor of Chemistry, LASST
 Dr. Bruce Segee, Associate Professor, Electrical and
 Computer Engineering
 Dr. Paul Millard, Assistant Professor, LASST
 Dr. Alfred Bushway, Professor of Food Science
 Dr. Rodney Bushway, Chair and Professor of Food Science

Other Community and State Collaboration:

Dr. Robert Ervin, Superintendent of Schools, Bangor
 Mr. Norris Nickerson, Principal, Bangor High School
 Peter Arno, Assistant Police Chief, Bangor
 Jeff Cammack, Fire Chief, Bangor
 Stan Moses, Community Development
 Paul Nichols, DEP for the state of Maine
 Mark Whiting, DEP (water quality),
 Bob Goodwin, Department of Marine Resources,
 Susan Morse, Bangor Area Comprehensive Transportation System
 (BACTS)
 Ken Beland, Atlantic Salmon Commission, state of Maine
 Dave Gould, Bangor Planning,
 John Murphy, City Engineering
 Rebecca Hupp, Bangor International Airport Director
 Jim Ring, City Engineer, Bangor
 Don Winslow, Police Chief, Bangor
 Rod McKay, Community Development, Bangor
 Rob Kenerson, Bangor Area Comprehensive Transportation
 System, BACTS
 Anne Hartmann, Discovery Museum, Bangor

Fellow Advisors:

Dr. Peggy Agouris, Assistant Professor of Spatial Information Science and Engineering, University of Maine: Dr. Agouris serves as advisor to GK-12 fellow Danielle Donovan.

Dr. Kevin J. Boyle, Professor and Chair of Resource Economics and Policy, University of Maine: Dr. Boyle serves as advisor to GK-12 fellow Brad Neumann.

Dr. Mauricio DaCunha, Assistant Professor of Electrical and Computer Engineering, University of Maine: Dr. DaCunha serves as advisor to GK-12 fellows Eric Berkenpas, Dana Gallimore, and Michael Lewark.

Dr. William J. Desisto, Assistant Professor of Chemical Engineering, University of Maine: Dr. Desisto serves as advisor to GK-12 fellow Raymond Kennard.

Dr. Richard Eason, Associate Professor of Electrical and Computer Engineering, University of Maine: Dr. Eason serves as advisor to GK-12 fellow Douglas Isenberg.

Dr. David Kotecki, Assistant Professor of Electrical and Computer Engineering, University of Maine: Dr. Kotecki serves as advisor to GK-12 fellow Crystal Kenney.

Dr. Paul Millard, Assistant Professor of Biological Engineering, University of Maine: Dr. Millard serves as advisor to GK-12 fellow Erik McCarthy.

Dr. Harlan Onsrud: Professor of Spatial Information Science and Engineering, University of Maine: Dr. Onsrud serves as advisor to GK-12 fellow Eeva Hedefine.

Dr. John F. Vetelino, Professor of Electrical Engineering, University of Maine: Dr. Vetelino serves as advisor to GK-12 fellows Lester French, Jesse Parks, Wade Pinkham and Chris York.

Dr. Clayton Wheeler, Assistant Professor of Chemical and Biological Engineering, University of Maine: Dr. Wheeler serves as advisor to GK-12 fellow Aaron Clark.

Post Doc and Other Professionals:

During the 2004-2005 year, no post doc employees were involved in the GK-12 Sensors! program.

Dr. Mark Anderson, UM Senior Instructor of Resource Economics and Policy, assisted former Program Evaluator Dr. Kevin Boyle in the evaluation of GK-12 Sensors!

David Frankel, Senior UM Research Scientist, George Bernhardt, UM Research Scientist, and Michael Call, UM Research Engineer, facilitated tours of various UM laboratories for visiting high school students.

Two UM graduate students in Resource Economics, Allison Reed and Semra Ozdemir, assisted former Program Evaluator Dr. Kevin Boyle in the collection and computation of GK-12 Sensors! data.

Activities and Findings

Research and Education Activities:

Executive Summary

Since its inception in 2002, the GK-12 Sensors! Program has been focused on bringing cutting-edge research in sensors to high school students in Maine in the anticipation of increasing the number of students pursuing a career in which science and engineering play a critical role. During the 2004-2005 academic year, this project has been a collaboration between an interdisciplinary team of University of Maine (UM) engineers and scientists working in sensors, nine Maine high schools (Bangor High School [BHS], Brewer High School [BrHS], Bucksport High School [BuHS], Central High School [CHS], Hampden Academy [HA], John Bapst Memorial High School [JBMHS], Jonesport-Beals High School [JBHS], Maine Central Institute [MCI] and Sumner Memorial High School [SMHS]) and five Maine middle schools (Caravel Middle School [CMS], William S. Cohen School [CoMS], James F. Doughty School [DMS], Hermon Middle School [HMS] and Reeds Brook Middle School [RBMS]). One additional middle school, Central Middle School (CMS), initiated collaboration with the program late in the 2005 spring, inviting a fellow to interact with a number of eighth grade classes. The goal is to use these high and middle schools as models and to extend the program to other Maine high schools.

During our third year, the program has undergone significant expansion as a result of PI John Vetelino's successfully funded 2004-2006 RET-Sensors! site proposal. The initial GK-12 Sensors! proposal sought to establish links with area high schools through connections that participating BHS faculty had with faculty in those schools. In the spring of 2003, Vetelino was awarded funding for an RET supplemental program, allowing him to bring four area high-school teachers to work in sensor research during the summer of 2003. The RET program, which allowed RETs and GK-12 fellows to interact in research, proved a new, effective avenue for transitioning GK-12 Sensors into area high schools by preparing participating teachers through an intensive eight-week summer research experience. In the spring of 2004, Vetelino was awarded funding for the 2004-2006 NSF RET-Sensors program, ensuring an ongoing mechanism for locating and preparing participating GK-12

Sensors! teachers and schools. The 2004 RET program brought six high-school and four middle-school teachers to UM. All ten teachers were interested in participating in 2004-2005 GK-12 Sensors! Three of the four middle-school teachers taught in schools systems with GK-12 fellows present at the high-school level. For the first time, GK-12 Sensors! would be present throughout the secondary curriculum of several participating school systems.

A proposal for five-year Track II-NSF funding for GK-12 Sensors! was submitted in June 2004. The Track II GK-12 Sensors! proposal was favorably reviewed and recommended for funding if available. However, in October of 2004, NSF notified UM that the Track II GK-12 Sensors! proposal had not been selected for funding, citing budgetary reductions as a principal factor in the decision. The NSF GK-12 Program Director advised Vetelino to resubmit the Track II proposal for reconsideration in June 2005, which is currently under preparation.

In the spring of 2005, Orono, Maine State Representative Emily Cain introduced Bill LD 119, which if passed by the legislature and governor would enact ongoing funds to create graduate fellowships within the University of Maine system that are geared at enhancing science and math education at the secondary school level. This bill has the strong support of University of Maine System Chancellor Joseph Westphal. The proposed annual funding level for the next two academic years is \$2.5 million. At present, the bill has passed committee hearings and awaits the legislature's action. If LD 119 passes it will guarantee a degree of sustainability to the GK-12 Sensors! program.

GK-12 Sensors! is also seeking a commitment from UM Vice-President for Research Michael Eckardt for bridge funding to supplement 2005-2006 fellowships for students currently in the GK-12 program, in anticipation of NSF Track II funding and/or sustainability from LD119.

Other major third year accomplishments include successful RET-GK-12 Sensors! summer 2004 workshop and subsequent transition of 2004 RET participants into the 2004-2005 GK-12 Sensors! program; introduction of GK-12 Sensors! into middle-school curricula; expansion of GK-12 Sensors! into seven high- and four-middle schools; establishment of initial contacts with additional schools through the 2005 Research Experience for Teachers (RET) summer fellowships; funding of an NSF REU site grant that will over the next three years fund the research participation at the University of Maine of 48 undergraduate students from Maine and throughout the country, providing undergraduates opportunity to address peers from their alma maters concerning their 2005 summer research experience; establishment of links between collaborating schools and the University of Maine via guided tours of research laboratories; addition of program evaluator Suzanne Hart, Research Associate/Policy Analyst, College of Education & Human Development, UM; implementation of INT 570 at UM, a preplanned experience requiring regular school visits to selected K-12 school(s) throughout the semester, during which fellows share their knowledge of emerging science and technology with K-12 school teachers and students; implementation of 'Introduction to Sensors' into BHS curriculum, an advanced course offered as a Senior Honors course; expansion of the 2004 pilot programs Sensors Sensitive and Bangor, Maine GIS Emergency Mapping Project and development of 2005 Bangor, Maine GIS Emergency Map for Bangor International Airport and Bangor Historical Maps projects at BHS; further refinement of teaching modules created by teachers and fellows during years one and two and creation of twenty new portable modules.

Introduction

The idea for the GK-12 Sensors! program was spawned in the summer of 2001 when Dr. John Vetelino from the University of Maine (UM) brought Stephen Godsoe, head of the Bangor High School (BHS) mathematics department, to UM in order to involve Steve in sensor research. As the summer progressed, Mr. Godsoe, Dr. Vetelino, and Dr. Constance Holden, a former high school teacher and currently an instructor at UM, began to discuss various methods to encourage Maine high school students to follow career paths in science and/or engineering. As a result of these discussions, it was decided that sensors would be the vehicle of choice to try to convince high school students to follow a science and/or engineering career path. This approach is unique in that it simply does not present interesting science or broad topics of science and/or engineering to high school students, but focuses on sensors. Students certainly know the impact of sensors by reading the daily newspaper and seeing articles relating to homeland security issues and environmental concerns. Students are also surrounded by sensors in their homes, schools and other places they frequent. Students, however, do not know the science or engineering that underlies sensors and sensor systems. This underlying science and engineering and how it relates to sensors can easily be integrated into high school classes such as chemistry, physics, mathematics, computer science and also social sciences such as civics. As a result of the discussions between Dr. Vetelino, Mr. Godsoe, and Dr. Holden, a proposal was developed and submitted to NSF to integrate sensors into the high school curriculum. This proposal was subsequently funded and the program began in the spring of 2002. GK-12 Sensors! is now in its third year of funding.

Benchmarks 2004-2005:

April 2004: All Maine High Schools were notified of a Research Experience for Teachers (RET) program that would be held at the University of Maine (UM) during the summer of 2004. Ten schools responded with particularly strong applicants.

May 2004: Article on GK-12 Sensors! activities at BHS published in Bangor Daily News.

June 2004: RET participants and new GK-12 fellows begin ECE 465, Introduction to Sensors. RET participants begin working closely with University of Maine research scientists on cutting-edge sensor technology.

July 2004: RET participants and 2004-2005 GK-12 fellows in similar research areas establish regular interaction.

August 2004: A three-day workshop is held for all RET and GK-12 Sensors! participants at UM. At this workshop, all teachers and fellows presented their summer research, GK-12 Sensors! 2004-2005 teacher-fellow assignments are formalized, paired teachers and fellows meet to develop schedules and module concepts for 2004-2005 implementation.

Fellow Lester French attends IEEE-UFFC conference in Montreal, Quebec, Canada.

Co-PI Constance Holden holds one-day workshop for 4-H groups from around the state at UM, at which GK-12 fellows Eeva Hedefine and Brad Neumann presented on the spring 2004 Emergency Mapping Project at BHS. With GK-12 fellow Danielle Donovan, Hedefine and Neumann assisted Holden with GPS and GIS labs for the 4-H workshop participants.

September 2004-May 2005 Implementation of 'Introduction to Sensors' course at BHS. GK-12 fellow Lester French teaches and coordinates. Fellow Dana Gallimore assists.

September 2004: GK-12 Sensors! expands from six schools to fourteen (BHS, BrHS, BuHS, CMS, CHS, CoMS, DMS, HA, HMS, JBMHS, JBHS, MCI, RBMS and SMHS). New schools represent diverse socio-economic conditions, including some of the poorest in Maine.

October 2004: PI John Vetelino holds meeting at UM with GK-12 fellows. Fellows report on interaction with teachers and students, development of classroom activities and presentations, and share insights on challenges encountered.

Teachers & fellows meet at UM for a presentation/demonstration by Northeast PASCO sensors representative & discussion with PI Vetelino to strategize obtaining additional sensor resources for program.

Vetelino presents on the GK-12 Sensors! program at the 2004 Frontiers in Education Conference, Oct. 20-23, Savannah, GA.

November 2004: Initial evaluation team transition meetings held.

Co-PI Constance Holden hosts meeting at UM of participating GK-12 teachers to discuss fellow interactions, classroom impact, curricular integration and challenges to implementation facing teachers.

December 2004: Article involving GK-12 Sensors! published in the Bangor High School Communiqu .

Fellow Eric Berkenpas completes his graduate requirements and leaves the GK-12 Sensors! program. Fellow Michael Lewark leave the GK-12 Sensors! program for personal reasons.

GK-12 Sensors! sponsors get-together of active NSF GK-12 programs at UM.

GK-12 Sensors! participating teachers submit initial resource assessments to PI John Vetelino.

January 2005: Abstract for paper on the GK-12 Sensors! program submitted to the 2005 IEEE Frontiers in Education (FIE) conference. This conference will be held October 2005 in Indianapolis, Indiana.

Participating teachers Patricia Bernhardt and Tracy Vassiliev present RET-GK-12 Sensors! curricular integration developments to Bangor School Committee, Jan. 24. Co-PIs Constance Holden and Stephen Godsoe, and Program Coordinator Joe Arsenault attend.

Two nuggets submitted for RET program selected by NSF ECE Director Mary Poats for highlight at annual NSF Grantees Conference. Both RETs, Patricia Bernhardt and Alan Tweedie, are participating GK-12 Sensors! teachers.

February 2005: Leroy Chiao, Commander aboard the International Space Station, recognizes BHS for its participation in the EarthKAM project. GK-12 Sensors! Fellow Danielle Donovan co-directs the program with teacher Margaret Chernosky. Audio available at http://www.earthkam.ucsd.edu/public/audio_clips/036_1842_eDPC.mp3

GK-12 Nuggets submitted.

Abstract for paper accepted for 2005 FIE conference. Full paper submission requested.

PI John Vetelino and Co-PI Constance Holden attend annual NSF Engineering and Computing Education Grantee Meeting, Feb. 16-18. Poster session on current RET-GK-12 participating teachers presented.

Evaluators Kevin Boyle and Mark Anderson complete 'GK -12 Sensors! Project Assessment Report û 2003-2004.'

March 2005: PI John Vetelino and Project Manager Joe Arsenault attend the GK-12 Annual meeting in Arlington, VA. Poster session on past and current program activities presented.

Paper on the GK-12 Sensors! program submitted to the 2005 IEEE Frontiers in Education (FIE) conference.

NSF REU site proposal is funded. Forty-eight undergraduate students from UM and throughout the U.S. will be coming to UM over the next three years to interact with graduate fellows. In summer 2005, all REUs will interact with both RETs and GK-12 fellows, and will present their research work to both teachers and fellows during an August 2005 workshop at UM, and at their secondary school alma maters during fall 2005.

GK-12 Fellows Eeva Hedefine and Bradley Neumann, with Jim Smith, submit two funding requests—one to the City of Bangor Fire and Police departments, one to the office of U.S. Senator Susan Collins—for continuation and completion of multi-year project concerning using spatial information to enhance homeland security and emergency response for the City of Bangor.

GK-12 Fellows Eeva Hedefine and Bradley Neumann, with BHS history teacher Jim Smith, meet with Jonathan Ford (representing the office of Maine U.S. Senator Susan Collins), Bangor city officials, Rebecca Hupp (Director, Bangor International Airport), participating BHS teachers and students, and GK-12 Sensors! Co-PI and program coordinator, to discuss the spring 2005 and future plans of the Emergency Response Project, a collaboration between BHS, the City of Bangor and UM.

Article on GK-12 Sensors! cooperating teachers published in the Bangor Daily News.

GK-12 Sensors! and RET 2005 annual conference poster sessions posted to UM Department of Electrical and Computing Engineering website: <http://www.eece.maine.edu/research/posters.html>

GK-12 Sensors! fellows Brad Neumann and Eeva Hedefine present a paper on their GK-12 Sensors! activities entitled 'Applying GIS Technologies to Enhance Emergency Response' at the National Science Teacher Convention (NSTA) in Dallas, TX.

Participating teacher Patricia Bernhardt presents a paper on GK-12 Sensors!-related integration of RET research into middle-school classrooms at NSTA in Dallas, TX.

March-April 2005: PI John Vetelino and Program Coordinator Joe Arsenault collaborate with other University of Maine System NSF GK-12 programs in a campaign to generate awareness of and support and advocacy for LD 119, a bill presented to the 122nd State of Maine legislative session that would provide ongoing funding for GK-12-type fellowships.

April 2005: Paper submitted to 2005 IEEE FIE Conference accepted.

PI John Vetelino, Co-PI Stephen Godsoe, Program Coordinator Joe Arsenault and Fellow Bradley Neumann attend State of Maine Joint Standing Appropriations Committee hearing of LD119. Neumann and Godsoe testify in support of the bill.

2004 RET and GK-12 Sensors! participating teacher Tracy Vassiliev presents a paper entitled 'Effects of Heavy Metals on Lobsters' at the National Shellfish Meeting, April 10-14, in Philadelphia, PA.

Joint Standing Appropriations Committee recommends LD119 to legislative vote.

Suzanne Hart assumes position of program evaluator.

May 2005: The Bangor, Maine GIS Emergency Map of Bangor International Airport (BIA) is presented to Bangor, Maine departments of Fire

and Police and to Bangor International Airport, by fellows Brad Neumann and Eeva Hedefine, teachers Jim Smith and students in Smith's Senior Seminar.

The City of Bangor implements GIS Emergency Map of Bangor International Airport as part of a mock disaster at BIA.

No-Cost Extension Request through June 2006 is filed with UM Office of Research and Sponsored Programs.

Fellows formalize new modules for review and submission June.

Maine State Bill LD119 is read in concurrence and agreed to as an Engrossed Bill by House and Senate, making it official state policy to have a UM System GK-12 program. Final decision on allocation of funds to be made by Appropriations Committee.

Research and Education Activities:

2004 Summer Activities

In the spring of 2004, the University of Maine, with John Vetelino as PI and Constance Holden as Co-PI, received funding for a three-year NSF grant, RET-Sensors (NSF-0401439). As a result, during the summer of 2004, ten middle and high school teachers from mostly rural areas were brought to UM and provided unique opportunities to be involved in research in sensor theory, design, fabrication, testing, and/or applications. The RET portion expanded the GK-12 Sensors! program into nine rural Maine high and middle schools: Brewer High School (BrHS) in Brewer, ME; Bucksport High School (BuHS) in Bucksport, ME; Central High School (CHS) in East Corinth, ME; Hampden Academy (HA), a high school in Hampden, ME; Hermon Middle School (HMS) in Hermon, ME; James F. Doughty School (JFDS), a middle school in Bangor, ME; Maine Central Institute (MCI), a high school in Pittsfield, Maine; Reeds Brook Middle School (RBMS) in Hampden, ME; and William S. Cohen School (WSCS), a middle school in Bangor, ME.

Teachers spent eight weeks becoming acquainted with cutting-edge sensor science and engineering through daily interactions with sensor faculty, senior researchers, graduate students, UM GK-12 Sensors! fellows, and Research Experience for Undergraduates (REU) students in the UM Laboratory for Surface Science & Technology (LASST). The RETs were involved in research on biosensors, chemical sensors, and fluid-phase sensors. Examples of RET research ranged from developing sensing systems for measuring motor oil degradation to detecting low levels of algae toxins and heavy metals in Maine lobsters. In addition to working with a specific sensor research group, teachers became familiar with other state-of-the-art sensor-related science and technology facilities in the university and neighboring small sensor businesses. The RETs also enrolled in ECE 465, an upper-level undergraduate course entitled Introduction to Sensors, which presented the theory and applications of various types of semiconductor, acoustic, magnetic, thermal and optical sensors, in order to give teachers a sound background in sensors. Teachers received academic and recertification credit for the course. The summer program concluded with the August Summer Workshop, during which the RETs shared their summer research experience in formal presentations and offered ideas for integrating sensor science and technology into their curricula. All 2004 RET participants became 2004-05 GK-12 Sensors! cooperating teachers, continuing working relationships established during the summer RET program with GK-12 fellows.

RET Sensors! established a formal bridge to GK-12 Sensors! and, as a result, a strong linkage between UM and participating secondary educational institutions. Furthermore, in school systems where GK-12 Sensors! has been established at the high school level, the RET-Sensors! program provides an opportunity to extend its presence into the systems' middle schools by offering fellowships to interested teachers in participating school systems. Expanding its presence from six to eleven schools, four of which were middle schools, GK-12 Sensors! anticipates achieving greater impact on student interest in pursuing careers in science and engineering. Introducing sixth, seventh and eighth graders to graduate researchers and engaging students in hands-on science and technology inquiries, and maintaining such exposure throughout high school, provides continuity of exposure throughout their secondary education.

'Introduction to Sensors' Course at BHS

Bangor High School introduced a course on sensor science and technology into its 2004-2005 curricula. 'Introduction to Sensors' is a hands-on, inquiry-based course being offered to Honors students. Co-PI Stephen Godsoe and third-year fellow Lester French designed the course using material gathered from sensor research performed in the Laboratory for Surface Science and Technology (LASST) at the University of Maine (UM). The year-long course features lectures, labs and other hands-on exercises, and field excursions such as visits to the United Technology Center's (UTC) Photonics Laboratory (Bangor, ME) and various sensor-research laboratories at UM. Early fall 2004 lectures introduced sensors and sensor systems by considering the human body as a sensor system. New concepts and technologies introduced in lecture were supported with in-class examples and demonstrations of sensors, including altitude sensors, accelerometers and piezoelectric sensors (from LASST). In the lab, students built optical interferometers, learned soldering skills, built and tested a photoelectric pulse plethysmograph

heart-rate monitor, and developed projects involving Lego Mindstorm robots equipped with pressure and light sensors. In spring 2004, hands-on activities included building a microphone using a thin-film pressure transducer and working in teams to propose, design, and build a physical sensor. Students are excited and have shown significant initiative in working on their class projects.

Bangor, Maine GIS Emergency Mapping Project and the Bangor, Maine GIS Emergency Map of Bangor International Airport

In addition to portable modules, fellows have been organizing community outreach programs, such as the 2004 Bangor, Maine GIS Emergency Response Mapping Project, which enabled students to produce valuable maps detailing the location of fire hydrants, shelters, and other emergency resources for local police and fire departments, and the 2005 Bangor, Maine GIS Emergency Map of Bangor International Airport (BIA). Because Bangor is willing to share its GIS equipment with our fellows, this project could be reproduced in other towns at little or no cost. Fellows presented the 2004 mapping project to the Bangor School Department in May of 2004, and they are scheduled to present the 2005 project to the Bangor City Council in mid-May, days before Bangor area emergency response teams will test the 2005 mapping project during a mock disaster at BIA.

Sensor Sensitive

At BHS, civics teacher Jim Smith has been worked with fellows implement the second year of a program called Sensors Sensitive. This two-day event targets all freshmen at BHS. During day one, all students take an interest survey with CHOICES software. The survey is designed to make students aware of how they can pursue science and engineering related occupations. During the second day of the program, students construct a poster presentation around a science and engineering occupation they might consider pursuing after graduation.

Digital Community Atlas of the Historical Geographies of Bangor

A multi-class Global Information System (GIS) project is currently being developed by fellow Brad Neumann with the History Department at BHS. The project, sponsored by Environmental Systems Research Institute, Inc. (ESRI), a world leader in GIS software development, involves creation of a digital community atlas of the historical geographies of Bangor. Known nationally as the Community Atlas Project, teachers and students are asked to define the nature of their community by creating maps, writing community descriptions, and compiling images to be combined in a visual presentation and posted on the Internet. The project involves four World Geography classes and two Civics classes, all at the freshman level and housed in the History Department. Students are creating their community atlas through the use of a Global Positioning System (GPS), GIS, basic html coding, digital cameras, scanners, and computer skills. As a result, they are developing research skills, spatial skills, analytical skills, technological skills, and group work skills. The final product will be posted on the Web by ESRI and presented to both the City of Bangor and the Bangor Historical Society as a display on the city's website, a digital PowerPoint presentation, and/or a physical poster presentation.

Continued Module Development

On the basis of the success of portable module development in prior years, our 2004-2005 fellows are creating 20 new portable modules that can be easily transported, either in their entirety or partially, from school to school. Taking advantage of the Maine Teaching-Learning Initiative's PASCO probe sensor lending library, a wide range of hands-on sensor-based activities have been incorporated into some of the poorer schools in Maine. The State of Maine's so-called Laptop Initiative, which provides all 7th and 8th graders in the state with laptop computers, provides an additional resource for interfacing with PASCO-type sensors in module development.

Integrating Sensors Into Sixth-Grade Science Classes

Georgiana Piete and GK-12 Sensors! fellow Eeva Hedefine have introduced sixth-grade science classes to earth science topics through a variety of hands-on activities. Specific sensor-related activities have included a two-day module on the Global Positioning System (GPS) involving a presentation and hands-on use of GPS receivers, and a presentation introducing students to common sensors in daily life. Additional projects involve building a weather station with the students to measure atmospheric pressure, temperature, wind direction, and rainfall.

Integrating Sensors Into Seventh-Grade Life Science Classes

GK-12 participating teacher Patricia Bernhardt, seventh grade life science teacher at JFDS in Bangor, ME has introduced her students to sensors by comparing human senses to sensors created through technology. With fellow Eeva Hedefine, she has facilitated in-class discussion and exploration into how the sensors in the human olfactory system detect odors through the process of cell diffusion. Students were shown how smoke detectors work and asked whether their noses or the sensor technology in the smoke detectors would be more sensitive in detecting smoke. Through these discussions students were able to relate the concept of cell diffusion to specific examples of common items they are familiar with, allowing them to better understand the role of sensors in their everyday lives. Hedefine has also helped design and set up an experiment with the students to determine the effect of pH on bacterial growth. Bernhardt has also added hands-on experiments in diffusion and pH that incorporate sensors.

Toothpick Bridge Challenge Brings Active Learning to 8th Grade Applied Science Classes

Tracy Vassiliev and GK-12 Sensors! fellow Jesse Parks have engaged Tracy's 8th-grade (quarterly) Applied Science classes in a project called The Toothpick Bridge Challenge. Teams of students build model bridges using only toothpicks and glue. Students are introduced to the concepts of compressive and tensile forces and the corresponding strains, scale drawing and diagramming from multiple points of view, and elements of bridge structure and design. Efficient use of time and maximum contribution to the team are emphasized. Each class is strongly encouraged to seek out students who participated in earlier quarters, to share ideas and information, and to foster the kind of communication, interaction and collaboration essential to scientific research.

Integrating Sensors Into Middle-School Animal & Human Biology Classes

Robert O'Leary, with GK-12 Sensors! fellow Danielle Donovan, have incorporated sensors into the animal and human biology middle-school science curriculum. Labs include a sensor webquest, a human dashboard, a sensor search of the home, and the use of Pasco sensor probes. A science unit on different sensor types and their roles in daily life is ongoing.

Integrating Sensors Into Middle School Computer Science Classes

Fellow Douglas Isenberg, working with HMS teacher Alan Tweedie, has successfully integrated robots which incorporate a range of sensor technologies into his middle-school computer science classes. Each week, more than 160 Hermon middle schoolers are impacted by the introduction of sensors into their computing classrooms. Isenberg and Tweedie have successfully used robots equipped with sensors to teach students introductory programming skills, along with the science and engineering principles which underlie the robots.

Highlights: Integrating Sensors Into High School Classrooms

Robert Littlefield and fellow Wade Pinkham have incorporated sensors in the Lego Mindstorms kits into projects that show students how sensors can be used in a mechanical sense, including bumper-bots, where the students used touch sensors to sense when their vehicle bumped into an object, and a strider, where students used a rotation sensor to calculate how far the car had traveled. They plan to develop a Mindstorm project incorporating a light sensor and a curricular section devoted to hydrogen cars.

Arthur Libby and fellow Erik McCarthy have worked to develop an electricity unit that can be taught to freshman physical sensor science classes. The focus of this unit is to work on sensor projects that interest students with a wide range of backgrounds in electronics. Components such as resistors, capacitors, and inductors are introduced as well as measurement techniques using digital multimeters. Students are building a lie detector using circuit boards.

John Mannette and fellow Aaron Clark have used sensors both to introduce physical concepts and to reinforce theoretical understanding with hands-on experience in the classroom. Sensors are similarly being used to teach concepts of electricity and magnetism to the students.

James Tyson of MCI and fellow Chris York, have incorporated sensors into most physics labs and activities to enhance students understanding of the laws of physics: acceleration, velocity, force, and effects of temperature. For spring 2005, each class will, in addition to regular class work, determine a sensor project to be researched, built, and tested. A 9th grade class will build gravity-powered cars and race them, applying a constructed timing system, using photoelectric or pressure-sensitive sensors as well as accelerometers attached to the cars themselves.

Findings:

1. Crucial to the smooth integration of GK-12 Sensors! fellows into participating teacher classrooms is the preparation of teachers through participation in the RET program and the interaction of teachers and fellows during the summer, allowing them to establish working relationships and acquaint themselves thoroughly with each others' interests, styles, strengths and weaknesses.
2. While the 2nd year evaluation report results suggest that among 11th-12th grade students the GK-12 Sensors! program and the presence of GK-12 fellows did not inspire students to explore STEM career paths unless they were already inclined prior to exposure to GK12, the report also suggests that the GK-12 Sensors! program and the presence of GK-12 fellows significantly strengthened and positively impacted students who aspired to explore STEM career paths before exposure to GK-12 Sensors!. This delta-shift result is not unexpected when one realizes that most high-school students with college aspirations are by the latter half of their junior year at the latest already involved in preparatory college board exams and discussions with family, school councilors and peers about college selection, academic interests and their career potentials. At this critical juncture in these students' development, the college track is tied to academic interests that may determine a career path (though in fact many college students will change majors at least once during their undergraduate careers).

The evaluation report suggests a somewhat greater shift toward consideration of STEM disciplines among 9th-10th grade students, though again it seems many students had eliminated consideration of pursuit of STEM disciplines prior to GK-12 Sensors! exposure. We suggest that one strong factor affecting these students may relate to the fact that most high schools in Maine provide several curricular tracks for which students may or may not qualify or from which they may be able to choose. As early as ninth grade, a student may limit her/his aspirations by assignment to a non-college preparatory track curriculum. For such students, the issue is not the same as encouraging a college-bound student to consider a pursuing a degree in a STEM area and a career path in science or engineering; rather, the issue concerns raising aspirations enough for them to attempt to switch to a college-preparatory curricular track in order to pursue higher education.

The introduction of GK-12 into 6th-8th grade classrooms also raised the issue of assuring program effectiveness: Bringing GK-12 Sensors! into middle-school classrooms might produce short-term positive effects, but will these students go on to consider STEM career paths in high school? The question is especially difficult if those students who are introduced to sensors and GK-12 fellows in seventh and eighth grades have no further opportunity for similar interaction in ninth grade and beyond. Thus it became clear that crucial to achieving the GK-12 Sensors!'s main goal (namely to motivate students to follow careers in science and engineering, more generally in any STEM area) is the consistent presence of GK-12 Sensors! throughout a student's secondary education. Students need to be introduced to GK-12 Sensors! at the middle-school level, at the latest.

Based on the qualitative experience of teachers, fellows, and students involved in the GK-12 program this year, the transition from middle to high school is key. We anticipate that students leaving eighth grade with a positive experience of science throughout middle school and the opportunity to continue with a similar kind of science engagement in high school will be more likely to choose curricular tracks maximizing their opportunities for such desired exposure. The 2004-2005 evaluation report on GK-12 Sensors will provide data concerning sixth through twelfth-grade students exposed to GK-12 Sensors!, but only the 2005-2006 report will provide concrete data from ninth-grade respondents who were also eighth-grade GK-12 Sensors! participants.

Training and Development:

2004 RET-GK-12 Interface

In the spring of 2004, Dr. John Vetelino and Dr. Constance Holden received an RET site grant from the National Science Foundation. As a result, during the summer of 2004 and for the next three summers, ten teachers will be brought to UM by the RET program each summer. As was the case with the RET's during the summer of 2003, these teachers will be paired with UM faculty members and work closely with current participants in the GK-12 Program. By bringing these teachers to UM, we hope to significantly increase the number of schools we can influence in Central and Northern Maine.

2004 Summer Workshop

In August of 2004, GK-12 Fellows, teachers from BHS, BrHS, BuHS, CHS, CoMS, Dexter Regional High School, DMS, HA, HMS, JBMHS, JBHS, Lee Academy, MCI, RBMS, and SMHS, and faculty members from UM met at UM for a three-day workshop to report on summer 2004 research activities and/or formalize GK-12 Sensors! activities for the 2004-2005 academic year. The workshop began with ten 2004 RET and fifteen GK-12 Fellow presentations of summer research. Participating teachers from the first two years of the program spoke to the challenges and accomplishments of the program, and former program evaluator Dr. Kevin Boyle presented on past and present program evaluation, focusing on methods for determining program impact on all participants. On the final day of the workshop, Dr. Vetelino established participant workgroups to discuss issues relevant to small and large high and middle schools. Each group addressed the following issues: A. Basic School Demographic Information; B. Existing Modules; C. New Module Ideas; D. Integration of University Research and Resources Into Classrooms;

and E. Extra-Curricular Activities. Workgroups shared results, then dissolved into RET-GK-12 fellow pairings, to plan schedules and modules for the 2004-2005 academic year.

Future Training

ò Summer 2006 RET program

ò REU-Sensors! site

During the spring of 2005, Dr. John F. Vetelino received a REU site grant from the National Science Foundation. As a result, during the summer of 2005 and for each of the next two summers, 16 undergraduates will be brought to UM by the REU program.

ò 'Introduction to Sensors' at BHS

The 2005 pilot program is scheduled for permanent inclusion in the BHS curriculum.

Outreach Activities:

Conferences:

Participating teacher Tracy Vassiliev presented a paper entitled 'Effects of Heavy Metals on Lobsters' at the 97th Annual Meeting of the National Shellfisheries Association, April 10-14, in Philadelphia, PA.

Fellows Brad Neumann and Eeve Hedefine, in collaboration with BHS teacher Jim Smith, presented a paper on their GK-12 Sensors! activities entitled 'Applying GIS Technologies to Enhance Emergency Response' at the National Science Teacher Convention (NSTA), March 31-April 3, 2005, in Dallas, TX.

Participating teacher Patricia Bernhardt presented a paper entitled 'GK-12 Sensors!-related integration of RET research into middle-school classrooms' at NSTA, March 31-April 3, 2005, in Dallas, TX.

PI John Vetelino and program coordinator Joe Arsenault presented a poster presentation entitled 'NSF GK-12 Sensors!' GK-12 National Meeting, March 4-6, 2005, in Arlington, VA.

PI John Vetelino and Co-PI Constance Holden presented a poster presentation entitled 'NSF 2004-05,' which described the collaboration of each fellow-teacher pairing, at the annual NSF Engineering and Computing Education Grantee Meeting RET meeting, February 16-18, in Washington, DC.

PI John Vetelino presented a paper on the GK-12 Sensors! program entitled 'GK-12 Sensors! at the University of Maine,' at the 2004 IEEE Frontiers in Education conference October 2004, in Savannah, Georgia.

Journal Publications

Carr, Crystal; Grant, Elaine; Puckett, Anthony, "Matrices and Digital Pictures", The Mathematics Teacher, p. , vol. , (). Submitted

French, Lester; Koch, Helmut, "A Sensor Design Project For High School Chemistry Classes", The Journal of Science Education, p. , vol. , (). Submitted

Lampron, Kenna; Hedlund, Wes, "The pH Sensor Lab", The Science Teacher, p. , vol. , (). Submitted

James, Cary; Martin, Andrea, "Air Quality Projects In a High School Chemistry Curriculum", The Journal of Chemical Education, p. , vol. , (). Submitted

Hedefine, Eeve; Neumann, Brad; Smith, Jim, "The Bangor, Maine GIS Emergency Mapping Project", The Science Teacher, p. , vol. , (). Submitted

Chenosky, Margaret; Donovan, Danielle; Pitcher, Stephanie, "Using Satellite Remote Sensing to Investigate the 5 Themes of Geography", The Journal of Geography, p. , vol. , (). Submitted

Burgess, Scott; Burkenpass, Eric; Lewark, Michael; Thiele, Jeremy, "Electronics Applied: The Light Sensor", The Physics Teacher, p. , vol. , (). Submitted

Crowley, Adam, "It's All About CHOICES", Communique, p. 7, vol. , (2004). Published

Hale, Sandra, "GK-12 Sensors! Partnership Opens Doors", Communique, p. 1, vol. , (2002). Published

Godsoe, Stephen, "GK-12 Sensors! Grant", Communique, p. 4, vol. , (2004). Published

Hale, Sandra, "Do You Want To Be An Engineer?", Communique, p. 14, vol. , (2003). Published

Crowley, A., Godsoe, S., Holden, C., Vetelino, J., "Work in Progress--Integration of Sensors into High School Classrooms", Proceedings: Frontiers in Education 34th Annual Conference, p. F4D-12, vol. II, (2004). Published

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Crowley, Adam, "GK-12 August Workshop Report, August 2003", (2003). Report, Published
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J. Arsenault, S. Godsoe, C. Holden, J. Vetelino., "GK-12 Sensors 2004-2005 Annual Report to NSF", (2005). Report, Submitted
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n/a, "JFD Teachers Participate in national Science Foundation Program--Applied Science an exciting new class", (2004). Newspaper Article, Published
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Eric Berkenpas, Aaron Clark, et al., "Fall 2004-2005 GK-12 Sensors! Fellow Journals", (2004). Project Report, Report filed; available upon demand.
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 Bibliography: Kesseli, D. "Bangor High seniors give city satellite-based maps." Bangor Daily News, May 14, 2004: 4.

Web/Internet Site

URL(s):

<http://www.eece.maine.edu/research/gk12/>

Description:

This site contains information on current activities, fellows and modules.

Other Specific Products

Product Type:

Web page

Product Description:

A catalogue of current portable modules can be found at the following address:

<http://www.eece.maine.edu/research/gk12/portablemodule.htm>

Sharing Information:

This product will be shared over the internet.

Contributions

Contributions within Discipline:

The principal disciplinary field of the project is sensors education. GK-12 Sensors! has developed and extended this field in the 6-12 environment through the ongoing development of portable modules, many currently available on our website, all to be posted no later than July 15, 2005. Indications of program success are described in 'Work in Progress' Introduction of Sensors in High School Classrooms,' published in Proceedings of the 2004 IEEE Frontiers in Education Conference (839-40). Additional details have been documented in 'Introduction of Sensors in High and Middle School Classrooms,' which will be presented at the October 2005 IEEE Frontiers in Education Conference.

Former GK-12 Fellow Andrea Martin successfully completed her Masters' thesis at UM in August 2004, using her experience with the GK-12 Sensors! program as a cornerstone for her thesis work.

Andrea Martin GK-12 Sensors! Related Research:

Implementing a project based atmospheric chemistry unit in a high school honors chemistry classroom helps students learn and apply science concepts that relate to environmental policy and health. At Bangor High School, in Mr. Cary James's classroom, an ozone monitoring station acquired from the Maine Department of Environmental Protection, sparked the development and integration of a series of air quality projects. The monitoring equipment detected ground level ozone concentrations outside the high school 24 hours a day, enabling students to analyze and interpret the data. The effectiveness of the air quality projects in meeting the following three goals: helping students obtain a better understanding of 1) atmospheric chemistry, 2) the environmental and health risks associated with different types of air pollution, and 3) the analytical methods for detecting various gases in the atmosphere, were evaluated using qualitative and quantitative data from 57 honors students who participated in the study. A comparison between the students' pre and post scores on an air quality questionnaire was used to assess how well the projects met the above three goals. Also, grading rubrics were provided to evaluate the students' performance on

individual projects.

The results verify the overall success- improved student scores on the questionnaire, successful completion of projects, including a service outreach component of students sharing learning with younger students, and positive comments about increased motivation, especially from four students who were given responsibility for setting up and maintaining the equipment.

GK-12 Fellows Contributions:

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Fellow Douglas Isenberg, working with HMS teacher Alan Tweedie, has successfully integrated robots which incorporate a range of sensor technologies into his middle-school computer science classes. Each week, more than 160 Hermon middle schoolers are impacted by the introduction of sensors into their computing classrooms. Isenberg and Tweedie have successfully used robots equipped with sensors to teach students introductory programming skills, along with the science and engineering principles which underlie the robots.

Robert Littlefield and fellow Wade Pinkham have incorporated sensors in the Lego Mindstorms kits into projects that show students how sensors can be used in a mechanical sense, including bumper-bots, where the students used touch sensors to sense when their vehicle bumped into an object, and a strider, where students used a rotation sensor to calculate how far the car had traveled. They plan to develop a Mindstorm project incorporating a light sensor and a curricular section devoted to hydrogen cars.

Arthur Libby and fellow Erik McCarthy have worked to develop an electricity unit that can be taught to freshman physical sensor science classes. The focus of this unit is to work on sensor projects that interest students with a wide range of backgrounds in electronics. Components such as resistors, capacitors, and inductors are introduced as well as measurement techniques using digital multimeters. Students are building a lie detector using circuit boards.

John Mannette and fellow Aaron Clark have used sensors both to introduce physical concepts and to reinforce theoretical understanding with hands-on experience in the classroom. Sensors are similarly being used to teach concepts of electricity and magnetism to the students.

James Tyson of MCI and fellow Chris York, have incorporated sensors into most physics labs and activities to enhance students understanding of the laws of physics: acceleration, velocity, force, and effects of temperature. For spring 2005, each class will, in addition to regular class work, determine a sensor project to be researched, built, and tested. A 9th grade class will build gravity-powered cars and race them, applying a constructed timing system, using photoelectric or pressure-sensitive sensors as well as accelerometers attached to the cars themselves.

Contributions to Other Disciplines:

During the 2004-20005 academic year, GK-12 Sensors! expanded its 2003-2004 incorporation into ninth grade Civics and Health classrooms to include ninth and tenth grade History and World Geography classes and further developed a significant presence in not only Life Science, Applied Science, Human and Animal Biology, Computer Science, but in many Social Studies classes at the sixth-eighth grade levels in five area middle schools.

Contributions to Human Resource Development:

The major goals of the project are achieved by using sensors as the vehicle to encourage students to pursue science and engineering careers. To this end the fellows act as role models as well as teachers. Emphasis toward encouraging underrepresented groups in science and technology, including females, minorities and disabled students is important to each teacher, faculty member and fellow working in the GK-12 Sensors! Program. It is anticipated that this program will significantly increase the number of high school students in Maine who will be choosing future careers in science and engineering.

Teachings of Geographic Information Systems (GIS) at Bangor High School have increased the knowledge of participating high school teachers and helped to establish a working relationship between the Bangor school system and the police and fire departments of the City of Bangor.

In particular, through the Bangor, Maine Emergency Mapping GIS Project, GK-12 fellows introduced fire, police and other city officials to GIS technology, enhancing their understanding of the technology and showing them what GIS can do for the city, including improvements to emergency response and homeland security. Learning more about the power and capabilities of GIS has drawn them closer towards larger-scale implementation of these technologies for the improvement of the community. Working with high-school students on the project also helped introduce students to GIS technology and involved them in a community-based project. This may encourage them to continue involvement in community service. The project gave students hands-on experience using GIS technology, providing them with new technical skills.

Contributions to Resources for Research and Education:

Fellows, working with teachers at all schools we interact with, continue to develop portable sensor modules for dissemination to other schools in the fall of 2005.

Sensor research is an interdisciplinary field with applications in all areas of science and mathematics. The students are introduced to the scientific approach to problem solving and invention.

Students are using math, physics, chemistry, biology, electrical circuitry, computer science and drafting knowledge to create laboratory sensors that employ principles involved in the most advanced technology systems.

Development of community-based GIS projects with BHS students has provided an opportunity for submission of a proposal to the City of Bangor for homeland security money to fund creation of a \$46,000 GIS lab at BHS.

Fellow and participating teacher presentations of GK-12 Sensors!-related educational activities at the National Science Teachers Association Convention (March 31-April 3, Dallas, TX) provided opportunities to disseminate resources to educators from throughout the U.S., exhibiting concrete models for implementing sensors into middle- and high-school curricula.

The facilities at the Laboratory of Surface Science and Technology (LASST) are available for research opportunities. Group and individual visits to LASST have enhanced the GK-12 Sensors! classroom experience.

Contributions Beyond Science and Engineering:

Teachings about GIS and focus on community-based projects has provided the City of Bangor with both emergency response-related spatial information, and maps of various historical geographies to be used in emergency situation and for education and marketing the city's resources.

GK-12 fellows have introduced fire, police and other city officials to GIS technology, enhancing their understanding of the technology and showing them what GIS can do for the city, including improvements to emergency response and homeland security. Learning more about the power and capabilities of GIS has drawn them closer towards larger-scale implementation of these technologies for the improvement of the community. Working with high-school students on the project also helped introduce students to GIS technology and involved them in a community-based project. This may encourage them to continue involvement in community service.

GK-12 fellows involved themselves in a variety of extracurricular activities, including assisting organize an engineering technical society for BHS 11th graders, a TEAMS (Tests of Engineering Aptitude, Mathematics and Science) competition for BHS students, reviving an after-school Electric Car Club at JBHS, and advising CHS 9th-grader independent project assessing the feasibility of renovating the CMS solar system.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Annual Report for Period:04/2005 - 04/2006

Submitted on: 06/21/2006

Principal Investigator: Vetelino, John F.

Award ID: 0139324

Organization: University of Maine

Title:

GK-12: Sensors!

Project Participants

Senior Personnel

Name: Vetelino, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Vetelino was born in Westerly R.I. He received the B.S., M.S., and Ph.D. in electrical engineering from the University of Rhode Island in 1964, 1966, and 1969, respectively. He was one of the founding members of the Laboratory for Surface Science and Technology at the University of Maine and is currently leader of the solid state research group. Four sensor companies û the BIODÉ Corp. in Westbrook, ME, Microsensor Conversion Technology in Brookings, SD, Sensor Research and Development Corp. in Orono, ME and Mainely Sensors, also in Orono, ME û have been incubated from his research group.

Dr. Vetelino's research in acoustic wave and metal oxide sensors served as the motivation for the GK-12 Sensors program. He previously served on many NSF Science Education Review panels for NSF Undergraduate Research Participation (URP), NSF Local Course Improvement (LOCI), NSF Student Science Training (SST), NSF instructional Scientific Equipment Program (ISEP) and NSF Small Business Innovation Research grants (SBIR) proposals. He also served in many NSF workshops and various panels relating to research addressing national needs.

As Principal Investigator, Dr. Vetelino makes the final decision on fellow selection, directs fellow activities, sets guidelines for module development, facilitates communication between the six GK-12 Sensors! schools and UM faculty, writes and submits supplemental and related grants for the program, establishes guidelines for fellow journal articles on the GK-12 program, and attends GK-12-related conferences.

Dr. Vetelino also serves as the advisor for GK-12 Sensors! fellows Lester French, Jesse Parks, Wade Pinkham and Chris York.

Name: Godsoe, Stephen

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephen Godsoe is from Bangor, Maine and has 37 years of high school teaching experience. Mr. Godsoe was the K-12 Mathematics Coordinator in Bangor from 1975-1983 and 1989-1991 and has served on several state committees to establish mathematics standards. He has taught all levels of high school mathematics, statistics, and computer science. He was one of twenty-eight teachers in the US to receive the Edith May Sliffe award in 2001. Since 1994, Mr. Godsoe has also taught 'Teaching K-8 Mathematics' at the University of Maine.

As Co-P.I. for GK-12 Sensors, Mr. Godsoe is an active team member in the classroom, helping GK-12 fellows. He directs the program's collaboration with the state and city agencies, and works to support the program with new initiatives. Mr. Godsoe organizes GK-12 activities at our largest site, Bangor High School. In this capacity, he pairs fellows with appropriate teachers, produces GK-12 press releases for the school paper, and regularly communicates with GK-12 satellite schools on issues relating to technology in the classroom.

Name: Holden, Constance

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Constance Holden has significant teaching experience at the local high school, University College of Bangor and the University of Maine. She has supervised student teachers, helped to develop the curriculum on workshops for secondary school teachers, and authored publications for professional journals related to teaching science and engineering.

As Co-P.I. for GK-12 Sensors, Dr. Holden brings her teaching experience to the task of supporting and training the GK-12 fellows. She teaches Spatial Science and Technology Information at the University of Maine, as well as meeting with the fellows on a

one-to-one basis, interacting with civic leaders, developing GIS programs for BHS courses, and helping to administer the program.

Name: Crowley, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

Adam Crowley is from Caribou, Maine and has taught at The University of Maine and Beal College. As the 2003-04 program manager, Mr. Crowley coordinated all GK-12 activities, set up meetings, promoted the program to the public, prepared reports, maintained the website, designed PowerPoint presentations on GK-12 Sensors, and assisted in the development of modules.

Name: Boyle, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

As program evaluator, Dr. Boyle gathered information on fellow classroom activities and surveyed GK-12 teachers to assess the impact of fellows on classroom activities. Dr. Boyle left the program February 2005.

Name: Arsenault, Jr., Joseph

Worked for more than 160 Hours: Yes

Contribution to Project:

Joe Arsenault has taught at The New School for Social and Behavioral Research (NYC) and at The University of Maine. As program manager from 2004 to present, Mr. Arsenault has coordinated all GK-12 Sensors activities and meetings; acted as a liaison between Co-PIs, fellows and teachers; prepared articles, reports and informational presentations on GK-12 Sensors!; assisted fellows in the development of modules and conference presentations; represented the program at national conferences; advocated for establishing ongoing State financial support for GK-12-type programs; worked with fellows to establish auxiliary support for GK-12 related activities.

Name: Hart, Suzanne

Worked for more than 160 Hours: Yes

Contribution to Project:

Suzanne Hart, Research Associate/Policy Analyst at the Center for Research and Evaluation (CRE), College of Education & Human Development, University of Maine, was the fall 2004-summer 2005 GK-12 Sensors! program evaluator. As such, Hart reviewed past and current evaluation efforts and instruments and performed additional analyses on prior evaluation reports. She administered and analyzed 2004-2005 evaluation data and developed an evaluation plan for the successful GK-12 Sensors! Track II proposal submitted June 2005. During fall 2005, she was transitioned seamlessly by the CRE from the position. A colleague at the Center has assumed her responsibilities.

Name: Doore, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Brian Doore became GK-12 Sensors! evaluator during the fall of 2005. He is responsible for all aspects of program evaluation.

Post-doc

Graduate Student

Name: Berkenpas, Eric

Worked for more than 160 Hours: Yes

Contribution to Project:

Eric Berkenpas from Northwest Iowa attended South Dakota State University where he received his undergraduate degree in Electrical Engineering with a Computer Science minor. Eric received the MS Electrical Engineering from UM in Summer 2005. His graduate research involved development of a novel sensor for detecting bio-terrorism pathogens. Eric worked with electronics classes at BHS and JBMHS and with chemistry and physics classes at Sumner Academy. Eric left the GK-12 program January 2005.

Name: Kenney, Crystal

Worked for more than 160 Hours: Yes

Contribution to Project:

Crystal Kenny is from China, ME. She received the Bachelors Degree from UM in Engineering Physics and Computer Engineering. She completed her Masters degree at UM in Electrical Engineering in August 2005. Her research involved magnetic flux sensors in hearing aid applications, with advisor David E. Kotecki. She worked with physics teachers at JBHS. Crystal left the GK-12 program in July 2005.

Name: Donovan, Danielle

Worked for more than 160 Hours: Yes

Contribution to Project:

Danielle Donovan is from Presque Isle, Maine. She received her Bachelors Degree from the University of Maine in Spatial Information Science and Engineering. In Summer 2005, she received the Masters degree in Spatial Information Science and Engineering at the University of Maine, specializing in remote sensing and geographic information systems (GIS). Danielle was instrumental in the development of the Sensor Sensitive program at BHS, detailed in a later portion of this report. Danielle also worked with life science teachers at RBMS. Danielle was one of two fellows who worked with NASA to develop EarthKam modules for participating classrooms.

Name: French, Lester

Worked for more than 160 Hours: Yes

Contribution to Project:

Lester French is pursuing a Ph.D in materials science, focusing on acoustic wave sensors for use as liquid-phase chemical sensors. Lester received the BSEE with a minor in optical and illumination engineering from the University of New Hampshire in 1993. Lester worked as a commercial engineer for Duro-Test Corporation and as a research engineer for BIODÉ, Inc. on the modeling, testing, and packaging of acoustic wave devices as liquid-phase chemical sensors. He received his MSEE from the University of Maine in 2002. Prior to the 2005-06 academic year, Lester worked primarily with the Chemistry department at Bangor High School for the NSF GK-12: Sensors! project. In particular, Lester worked closely with BHS Chemistry teacher Helmut Koch, designing and implementing sensor modules that detect acidity and viscosity in various substances. In the spring of 2003, Lester traveled to Magdeburg, Germany to take part in a program related research experience at the Otto-von-Guericke University. Working with co-PI Stephen Godsoe of BHS, Les designed and taught a senior-level pilot course on sensor science and engineering. This year Lester has been working with teachers at Caravel Middle School and Hermon Middle and High schools.

Name: Hedefine, Eeva

Worked for more than 160 Hours: Yes

Contribution to Project:

Eeva Hedefine, a Maine native, is a MS student in the Department of Spatial Information Science and Engineering at the University of Maine. Eeva is researching privacy issues relating to sensors. She received a Bachelors Degree in Spatial Information Engineering from the University of Maine and an Associate Degree in Legal Technology from the University of Maine at Augusta. Eeva has worked with the Senior Seminar, Civics, Geography, and Advanced Drafting classes at BHS. In 2004 and 2005 Eeva was central to the development of the Bangor, Maine GIS Emergency Mapping Projects, detailed in a later portion of this paper.

Name: Kennard, Raymond

Worked for more than 160 Hours: Yes

Contribution to Project:

Raymond Kennard is from South Paris Maine. He graduated from Ithaca College in '99 with a B.S. in Chemistry and a minor in Physics. During the next four years, Raymond taught physical sciences at Fryeburg Academy (Fryeburg, ME). In the fall of 2002, he decided to return to school to pursue a Ph.D in Chemical Engineering at UM. Raymond is currently researching mesoporous thin films and their application to Sensor as a molecular prefilter. As a fellow, he has worked with chemistry faculty at BHS, faculty at DMS and CMS, and the downtown Bangor Discovery Museum.

Name: Krassikoff, John

Worked for more than 160 Hours: Yes

Contribution to Project:

John Krassikoff received the Ph.D Physics in Spring 2005. He was involved with the Laboratory for Surface Science and Technology where he performed research tasks related to sensor development for monitoring high temperature oxidation of SiAlON fracture resistant thin films. John served, in various capacities, during ten years in the United States Air Force. He subsequently worked as an electronics technician for Hipotronics, a high-voltage test equipment company and was an engineering technician for the United Parcel Service at its R&D facility, working on voice recognition systems. Finally, John worked as a staff engineer at Lorex Industries working on the design of optical and acoustic measurement systems for the telecom and semiconductor industries. He left industry to attend graduate school after completing his second bachelor's degree, in Physics, at

the State University of New York at New Paltz. At John Bapst High School, John worked closely with students from general physics classes to help them produce sensor-oriented projects for annual physics project competition. Furthermore, John introduced electricity into the curriculum of ninth grade science classes. John Krassikoff left the GK-12 Sensors! program in October of 2003.

Name: Lampron, Kenna

Worked for more than 160 Hours: Yes

Contribution to Project:

Kenna Lampron from Standish, Maine received her Bachelors degree from the University of Maine in Electrical Engineering August 2003 and began working on her MS at the University of Maine in the same field as her undergraduate study. Her research involved semiconducting metal-oxide (SMO's) sensors. Kenna worked with biology classes at BHS, developing portable learning modules for biology classes focusing on PH sensing. Kenna left the GK-12 program August 2004.

Name: Lewark, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Michael Lewark from Jonesport, Maine, was a candidate for a PhD in Electrical Engineering at the University of Maine. He received his undergraduate degree in Electrical Engineering from the University of Maine in May of 2003. Michael's area of research was in material characterization for microwave acoustic applications. During the 2003-04 academic year and fall of 2004, Michael worked with science classes at Jonesport-Beals High School (JBHS). In the fall of 2004, Mike was instrumental in reviving the school's Electric Car Club. Mike left the GK-12 program January 2005.

Name: Martin, Andrea

Worked for more than 160 Hours: Yes

Contribution to Project:

Andrea Martin from Indiana and received her degree in forensic chemistry from Ohio University. She is currently pursuing her PhD in chemistry at the University of Maine and works on the development of a nitric oxide gas sensor in the Laboratory for Surface Science and Technology. At Bangor High School, Andrea is working with the students in the chemistry classes. As a fellow, Andrea has developed one of only two air quality monitoring stations in the state of Maine. This station is located at Bangor High School. She has designed a number of modules around the station and has developed a system for the dissemination of this information to our satellite schools. In the summer of 2003, Andrea traveled to Brescia, Italy to take part in a program related research experience at the University of Brescia.

Name: McCarthy, Erik

Worked for more than 160 Hours: Yes

Contribution to Project:

Erik McCarthy, originally from Greene, ME, is a graduate of Leavitt Area High School in Turner. He received a B.S. degree in Electrical Engineering from the University of Maine in May, 2003 and currently is working on a Master's degree in Biological Engineering. His graduate research is focused on attaching selective biomolecular layers to sensors that may be used to detect pathogens in aqueous environments. Erik joined the GK-12 Sensors! program in February, 2004 working at BHS, Lee Academy and SHS in a variety of subject areas, including calculus, physical science, chemistry and computer programming. During the 2004-05 academic year, Erik worked at BrHS, collaborating with teachers to design and implement an electronics unit for 9th-grade physical science classes. Erik left the GK-12 program July 2005.

Name: Neumann, Brad

Worked for more than 160 Hours: Yes

Contribution to Project:

Brad Neumann, from Northern Michigan, received his Master of Science in the UM Department of Resource Economics and Policy in August 2005. He received his Bachelor of Science degree from Northern Michigan University, where he dual-majored in Economics and Land Use Planning, and studied Geographic Information Systems (GIS) as a minor concentration. Brad has worked as a GIS intern for Environmental Systems Research Institute, Inc., and has also worked as an independent consultant on GIS and land use planning projects. His research at the University of Maine primarily dealt with evaluating the effects that preserved land has on neighboring property values. Brad was brought into the program in 2003 as a social science fellow. He worked at Bangor High School in the Social Studies Department and was involved in Senior Seminar, Civics, and World Geography classes. Along with fellow Eeva Hedefine, Brad developed the Bangor, Maine Emergency Response GIS Project and several related projects. Brad left the GK-12 Sensors! program in July 2005.

Name: Pitcher, Stephanie

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephanie Pitcher received the MS degree in Electrical Engineering. Stephanie's research was focused on developing an impedance-based metal-oxide gas sensor for ethylene detection and fruit ripening. Stephanie grew up in Washington State during elementary and high school, and studied at the University of Colorado at Colorado Springs for her undergraduate BS degree in Electrical Engineering. She worked with the BHS biology department. Stephanie is one of two fellows who worked with NASA to develop GK-12 Sensors! classroom modules. Along with fellow Danielle Donovan, Stephanie was central in the development of the Sensor Sensitive program, detailed in later section of this report. Stephanie left the GK-12 program in July 2004.

Name: Puckett, Anthony

Worked for more than 160 Hours: Yes

Contribution to Project:

Anthony Puckett received the PhD in mechanical engineering. His research focused on ultrasonic methods for material characterization using solid cylindrical waveguide used in non destructive sensing. Anthony was born and raised in New Mexico. He received his BS and MS in Mechanical Engineering from Colorado State University. Anthony worked mainly with pre-calculus classes at BHS. Anthony Puckett left the GK-12 Program in April of 2004.

Name: Woodward, Becky

Worked for more than 160 Hours: Yes

Contribution to Project:

Becky Woodward received the Ph.D in biology in 2004. In her research she conducted a cross-species comparison of the morphologies and performance abilities of four baleen whale species. Her work involved the use of suction-cup attached, multi-sensor data logging tags to monitor the underwater movements of large whales at sea. Becky designed a whale watching module that brought students from several schools to the coast of Maine to observe and classify the habits of humpback whales. Becky Woodward left the Gk-12 Sensors! program at the end of 2003.

Name: Reed, Allison

Worked for more than 160 Hours: Yes

Contribution to Project:

Allison Reed has been assisting Dr. Boyle in his evaluation of the GK-12 Sensors! program.

Name: Ozdemir, Smera

Worked for more than 160 Hours: Yes

Contribution to Project:

Smera Ozdemir has been assisting Dr. Boyle in his evaluation of the GK-12 Sensors! program.

Name: Clark, Aaron

Worked for more than 160 Hours: Yes

Contribution to Project:

Aaron Clark is from Hermon, Maine. He is currently working on his Ph.D. in Chemical Engineering at the University of Maine. His research involves the development of metal-oxide chemical microsensors for gas sensing applications. He received his Bachelors Degrees from the University of Maine in Chemical Engineering and Mathematics in 2002, and a Masters Degree in Chemical Engineering in 2004. Aaron is a second-year fellow with the NSF GK-12: Sensors! Program; he works with teachers in the Bucksport School System.

Name: Gallimore, Dana

Worked for more than 160 Hours: Yes

Contribution to Project:

Dana Gallimore attended UM and received an undergraduate degree in Electrical Engineering, with a minor in mathematics. Dana is currently a Ph.D. student in Electrical Engineering. Her research involves determining the elastic properties of biofilms on surface acoustic wave sensors. Dana worked with the BHS mathematics department. Dana left the GK-12 program July 2005.

Name: Isenberg, Douglas

Worked for more than 160 Hours: Yes

Contribution to Project:

Douglas Isenberg was a Masters student in Electrical Engineering at UM during the 2004-05 academic year. He received his BS in Electrical Engineering at the University of North Carolina at Charlotte. Douglas worked with computer classes at Hermon Middle School, introducing the students to computer programming and robotics. Douglas left the GK-12 program July 2005.

Name: Pinkham, Wade

Worked for more than 160 Hours: Yes

Contribution to Project:

Wade Pinkham is from Damariscotta, Maine. He received his BS in Electrical Engineering from UM in 2004 and is currently working on a MS degree in Electrical Engineering at UM. He is specializing in applying bulk acoustic wave sensors to pesticide detection. Last year, Wade worked with physics classes at CHS in Corinth, ME. This year, he is working with middle school science teachers at CMS and SVMS.

Name: Parks, Jesse

Worked for more than 160 Hours: Yes

Contribution to Project:

Jesse Michael Parks was born in Calais, ME and is currently pursuing a Ph.D. in Electrical Engineering at UM. He received his BS in Electrical Engineering from UM in 1999 and worked at Sensor Research & Development in Orono, ME and Edwards Systems Technology in Pittsfield, ME before returning to UM in 2004. Jesse's research interests include sensor design and modeling and sensor response analysis. He is a second-year fellow with the NSF GK-12 Sensors! He has worked with teachers at BHS, CMS and DMS.

Name: York, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

Chris York was born in Levittown Pennsylvania and attended high school in Belfast Maine. Chris earned his undergraduate degree in Electrical Engineering at the University of Maine and is currently working on an MS in Electrical Engineering. Supported by Dr. John Vetelino, Chris is part of a group developing the lateral field excited (LFE) acoustic wave sensor, a new sensor platform. In particular, he is examining the LFE for use in biosensor applications, such as detecting E. coli in water supplies. Chris was a NSF GK-12 Sensors! fellow for the 2004-05 year, working primarily with Jim Tyson at MCI, a high school located in the town of Pittsfield. Chris left the program in July 2005.

Name: Walker, Judith

Worked for more than 160 Hours: Yes

Contribution to Project:

Judith Walker is a 2005-06 first-year GK-12 Sensors! fellow. She is originally from New Castle, Delaware. Currently she is working on her Masters in the Resource Economics and Policy Department under the advisement of Dr. Kathleen P. Bell. Her research involves community selection decisions in rural coastal communities focusing on the importance of community characteristics. Judith completed her undergraduate program at the University of Delaware in 2004. She majored in Natural Resource Management and earned minors in Resource Economics and Legal Studies. As an undergraduate Judith was accepted to participate in Columbia University's Biosphere 2 Program in Arizona for a semester. This year she is working with Jim Smith, Margaret Chernosky, and other teachers in the History Department at Bangor High School.

Name: Nagy, Edwin

Worked for more than 160 Hours: Yes

Contribution to Project:

Born in Lincoln, NE, Edwin Nagy is a 2006 GK-12 Fellow pursuing a Ph.D. in Civil Engineering. His research focuses on mechanics of materials. Currently, he is developing a 3d morphological lattice model of softwood to enhance our ability to predict mechanical properties of wood subjected to complex stress states. The model is being built and verified with data from small scale physical testing. He received his masters degree from the University of Maine in 1998 based on research involving 3d X-ray Microtomography of concrete under load. He received his A.B. in math and physics from Amherst College in 1993. Between undergrad and the masters, Edwin worked as a Peace Corps volunteer in Niger, West Africa. His duties primarily consisted of teaching high school math. Between the masters and returning to pursue the doctoral degree, Edwin worked as a structural engineer in central Arizona. Throughout the years, Edwin has been active in local theater, mostly working on sets and lighting, although lately he has begun trying his hand at directing with the Orono Community Theatre. Edwin has worked with teachers and BrHS and BrMS.

Name: Duy, Janice

Worked for more than 160 Hours: Yes

Contribution to Project:

Janice Duy is a first-year graduate student in the Department of Electrical and Computer Engineering. She received her BS in Electrical Engineering from the University of Maine in 2005. Her current research involves the development of biosensors to detect the potato wart fungus. Janice grew up in Manila, Philippines. During the spring 2005-06 academic year, Janice has interacted with teachers from CaMS, HMS and HHS.

Name: Shareef, Ali

Worked for more than 160 Hours: Yes

Contribution to Project:

Fellow Ali Shareef works at BHS in computing and electronics while pursuing a Masters Degree in Computer Engineering. He obtained his BS in Computer Engineering from Purdue University May 2004. Ali is working on integrating microprocessors using Dynamic Voltage Scaling (DVS) with sensors in the area of tracking. His other interests include Artificial Intelligence, Imbedded Systems, and Cluster Computing. He is originally from India.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Bangor High School

Bangor High School:

2005-06 DATA

Number of Fellows: 5

Number of teachers impacted: 10

Number of classes impacted: 32

Type of School: urban

% of free or reduced price Lunch: 20%

% minority: 8%

Academic Standing: Exceeds state averages in math, reading, and writing.

Bangor High School Teachers:

Andrew Bouchard Physics
 Margaret Chernosky Geography
 Don Erb Math/Computer Science
 Stephen Godsoe Math
 Cary James Chemistry
 Felicia Llyons Geography
 Roger Reed Civics
 Jim Smith Civics
 Theodore Taylor Earth Science
 Geoffrey Wingard History

John Bapst Memorial High School

John Bapst Memorial High School:

2005-06 DATA

Number of Fellows: 1
 Number of teachers effected: 2
 Number of classes effected: 4
 Type of School: urban
 % of free or reduced price Lunch: This school does not have a lunch program.
 % minority: 6%
 Academic Standing: Exceeds state average for reading, writing and math.

John Bapst Memorial High School Teachers:

Scott Burgess Physics
 Kurt Klappenbach Physics

Bucksport High School

Bucksport High School:

Number of Fellows: 1
 Number of Teachers effected: 3
 Number of classes effected: 13
 Type of School: Urban
 % of free or reduced price lunch: 25.28%
 % minority: 2%
 Academic Standing: Fails to meet state average in reading, writing and math.

Bucksport High School Teachers:

John Mannette Physics, Physical Science, Earth Science
 Denise Smith Biology, Earth Science
 Virginia White Chemistry

Sumner Memorial High School

Sumner Memorial High School:

Number of Fellows: 1
 Number of Teachers Effected: 2
 Number of classes effected: 5
 Type of School: Rural
 % of free or reduced price Lunch: 31.89%
 % minority: 2%
 Academic Standing: Fails to meet state average in reading, writing and math.

Sumner High School Teachers:

Henri Gignoux Physics
 Mike Benjamine Physical Science

Lee Academy

Lee Academy:

Number of Fellows: 12
 Number of Teachers effected: 1

Number of classes effected: 4
 Type of School: Rural
 % of free or reduced price lunch: 53%
 % minority: 23%
 Academic Standing: Fails to meet state average in reading,
 writing, and math

Lee Academy Teacher:

John Simone Chemistry

Jonesport-Beals High School

Jonesport-Beals High School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected: 3
 Type of School: Rural
 % of free or reduced price lunch: 41%
 % minority: 0%
 Academic Standing: Fails to meet state average in writing, reading
 and math.

Jonesport-Beals High School Teacher:

Lynn Alley All Science Classes

Bangor, Maine City Council

The council has taken a role in the development of the 2004 Bangor, Maine GIS Emergency Mapping Project and the 2005 Emergency Mapping Project for Bangor International Airport, developed by GK-12 Sensors! fellows in collaboration with faculty at Bangor High School.

Bangor Maine Fire Department

By loaning materials and training time, the Bangor Fire Department has assisted the development of the 2004 Bangor, Maine GIS Emergency Mapping Project and the 2005 GIS Emergency Mapping Project of the Bangor International Airport.

Bangor, Maine Police Department

Bangor Police Department has provided data, facilities and staff assistance for the 2004 Bangor, Maine GIS Emergency Mapping Project, the 2005 GIS Emergency Mapping Project for Bangor International Airport, and the 2006 Bangor, Maine GIS OUI Mapping Project.

NASA

Two of our fellows have developed a number of modules using information they have received at Maine Teachers of Earth and Space Science Workshop 2003 in Washington, DC. This workshop was sponsored by NASA.

Brewer High School

Brewer High School

2005-06 DATA

Number of Fellows: 1
 Number of teachers effected: 4
 Number of Classes effected: 15
 Type of School: Urban
 % of free or reduced price Lunch: 19.05%
 % minority: 3%

Academic Standing: Fails to meet state average in reading and writing; exceeds state average in math.

Brewer High School Teachers:

Arthur Libby Physical Science
 Andy Geaghan Physical Science
 Todd Hillier Physical Science
 Darrell King Physical Science, Physics

Caravel Middle School

Caravel Middle School:

2005-06 DATA

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected: 4
 Type of School: Rural
 % of free or reduced price lunch: 42.32%
 % minority: 1%
 Academic Standing: Exceeds state average in reading, writing and math.

Caravel Middle School Teachers:

Richard Burger Science

Central High School

Central High School:

Number of Fellows: 1
 Number of Teachers effected: 2
 Number of classes effected: 3
 Type of School: Rural
 % of free or reduced price lunch: 38%
 % minority: 2 %
 Academic Standing: Meets state average in reading; fails state average in writing and math.

Central High School Teachers:

Robert Littlefield Physics
 Ed Lindsey Earth Science

Central Middle School

Central Middle School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected: 5
 Type of School: Rural
 % of free or reduced price lunch: 53.07%
 % minority: 2%
 Academic Standing: Meets state average in reading, fails state average in writing and exceeds state average in math.

Central Middle School Teacher:

Cathy Tilton Science

William S. Cohen School

William S. Cohen [Middle] School:

2005-06 DATA

Number of Fellows: 1

Number of Teachers effected: 2

Number of classes effected: 6

Type of School: Urban

% of free or reduced price lunch: 23.08%

% minority: 8%

Academic Standing: Exceeds state average in reading, writing and math.

William S. Cohen [Middle] School Teachers:

Timothy Surette Physical Science

Tracy Vassiliev Applied Science

James F. Doughty School

James F. Doughty [Middle] School:

Number of Fellows: 2

Number of Teachers effected: 2

Number of classes effected: 7

Type of School: Urban

% of free or reduced price lunch: 46.06%

% minority: 8%

Academic Standing: Exceeds state average in reading and math, fails state average in writing.

James F. Doughty [Middle] School Teachers:

Patricia Bernhardt Life Science

Tracy Vassiliev Applied Science

Hampden Academy

Hampden Academy:

2005-06 DATA

Number of Fellows: 1

Number of Teachers effected: 2

Number of classes effected: 6

Type of School: Rural

% of free or reduced price lunch: 9.86%

% minority: 2%

Academic Standing: Exceeds state average in reading, writing and math.

Hampden Academy Teachers:

Marc O'Clair Physical Science & Earth Science

Danielle Donovan Physical Science & Earth Science

Hermon Middle School

Hermon Middle School:

Number of Fellows: 1

Number of Teachers effected: 1

Number of classes effected: 9

Type of School: Rural

% of free or reduced price lunch: 19.79%

% minority: 3%

Academic Standing: Fails state average for reading and writing, meets state average for math.

Hermon Middle School Teacher:

Alan Tweedie Computer Science

Maine Central Institute

Maine Central Institute:

Number of Fellows: 1

Number of Teachers effected: 3

Number of classes effected: 7

Type of School: Rural

% of free or reduced price lunch: 12.92%

% minority: 6%

Academic Standing: Exceeds state average in reading, writing and math.

Maine Central Institute Teachers:

Linda Amsden Statistics

Irma Cushing Algebra

Jim Tyson Physics, Integrated Science

Reeds Brook Middle School

Reeds Brook Middle School:

Number of Fellows: 2

Number of Teachers effected: 5

Number of classes effected: 10

Type of School: Rural

% of free or reduced price lunch: 13.35%

% minority: 2%

Academic Standing: Exceeds state average in reading, writing and math.

Reeds Brook Middle School Teachers:

Jen Bowman-Mckay Social Studies

Kim Haggan Social Studies

Robert O'Leary Life Science

Georgiana Piete Science, Social Studies

Deb Sykes Social Studies

Bucksport Middle School

Bucksport Middle School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected:
 Type of School: Urban
 % of free or reduced price lunch: %
 % minority:
 Academic Standing:
 Bucksport High School Teachers:

Jennifer Skala 8th Grade Life Science

Sebasticook Valley Middle School

Sebasticook Valley Middle School:

Number of Fellows: 1
 Number of Teachers effected: 1
 Number of classes effected:
 Type of School: Rural
 % of free or reduced price lunch:
 % minority:
 Academic Standing:

Sebasticook Valley Middle School Teachers:

Jane Stork Math

Maine Discovery Museum

In 2005-06, Maine Discovery Museum interacted with GK-12 Sensors! Fellows to establish sensor-related exhibits in the museum, geared toward ages 2-10.

Bangor Historical Society/Museum

The Bangor Historical Society/Museum has helped develop several projects with GK-12 Fellows, students and faculty at Bangor High School, including the award-winning GIS-web-based 2005 presentation Historical Atlases of Bangor, Maine (view 2004-05 award at <http://www.esri.com/industries/k-12/atlas/index.html>).

Brewer Middle School

In Spring 2006, GK-12 Fellows began interacting with Brewer Middle School faculty.

Other Collaborators or Contacts

Other University of Maine Collaboration:

Dr. Robert Kennedy, President of the University of Maine
 Dr. Peter Hoff, Former President of the University of Maine
 Dr. Robert Lad, Director of the Laboratory for Surface
 Science and Technology (LASST) and Professor of Physics
 Dr. Carl Tripp, Associate Professor of Chemistry, LASST
 Dr. Bruce Segee, Associate Professor, Electrical and
 Computer Engineering
 Dr. Paul Millard, Assistant Professor, LASST
 Dr. Alfred Bushway, Professor of Food Science

Dr. Rodney Bushway, Chair and Professor of Food Science

Other Community and State Collaboration:

Dr. Robert Ervin, Superintendent of Schools, Bangor
 Mr. Norris Nickerson, Principal, Bangor High School
 Peter Arno, Assistant Police Chief, Bangor
 Jeff Cammack, Fire Chief, Bangor
 Stan Moses, Community Development
 Paul Nichols, DEP for the state of Maine
 Mark Whiting, DEP (water quality),
 Bob Goodwin, Department of Marine Resources,
 Susan Morse, Bangor Area Comprehensive Transportation System
 (BACTS)
 Ken Beland, Atlantic Salmon Commission, state of Maine
 Dave Gould, Bangor Planning,
 John Murphy, City Engineering
 Rebecca Hupp, Bangor International Airport Director
 Jim Ring, City Engineer, Bangor
 Don Winslow, Police Chief, Bangor
 Rod McKay, Community Development, Bangor
 Rob Kenerson, Bangor Area Comprehensive Transportation
 System, BACTS
 Anne Hartmann, Discovery Museum, Bangor

Fellow Advisors:

Dr. Peggy Agouris, Assistant Professor of Spatial Information Science and Engineering, University of Maine: Dr. Agouris serves as advisor to GK-12 fellow Danielle Donovan.

Dr. Kevin J. Boyle, Professor and Chair of Resource Economics and Policy, University of Maine: Dr. Boyle serves as advisor to GK-12 fellow Brad Neumann.

Dr. Mauricio DaCunha, Assistant Professor of Electrical and Computer Engineering, University of Maine: Dr. DaCunha serves as advisor to GK-12 fellows Eric Berkenpas, Dana Gallimore, and Michael Lewark.

Dr. William J. Desisto, Assistant Professor of Chemical Engineering, University of Maine: Dr. Desisto serves as advisor to GK-12 fellow Raymond Kennard.

Dr. Richard Eason, Associate Professor of Electrical and Computer Engineering, University of Maine: Dr. Eason serves as advisor to GK-12 fellow Douglas Isenberg.

Dr. David Kotecki, Assistant Professor of Electrical and Computer Engineering, University of Maine: Dr. Kotecki serves as advisor to GK-12 fellow Crystal Kenney.

Dr. Paul Millard, Assistant Professor of Biological Engineering, University of Maine: Dr. Millard serves as advisor to GK-12 fellow Erik McCarthy.

Dr. Harlan Onsrud, Professor of Spatial Information Science and Engineering, University of Maine: Dr. Onsrud serves as advisor to GK-12 fellow Eeva Hedefine.

Dr. John F. Vetelino, Professor of Electrical Engineering, University of Maine: Dr. Vetelino serves as advisor to GK-12 fellows Lester French, Jesse Parks, Wade Pinkham and Chris York.

Dr. Clayton Wheeler, Assistant Professor of Chemical and Biological Engineering, University of Maine: Dr. Wheeler serves as advisor to

GK-12 fellow Aaron Clark.

Post Doc and Other Professionals:

No post doc employees were involved in the GK-12 Sensors! program.

During 2003-04, Dr. Mark Anderson, UM Senior Instructor of Resource Economics and Policy, assisted former Program Evaluator Dr. Kevin Boyle in the evaluation of GK-12 Sensors!

David Frankel, Senior UM Research Scientist, George Bernhardt, UM Research Scientist, and Michael Call, UM Research Engineer, facilitated tours of various UM laboratories for visiting high school students.

Two UM graduate students in Resource Economics, Allison Reed and Semra Ozdemir, assisted former Program Evaluator Dr. Kevin Boyle in the collection and computation of GK-12 Sensors! data during 2003-04.

Activities and Findings

Research and Education Activities:

Executive Summary

Since its inception in 2002, the GK-12 Sensors! Program has been focused on bringing cutting-edge research in sensors to high and middle school students in Maine in the anticipation of increasing the number of students pursuing a career in which science and engineering play a critical role. During the 2005-06 academic year, this project has been a collaboration between an interdisciplinary team of University of Maine (UM) engineers and scientists working in sensors, six Maine high schools (Bangor High School [BHS], Brewer High School [BrHS], Bucksport High School [BuHS], Hampden Academy [HA], Hermon High School [HHS] and John Bapst Memorial High School [JBMHS]) and nine Maine middle schools (Brewer Middle School [BrMS], Bucksport Middle School [BuMS], Caravel Middle School [CaMS], Central Middle School [CMS], William S. Cohen School [CoMS], James F. Doughty School [DMS], Hermon Middle School [HMS], Reeds Brook Middle School [RBMS], and Sebasticook Valley Middle School [SVMS]). The goal is to use these high and middle schools as models and to extend the program to other Maine high and middle schools.

During our no-cost extension fourth year, the program intensified its presence throughout grades 6-12 of participating school systems, considerably facilitated by PI John Vetelino's successfully funded 2004-2006 RET-Sensors! site proposal. The initial GK-12 Sensors! proposal sought to establish links with area high schools through connections that participating BHS faculty had with faculty in those schools. In the spring of 2003, Vetelino was awarded funding for an RET supplemental program, allowing him to bring four area high-school teachers to work in sensor research during the summer of 2003. The RET program, which allowed RETs and GK-12 fellows to interact in research, proved a new, effective avenue for transitioning GK-12 Sensors into area high schools by preparing participating teachers through an intensive eight-week summer research experience. In the spring of 2004, Vetelino was awarded funding for the 2004-2006 NSF RET-Sensors program, ensuring an ongoing mechanism for locating and preparing participating GK-12 Sensors! teachers and schools. The 2005 RET program brought five high-school and five middle-school teachers to UM. All successful participants became 2005-2006 GK-12 Sensors! participating teachers. Three of the five middle-school teachers taught in schools systems with GK-12 fellows present at the high-school level. Consistent with findings in the 2004-2005 Annual Report, 2005-2006 GK-12 Sensors! introduced the program at the middle-school level while maintaining a significant presence throughout the high-school curricula of participating school systems.

GK-12 Sensors! received commitment from UM Vice-President for Research Michael Eckardt for bridge funding to supplement 2005-2006 fellowships for seven graduate students already involved in the GK-12 program. This bridge funding allowed continuous operation of the program beyond the term of the Track I proposal.

A proposal for five-year Track II-NSF funding for GK-12 Sensors! was submitted in June 2005. The Track II GK-12 Sensors! proposal was favorably reviewed and recommended for funding. The proposal was awarded January 2006. Three new Fellows entered the program February 2006, bringing the current total to ten Fellowships.

In the spring of 2005, Orono, Maine State Representative Emily Cain introduced Bill LD 119, an act to establish ongoing funds creating graduate fellowships within the University of Maine system geared at enhancing science and math education at the secondary school level. The proposed annual funding level each academic year was \$2.5 million. This bill had the strong support of University of Maine System Chancellor Joseph Westphal. The bill was passed in May 2005 as an engrossed bill, to be brought back before the legislature during its spring 2006 session to determine its funding level. LD 119 offers the promise of a degree of sustainability to the GK-12 Sensors! program. As of March 31, 2006, LD 119 awaits legislative action.

Other major fourth year accomplishments include a successful RET-GK-12 Sensors! summer 2005 workshop and subsequent transition of 2005 RET participants into the 2005-2006 GK-12 Sensors! program; intensification of GK-12 Sensors! integration into middle-school curricula; expansion of GK-12 Sensors! into six high- and nine middle- schools; establishment of initial contacts with new partner schools through the 2006 Research Experience for Teachers (RET) summer fellowships; first year activities of NSF REU-Sensors!, which funded UM research of 17 undergraduate students from Maine and throughout the country and offered undergraduates opportunities to address peers from their high-school alma maters concerning their 2005 summer research experience; establishment of links between collaborating schools and the University of Maine by coordinating guided tours of on-campus research facilities; strengthening community investment through expansion of 2005 pilot programs such as the Bangor Historical Maps projects at BHS as well as development of six projects involving Bangor municipal officers; addition of program evaluator Brian Doore, Research Associate/Policy Analyst, Center for Research and Evaluation, College of Education & Human Development, UM; implementation of 'Introduction to GIS' into BHS curriculum, an advanced geography course integrating sensor science and technology into understanding global information systems; initiation of 'Sam the Ram,' an outreach program to educate the public about Bangor City evacuation plans and homeland security centered on disseminating information through presentations to grades 2-5 students, with supporting activities involving parents, guardians and other family members; further refinement of teaching modules created by teachers and fellows during years one and two and creation of twenty new portable modules.

Introduction

The idea for the GK-12 Sensors! program arose in the summer of 2001 when Dr. John Vetelino from the University of Maine (UM) brought Stephen Godsoe, head of the Bangor High School (BHS) mathematics department, to UM in order to involve Mr. Godsoe in sensor research. As the summer progressed, Mr. Godsoe, Dr. Vetelino, and Dr. Constance Holden, a former high school teacher and currently an instructor at UM, began discussing various methods for encouraging Maine high school students to follow career paths in science and/or engineering. As a result of these discussions, it was decided that sensors would be the vehicle of choice to try to convince high school students to follow a science and/or engineering career path. This approach is unique in that it simply does not present interesting science or broad topics of science and/or engineering to high school students, but focuses on sensors. Students certainly know the impact of sensors by reading the daily newspaper and seeing articles relating to homeland security issues and environmental concerns. Students are also surrounded by sensors in their homes, schools and other places they frequent. Students, however, do not know the science or engineering that underlies sensors and sensor systems. This underlying science and engineering and how it relates to sensors can easily be integrated into high school classes such as physics, chemistry, biology, environmental science, physical science or general science, mathematics, computer science, social studies, civics, geography, history and health. As a result of the discussions between Dr. Vetelino, Mr. Godsoe, and Dr. Holden, a proposal was developed and submitted to NSF to integrate sensors into the high school curriculum. This proposal was subsequently funded and the program began in the spring of 2002. GK-12 Sensors! is now in its first year of Track II funding.

Benchmarks 2005-2006:

March-April 2005: PI John Vetelino and Program Coordinator Joe Arsenault collaborate with other University of Maine System NSF GK-12 programs in a campaign to generate awareness of and support and advocacy for LD 119, a bill presented to the 122nd State of Maine legislative session that would provide ongoing funding for GK-12-type fellowships.

April 2005: Paper submitted to 2005 IEEE FIE Conference accepted.

PI John Vetelino, Co-PI Stephen Godsoe, Program Coordinator Joe Arsenault and Fellow Bradley Neumann attend State of Maine Joint Standing Appropriations Committee hearing of LD119. Neumann and Godsoe testify in support of the bill.

2004 RET and GK-12 Sensors! participating teacher Tracy Vassiliev presents a paper entitled 'Effects of Heavy Metals on Lobsters' at the National Shellfish Meeting, April 10-14, in Philadelphia, PA.

Joint Standing Appropriations Committee recommends LD119 to legislative vote.

Suzanne Hart assumes position of program evaluator.

May 2005: The Bangor, Maine GIS Emergency Map of Bangor International Airport (BIA) is presented to Bangor, Maine City Council, departments of Fire and Police and to Bangor International Airport, by fellows Brad Neumann and Eeva Hedefine, teachers Jim Smith and students in Smith's Senior Seminar.

The City of Bangor implements GIS Emergency Map of Bangor International Airport as part of a mock disaster at BIA.

No-Cost Extension Request through June 2006 is filed with UM Office of Research and Sponsored Programs.

Fellows formalize new modules for review and submission June.

Environmental Systems Research Institute, Inc. (ESRI), one of the world's largest Geographic Information System (GIS) mapping software and services providers, selected the GK-12 Sensors!-Bangor High School 2005 GIS project, a community atlas of Bangor, ME, as the top national 2004-05 model GIS K-12 educational project. (<http://www.esri.com/industries/k-12/atlas/model.html>)

Maine State Bill LD119 is read in concurrence and accepted as an Engrossed Bill by House and Senate, making it official state policy to have a UM System GK-12 program. Final decision on allocation of funds to be recommended by Appropriations Committee.

No-Cost Extension Request through June 2006 is approved.

June 2005-Spring 2006: Maine Appropriations Committee postpones LD119 funding recommendations pending additional legislative action. Bill to be taken up during Spring 2006 legislative session.

June 2005: Fellow Aaron Clark and cooperating BuHS teacher John Mannette bring 30 students from BuHS to tour UM facilities in the Laboratory for Surface Science and Technology (LASST), the Advanced Engineering Wood Composites (AEWC) facility, and Chemical Engineering department.

RET and REU participants begin ECE 465, Introduction to Sensors. RET and REU participants begin working closely with University of Maine research scientists on cutting-edge sensor technology. GK-12 fellows serve as mentors.

GK-12 fellows submit learning modules to be included in online library.

Bradley Neumann, Danielle Donovan and Crystal Kenney complete their graduate requirements and leave the program.

Douglas Isenberg, Dana Gallimore, Erik McCarthy and Chris York leave the program.

July 2005: RET participants and 2005-2006 GK-12 fellows in similar research areas establish regular interaction.

One-day workshop held for RET participants. GK-12 fellows present current research work and GK-12 activities.

Judith Walker, a graduate student in Research Economics and Policy, is selected as GK-12 Sensors! fellow.

August 2005: A two-day workshop is held for all RET and GK-12 Sensors! participants at UM. At this workshop, all teachers present their summer research, GK-12 Sensors! 2005-2006 teacher-fellow assignments are formalized, paired teachers and fellows meet to develop schedules and module concepts for 2005-2006 implementation.

RET-GK-12 Workshop Feature Report broadcast on Bangor ABC affiliate WVII-TV 'ABC 7 News @ 6.' NSF, RET and GK-12 are identified in the feature.

UM bridge funding awarded from VP for Research Michael Eckardt.

September 2005: GK-12 Sensors! begins activities with seven fellows in thirteen schools (BHS, BuHS, BuMS, CaMS, CMS, CoMS, DMS, HA, HHS, HMS, JBMHS, RBMS and SVMS). These schools represent diverse socio-economic conditions, including some of the poorest in Maine.

Fellow Wade Pinkham presents panel paper 'A Lateral Field Excited Acoustic Wave Pesticide Sensor' at IEEE Ultrasonics Symposium, Rotterdam, The Netherlands (Pinkham receives best poster presentation award). The NSF grant award is identified in the paper's Acknowledgements.

Former fellow Chris York presents panel paper 'A Lateral Field Excited Acoustic Wave Biosensor' at IEEE Ultrasonics Symposium, Rotterdam, The Netherlands. The NSF grant award is identified in the paper Acknowledgements.

PI John Vetelino presentation at Pan-REU Conference, Arlington, VA, emphasizes integrative REU-GK-12-RET model. Project coordinator Joe Arsenault also attends conference.

Article 'Pinkham wins international award' recognizing research accomplishments of fellow Wade Pinkham at IEEE Ultrasonics Symposium is published in The Lincoln County News. NSF and the GK-12 program are both identified in the article.

Inaugural edition of GK-12 Sensors! newsletter 'Sensors! Alert' distributed to GK-12 fellows, cooperating teachers and administrators.

October 2005: PI John Vetelino holds meeting at UM with GK-12 fellows. Fellows report on interaction with teachers and students, development of classroom activities and presentations, and share insights on challenges encountered.

Vetelino presents on the GK-12 Sensors! program at the 2005 IEEE Frontiers in Education Conference, Oct. 19-22, Indianapolis, IN.

Fellows submit new learning modules to be included in online library.

November 2005: Co-PI Constance Holden hosts meeting at UM of participating GK-12 teachers to discuss fellow interactions, classroom impact, curricular integration and challenges to implementation facing teachers.

Fellow Wade Pinkham and cooperating CMS teacher Catherine Tilton-Davis bring 90 CMS eighth-grade students to tour UM facilities in the LASST/Electrical and Computer Engineering Department, the Advanced Engineering Wood Composites (AEWC) facility, and the UM Planetarium.

Fellow Raymond Kennard initiates discussion with Children's Discovery Museum about developing permanent sensor science and engineering interactive exhibits at the museum.

December 2005: Bangor School Committee unanimously votes to adopt 'Introduction to GIS' as a permanent curricular offering. Fellow Judith Walker, working with BHS teachers Jim Smith and Margaret Chernosky, developed the classroom curriculum for the new course proposal.

'6th graders team up with NASA to take photos from Space Station,' focusing on GK-12 Sensors! fellow Eeva Hedefine's GK-12 activities at Reeds Brook Middle School is published in Link-22, the school administrative district's newsletter. NSF and the GK-12 program are both identified in the article.

Article 'GK-12 Sensors: It's Not Business as Usual,' focusing on GK-12 Sensors! fellow Raymond Kennard's GK-12 activities is published in the Bangor High School Communiqué. NSF and the GK-12 program are both identified in the article.

PI Vetelino and Project Coordinator Joe Arsenault develop responses to reviewers' concerns re: Track II proposal and successfully rework budget to meet program-wide reduction targets.

Fellows submit new learning modules to be included in online library.

January 2006: Abstract for paper on the GK-12 Sensors! program submitted to the 2006 IEEE Frontiers in Education (FIE) conference. This conference will be held October 2006 in San Diego, CA.

NSF notifies UM Office of Research and Sponsored Programs of GK-12 Sensors! Track II award.

Fellow Raymond Kennard begins collaboration with Children's Discovery Museum (Bangor, ME) director and staff to develop permanent sensor science and engineering interactive exhibits at the museum.

'Sensors Feature,' UMaine Media, half-time feature aired on Bangor CBS affiliate WABI-TV. NSF and the GK-12 program are both identified in the four-minute feature.

February 2006: Seven GK-12 Sensors! fellowships are renewed under Track II funding.

Three UM graduate students are awarded first-time GK-12 Sensors! Track II fellowships: Janice Duy, Edwin Nagy, Ali Shareef.

Article 'When Life Gives You Lemons, Make a Battery' appears in local weekly newspaper The Ellsworth American. NSF and the GK-12 program are both identified in the article.

Fellow Lester Smith and cooperating CaMS teacher Richard Burger bring 80 CaMS eighth-grade students to tour UM facilities in the LASST/Electrical and Computer Engineering Department and the Advanced Engineering Wood Composites (AEWC) facility.

GK-12 Nuggets submitted.

Abstract for paper accepted for 2005 FIE conference. Full paper submission requested.

March 2006: Working with UM Office of Public Relations, a postcard campaign describing the GK-12 Sensors! program and impact is successfully developed and distributed. The campaign targets key state legislators and seeks support for UM sustainability initiatives, including LD 119 (see March-April 2005 above). NSF and the GK-12 program are both identified in the project description.

Front page article 'Lab Partner' appears in area newspaper Bangor Daily News. NSF and the GK-12 program are both identified in the article.

Fellow Edwin Nagy establishes interactions with BrMS.

Fellow Raymond Kennard submits proposal to Children's Discovery Museum (Bangor, ME) director and staff for developing a permanent sensor science and engineering interactive exhibits at the museum. Proposal is currently under review by museum director and staff.

PI John Vetelino, Program Evaluator Brian Doore and Project Manager Joe Arsenault attend the GK-12 Annual meeting in Washington, D.C. Poster session on past and current program activities presented.

Fellow Lester French provides overview of GK-12 Sensors! program at presentation given at the 'TWENTY-SIXTH STATE-WIDE MEETING OF HIGH SCHOOL PHYSICS AND PHYSICAL SCIENCE TEACHERS.'

Fellow RET and GK-12 cooperating teacher Jane Stork of SVMS, assisted by GK-12 Fellow Wade Pinkham, gives presentation about RET-GK-12 Sensors! sensor integration into eighth-grade mathematics curriculum at the Association of Teachers of Mathematics in Maine (ATOMIM) Spring 2006 meeting.

Fellow Wade Pinkham submits extended abstract 'Detection of Phosmet in Apples Using a Lateral Field Excited Acoustic Wave Sensor' to The 11th International Meeting on Chemical Sensors (IMCS 11), University of Brescia, Italy, July 2006. The NSF grant award is identified in the abstract Acknowledgements.

Fellow Jesse Parks submits extended abstract 'Crystal Orientations for Lateral Field Excited Sensor Applications' to The 11th International Meeting on Chemical Sensors (IMCS 11), University of Brescia, Italy, July 2006. The NSF grant award is identified in the abstract Acknowledgements.

Fellows submit new learning modules to be included in online library.

GK-12 Sensors! referenced in NSF Director address at 2006 NSF-AAAS GK-12 Annual Meeting in Washington, DC.

GK-12 Sensors! image used in NSF GK-12 Director's address at 2006 NSF-AAAS GK-12 Annual Meeting in Washington, DC.

NSF Image Researcher contacts PI Vetelino for permission to include GK-12 Sensors! images in upcoming presentations by NSF Director and Deputy Director.

Research and Education Activities:

2005 Summer Activities

In the summer of 2005, the University of Maine, with John Vetelino as PI and Constance Holden as Co-PI, conducted the second year of a

three-year NSF grant, RET-Sensors (NSF-0401439). Five middle and five high school teachers from mostly rural areas were brought to UM and provided unique opportunities to be involved in research in sensor theory, design, fabrication, testing, and/or applications. Linkages to schools through the RET program enabled GK-12 Sensors! to expand into fifteen rural Maine high and middle schools: BHS, CoMS and DMS in Bangor, ME; BrHS and BrHM, in Brewer, ME; BuMS and BuHS, in Bucksport, ME; CMS, in Corinth, ME; CaMS, in Caravel, ME; HA, a high school, and RBMS, in Hampden, ME; HHS and HMS, in Hermon, ME; JBMHS in Bangor, ME; and SVMS, in Newport, ME. Teachers spent eight weeks becoming acquainted with cutting-edge sensor science and engineering through daily interactions with sensor faculty, senior researchers, graduate students, UM GK-12 Sensors! fellows, and Research Experience for Undergraduates (REU) students in the UM Laboratory for Surface Science & Technology (LASST). RETs were involved in research on biosensors, chemical sensors, and fluid-phase sensors.

Examples of RET research ranged from developing sensing systems for measuring motor oil degradation to detecting low levels of algae toxins and heavy metals in Maine lobsters.

In addition to working with a specific sensor research group, teachers became familiar with other state-of-the-art sensor-related science and technology facilities in the university and neighboring small sensor businesses. RETs also enrolled in ECE 465, an upper-level undergraduate course entitled Introduction to Sensors, which presented the theory and applications of various types of semiconductor, acoustic, magnetic, thermal and optical sensors, in order to give teachers a sound background in sensors. Teachers received academic and recertification credit for the course. The summer program concluded with the August Summer Workshop, during which the RETs shared their summer research experience in formal presentations and offered ideas for integrating sensor science and technology into their curricula. All successful 2005 RET participants became 2005-06 GK-12 Sensors! cooperating teachers, continuing working relationships established during the summer RET program with GK-12 fellows.

RET Sensors! established a formal bridge to GK-12 Sensors! and, as a result, a strong linkage between UM and participating secondary educational institutions. Furthermore, in school systems where GK-12 Sensors! had been established at the high or middle school level, the RET-Sensors! program has provided opportunity to extend its presence throughout grades 6-12 by offering fellowships to interested teachers in participating school systems. Expanding its presence from eleven to fifteen schools, nine of which are middle schools, GK-12 Sensors! anticipates achieving greater impact on student interest in pursuing careers in science and engineering. Introducing sixth, seventh and eighth graders to graduate researchers and engaging students in hands-on science and technology inquiries, and maintaining such exposure throughout high school, provides continuity of exposure throughout their secondary education.

'Introduction to GIS' Course at BHS

Bangor High School will implement a course embedding sensor science and engineering units into its 2005-06 curriculum. Piloted during the 2004-05 year, 'Introduction to GIS' is a hands-on, inquiry-based course being offered as part of the BHS advanced geography curriculum. First-year fellow Judith Walker and BHS teacher Margaret Cheronky, with input from teacher Jim Smith, designed the course. This course was in part developed in response to strongly positive feedback from students involved in other GIS-based inquiry-learning projects Walker facilitated this fall and other fellows previously coordinated. The Bangor School Committee at its December 19, 2005 meeting unanimously voted to adopt 'Introduction to GIS' as a permanent curricular offering.

Bangor, Maine GIS Emergency Mapping Project and the Bangor, Maine GIS Emergency Map of Bangor International Airport

In addition to portable modules, fellows have been organizing community outreach programs, such as the 2005 Bangor, Maine GIS Emergency Map of Bangor International Airport (BIA). Fellows and BHS teachers and students presented the 2005 mapping project to the Bangor School Department and members of the Bangor City Council, Fire and Police departments, in May of 2005, three days before Bangor area emergency response teams tested the 2005 mapping project as part of its emergency preparedness test, a mock disaster at BIA. Because Bangor is willing to share its GIS equipment with our fellows, aspects of this project have been introduced to other school systems such as Caravel and Hampden at little or no cost.

Digital Community Atlas of the Historical Geographies of Bangor

A multi-class Global Information System (GIS) project was developed by fellow Brad Neumann with the History Department at BHS. The project, sponsored by Environmental Systems Research Institute, Inc. (ESRI), a world leader in GIS software development, involved creation of a digital community atlas of the historical geographies of Bangor. Known nationally as the Community Atlas Project, teachers and students were asked to define the nature of their community by creating maps, writing community descriptions, and compiling images to be combined in a visual presentation and posted on the Internet. The project involved four World Geography classes and two Civics classes, all at the first-year level and housed in the History Department. Students created their community atlas through the use of a Global Positioning System (GPS),

GIS, basic html coding, digital cameras, scanners, and computer skills. As a result, they developed research skills, spatial skills, analytical skills, technological skills, and group work skills. The final product was presented to both the City of Bangor and the Bangor Historical Society as a display on the city's website, a digital PowerPoint presentation, and a physical poster presentation. ESRI awarded the GK-12 Sensors!-Bangor High School 2005 GIS project with recognition as the best national 2004-05 model GIS K-12 educational project (<http://www.esri.com/industries/k-12/atlas/model.html>).

Sam the Ram: Educating the Public About Evacuation Plans & Homeland Security Through Elementary Students

Working with the Bangor Fire Chief, GK-12 Sensors! Fellow Judith Walker and teacher Jim Smith of the Bangor High School (BHS) History department are coordinating an after-school Global Information Systems (GIS) mapping club program, three Senior Seminar classes (75 students) and three Computer Science classes (60 students) in designing portable presentations about emergency preparedness and homeland security. These presentations are given to classes of 2nd and 3rd graders in the Bangor area. Each lesson presents basic information on a topic (such as hurricanes) and incorporates emergency response information as well as descriptions of careers relating to the topics. Included in the description of the career is an example of a sensor encountered on-the-job. Each lesson is 'taught' by BHS mascot Sam the Ram, the Bangor High mascot.

Continued Module Development

On the basis of the success of portable module development in prior years, our 2005-06 fellows are each creating four new learning modules that can be easily transported, either in their entirety or partially, from school to school. Taking advantage of the Maine Teaching-Learning Initiative's PASCO probe sensor lending library, a wide range of hands-on sensor-based activities have been incorporated into some of the poorer schools in Maine. The State of Maine's so-called Laptop Initiative, which provides all 7th and 8th graders in the state with laptop computers, provides an additional resource for interfacing with PASCO-type sensors in module development.

Highlights: Integrating Sensors Into Secondary School Systems

Working with 2005 RET-Sensors participant (hereafter written 2005 RET) Jennifer Skala of BuMS 2004 RET John Mannede of Bucksport High School and other teachers, fellow Aaron Clark has implemented hands-on modules such as introducing the concept of sensors, measuring atmospheric pressure, making fruit batteries, sensing global warming, understanding wood composites. Using the middle school's climbing wall, he also helped start the Bucksport System Climbing Club in Fall 2005.

Fellow Lester French interacts with teachers at three rural schools, primarily 2005 RET Richard Burger of CaMS, 2004 RET Alan Tweedie of HMS and 2005 Joanna Lisker of HHS. At the middle schools, Les has introduced modules involving drinking water quality sensors, Global Positioning Systems, how sensors allow internet data storage such as photos from the International Space Station, and others. At the high school, Les has introduced hands-on activities involving quartz crystal microbalances to help teach concepts such as Newtonian and spring forces. Les also coordinated UM advanced research facilities tours for Caravel Middle School eighth graders.

Working with 2005 RET Marc O'Clair and former GK-12 Sensors! fellow Danielle Donovan of HA and 2004 RET Georgiana Piette of RBMS, fellow Eeva Hedefine has motivated discussions about sensors through hands-on activities involving Geographic Positioning Systems, online interaction with the International Space Station, force and motion sensors, spectrometers and spectroscopes, remote-sensing of black holes, and trips to the Challenger Learning Center (Bangor, ME). Eeva also works after-school with fellow Judith Walker, faculty and students at BHS on a GIS project for The City of Bangor.

Fellow Raymond Kennard has worked with 2005 RET Timothy Surette and 2004 RET Tracy Vassiliev at both CoMS and DMS, and the science faculty at John JBMHS, all located in Bangor, ME. He has introduced sensors into topics such as ink chromatography, spectrum analysis, the relation between the moon and the earth, monitoring solar activity. Sensors is the emphasis for the Spring 2006 DMS Student Invention Convention. Raymond is also working with staff at the Maine Discovery Museum (Bangor, ME) to develop permanent interactive exhibits relating to sensors, geared to ages 2-12.

Fellow Jesse Parks works with Physics teacher and 2005 RET Andrew Bouchard and Environmental Science teacher Theodore Taylor, also a 2005 RET, both of BHS. In physics classes, Jesse has incorporated sensor science and engineering into major modules in Energy and in Electronics. He has introduced sensors to Taylor's students through modules relating to plate tectonics, oceanography and meteorology.

Wade Pinkham engages 2005 RET Catherine Tilton-Davis's middle-school classrooms at CMS and 2005 RET Jane Stork's SVMS students. Starting from awareness exercises of human and everyday sensors, Wade has introduced students to sensors-related activities in techniques for biological sensing, velocity and acceleration, electricity, spectroscopy with diffraction gratings, hydro-fuel cells and Global Positioning Systems. Wade also coordinated a University of Maine advanced research facilities tour for Central Middle School eighth graders.

Judith Walker, who became a GK-12 Sensors! Fellow in July 2005, is engaged in a variety of sensor-related community-based projects with BHS students and faculty of the History Department. They have produced maps of both standard and hazardous-materials evacuation routes for Bangor; worked with Assistant Bangor Police Chief to use dispatch data in electronic format to geocode OUI data to alcohol providers; collaborated with the Bangor Historical Society to map the historical movement of area cemeteries, Jewish historical sites and Irish historical sites; used data provided by the Bangor Area Transport system to geocode Greater Bangor area public bus routes and census data. Walker also developed the classroom curriculum for a permanent BHS GIS course proposal that was adopted unanimously by the Bangor School Board in December 2005.

Findings:

1. Crucial to the smooth integration of GK-12 Sensors! fellows into participating teacher classrooms is the preparation of teachers through participation in the RET program and the interaction of teachers and fellows during the summer, allowing them to establish working relationships and acquaint themselves thoroughly with each others' interests, styles, strengths and weaknesses. RET Sensors! serves as a formal bridge to GK-12 Sensors!, forming a strong linkage between UM and participating secondary educational institutions. Furthermore, in school systems where GK-12 Sensors! was established at one of the middle or high school levels, the RET-Sensors! program has provided opportunities to extend the GK-12 presence throughout the 6-12 school system by offering fellowships to interested teachers in participating school systems. Expanding its presence from eleven to fifteen schools, nine of which were middle schools (NOTE: 2005-06 has seen the program shift from a high school to a middle school emphasis), GK-12 Sensors! anticipates achieving greater impact on student interest in pursuing careers in science and engineering. Introducing sixth, seventh and eighth graders to graduate researchers and engaging students in hands-on science and technology inquiries, and maintaining such exposure throughout high school, provides continuity of exposure throughout their secondary education.

2. Both fellows and participating teachers have expressed interest of spending more time during the summer hiatus focusing on curricular preparation. The program is planning to provide periodic informal workshop events throughout the summer to address the need for more time and coordination for preparing fellows, especially new fellows. Teachers will have the opportunity to share in-class management skills and discuss teaching-learning styles. Advantages of this approach include producing teaching tools targeted to grade level and classroom, allowing fellows to develop strong sense of participating teachers' teaching styles, values and classroom management styles; generating a link strengthened by greater confidence of both fellows and teachers. The pedagogical objective is to establish clear understanding of roles, expectations, in-class instructional strategies, and role parity in order to foster strong collaboration throughout the academic year. The functional objective is to improve fellow-teacher preparation through efficient use of time and resources.

3. The introduction of GK-12 Sensors! into grades 6-8 has shown positive effects in terms of 9th grade student enthusiasm for both STEM subject matter and the presence of a GK-12 fellow in the 9th grade classroom. This enthusiasm provides support for the insistence on maintaining a GK-12 presence throughout middle and high schools in a single school system. It continues to be anticipated that a significant number of these students will go on to consider STEM career paths in high school and beyond. Anecdotal evidence from self-reported student cases indicates a strong positive influence of GK-12 fellows on post-12 educational choices. Indeed, several post-12 students report having chosen to pursue STEM fields of study because of the presence of a GK-12 Sensors! fellow in the classroom. Middle-school teachers have reported very positively concerning student admiration of their fellows and have recounted stories of great student enthusiasm for activities-based STEM learning, especially on the days the fellow is expected in-class.

Thus crucial to achieving the GK-12 Sensors!'s main goal (namely to motivate students to follow careers in science and engineering, more generally in any STEM area) is the consistent presence of GK-12 Sensors! throughout a student's 6-12 education. Students need to be introduced to GK-12 Sensors! at the middle-school level, at the latest.

4. Evidence of the maturity of the linkage between UM and Bangor High School is given by 'Introduction to Global Information System (GIS),' a hands-on, inquiry-based course to be offered as part of the BHS advanced geography curriculum. This course embeds sensor science and engineering into each curricular unit. Piloted during the 2004-05 year, 'Introduction to GIS' was in part developed in response to strongly positive feedback from students involved in other GIS-based inquiry-learning projects facilitated this and previous academic years. The Bangor School Committee at its December 19, 2005 meeting unanimously voted to adopt 'Introduction to GIS' as a permanent curricular offering.

5. The perceived role of evaluation relative to program activities and administration has shifted significantly. In short, in order for the GK-12 Sensors! evaluation process to become successful, it should not be viewed as a static semi-autonomous entity that judges program impact and effectiveness, but instead should be viewed as a tool for reflection and communication that evolves with the program. The following description provides background, context and shows the intellectual shift that has occurred.

At the time when the GK-12 Sensors! was proposed, the perceived need for program evaluation was for quantitative program impact/outcomes

reporting to GK-12 and NSF program officers and the U.S. Congress. However, no explicit impact or outcomes expectations or criteria had been established by NSF, and the importance of adequate evaluation became more strongly emphasized (and the emphasis on evaluation continues to strengthen) between the time of proposal submission and its award. Thus, a concern for GK-12 Sensors! management was obtaining assurance from program evaluators that the proposed evaluation scheme would be deemed adequate by federal reviewers. The tensions that resulted from the conflicting needs involved in meeting (1) agreed-to scope-of-work and (2) the shifting significance of program evaluation, limited first and second year efforts to equilibrate the evaluation component.

Whereas initial Track I efforts to devise evaluation plans focused on determining content of evaluation processes, little or no attention was paid to the actual administration of evaluation instruments; it was, rather, a black-box assumption that evaluations would be performed independent of and concurrent with other program activities. This in practice proved infeasible during the first year of Track I and the proposed second year solution, which involved fellows in a time-intensive, rigid, ongoing program of frequent in-class pre- and post-evaluations, periodic student attitudinal evaluations throughout the year, fellows and teachers surveys and interviews, proved overambitious at all administrative levels, which is partially reflected in the underdeveloped second-year program report.

The problems raised by the implementation failures of the initial modest evaluation plan and the succeeding year's overly ambitious plan pointed to the need for a fundamental shift in the perception of the role of program evaluation within GK-12 Sensors!. How that shifted perception should be constituted has taken a year-and-a-half worth's sustained study and dialogue with professional evaluators and colleagues at other GK-12 programs to articulate. Part of that articulation has involved a modular implementation process for building a workable, sustainable evaluation plan, one that is currently operational in its initial phases, with a plan for additional implementations over the next year.

Key to reconceptualizing the role of program evaluation was the idea of using program evaluation as an internal tool providing near-real-time feedback mechanism for program administrators. The evaluation program monitors and measures program effectiveness as a means for communicating areas in need of change/improvement. This strategy of using evaluations as an internal communications tool instead of an external reporting mechanism only took root during the third year of Track I.

A concerted effort on the part of the GK-12 Sensors! program administrators (PI, co-PIs and program coordinator) working with the Center for Research and Evaluation of the Maine Education Policy Research Institute, an agency external to the UM but housed on the campus, has over the last two years generated an evaluation program (one that now subsumes the Track II evaluation plan as a proper subcomponent) that repurposes the formal reporting requirement of evaluations as a communications tool facilitating open, frank and safe feedback to program management from fellows, teachers, administrators and community partners, grades 6-12 students, faculty advisors and other academic participants. Positioning evaluation instruments in this light has resulted in greater, more enthusiastic participation at all levels as well as more openness to bringing evaluation instruments into participating classrooms.

(Previous and current program evaluation reports are anticipated by June 2006.)

Training and Development:

2005 RET-GK-12 Interface

In the summer of 2005, ten teachers were brought to UM by the RET-Sensors program. As was the case with the RET's during previous summers, these teachers were paired with UM faculty members and worked closely with participants in the GK-12 Program. By bringing these teachers to UM, we have realized a significant increase in the number of schools we have influenced in Central and Northern Maine.

2005 Summer Workshop

In August of 2005, GK-12 Fellows, teachers from BHS, BrHS, BuHS, BuMS, CMS, CHS, CoMS, DMS, HA, HMS, HHS, JBHS, RBMS, and SVMS, and faculty members from UM met at UM for a two-day workshop to report on summer 2005 research activities and formalize GK-12 Sensors! activities for the 2005-2006 academic year. The workshop began with ten 2005 RET presentations of summer research. Participating teachers from the first three years of the program spoke to the challenges and accomplishments of the program. On the second day of the workshop, Dr. Vetelino established participant workgroups composed of participating RETS and other participating teachers from a single school system, along with the GK-12 fellow(s) assigned to that system, to plan schedules and modules for the 2005-2006 academic year.

Future Training

ò Summer 2006 RET program

ò REU-Sensors! site

During the spring of 2005, Dr. John F. Vetelino received a REU site grant from the National Science Foundation. As a result, during the

summer of 2005 and for each of the next two summers, 17 undergraduates will be brought to UM by the REU program.

o 'Introduction to GIS' at BHS

This permanent inclusion in the BHS curriculum will begin academic year 2006-07.

Outreach Activities:

Conferences:

PI John Vetelino, evaluator Brian Doore and program coordinator Joe Arsenault presented a poster presentation entitled 'NSF GK-12 Sensors!' GK-12 National Meeting, March 24-26, 2006, in Washington, DC.

Fellow RET and GK-12 cooperating teacher Jane Stork of SVMS, assisted by GK-12 Fellow Wade Pinkham, presented RET-GK-12 Sensors! sensor integration activities at the Association of Teachers of Mathematics in Maine (ATOMIM) Spring 2006 meeting, March 25, 2006, Portland, ME.

Fellow Lester French provides overview of GK-12 Sensors! program at presentation given at the 'TWENTY-SIXTH STATE-WIDE MEETING OF HIGH SCHOOL PHYSICS AND PHYSICAL SCIENCE TEACHERS,' March 17, 2006, Orono, ME

PI John Vetelino presented a paper entitled 'Integration of Sensors into Secondary School Classrooms,' IEEE Frontiers in Education Conference, Oct. 19-22, 2005, Indianapolis, IN.

PI John Vetelino gave featured session talk at Pan-REU Conference, Arlington, VA. emphasizing integrative REU-GK-12-RET model. Project coordinator Joe Arsenault assisted with presentation.

Participating teacher Tracy Vassiliev presented a paper entitled 'Effects of Heavy Metals on Lobsters' at the 97th Annual Meeting of the National Shellfisheries Association, April 10-14, in Philadelphia, PA.

Fellows Brad Neumann and Eeve Hedefine, in collaboration with BHS teacher Jim Smith, presented a paper on their GK-12 Sensors! activities entitled 'Applying GIS Technologies to Enhance Emergency Response' at the National Science Teacher Convention (NSTA), March 31-April 3, 2005, in Dallas, TX,.

Participating teacher Patricia Bernhardt presented a paper entitled 'GK-12 Sensors!-related integration of RET research into middle-school classrooms' at NSTA, March 31-April 3, 2005, in Dallas, TX.

Journal Publications

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French, Lester; Koch, Helmut, "A Sensor Design Project For High School Chemistry Classes", The Journal of Science Education, p. , vol. , (). Submitted

Lampron, Kenna; Hedlund, Wes, "The pH Sensor Lab", The Science Teacher, p. , vol. , (). Submitted

James, Cary; Martin, Andrea, "Air Quality Projects In a High School Chemistry Curriculum", The Journal of Chemical Education, p. , vol. , (). Submitted

Hedefine, Eeve; Neumann, Brad; Smith, Jim, "The Bangor, Maine GIS Emergency Mapping Project", The Science Teacher, p. , vol. , (). Submitted

Chenosky, Margaret; Donovan, Danielle; Pitcher, Stephanie, "Using Satellite Remote Sensing to Investigate the 5 Themes of Geography", The Journal of Geography, p. , vol. , (). Submitted

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Crowley, Adam, "It's All About CHOICES", Communique, p. 7, vol. , (2004). Published

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Editor(s): J. Arsenault

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Web/Internet Site

URL(s):

<http://www.eece.maine.edu/research/gk12/>

Description:

This site contains information on current activities, fellows and modules.

Other Specific Products

Product Type:

Web page

Product Description:

A catalogue of current portable modules can be found at the following address:

<http://www.eece.maine.edu/research/gk12/portablemodule.htm>

Sharing Information:

This product will be shared over the internet. GK-12 Sensors is also collaborating with Dr. Gary Ybarra and Dr. Paul Klenk of Duke University to incorporate the GK-12 module library into their online resource TeachEngineering.com.

Contributions

Contributions within Discipline:

The principal disciplinary field of the project is sensors education. GK-12 Sensors! has developed and extended this field in the 6-12 environment through the ongoing development of portable modules, many currently available on our website. GK-12 Sensors is also collaborating with Dr. Gary Ybarra and Dr. Paul Klenk of Duke University to incorporate the GK-12 module library into their online resource 'TeachEngineering.com.' Indications of program success are described in 'Introduction of Sensors in Secondary School Classrooms,' which will be published in Proceedings of the 2005 IEEE Frontiers in Education Conference. (The document is attached to this report as an appendix.)

GK-12 Fellows Contributions:

Bangor High School will implement a course embedding sensor science and engineering units into its 2005-06 curriculum. Piloted during the 2004-05 year, 'Introduction to GIS' is a hands-on, inquiry-based course being offered as part of the BHS advanced geography curriculum. First-year fellow Judith Walker worked with BHS faculty to design the course, which was in part developed in response to strongly positive feedback from students involved in other GIS-based inquiry-learning projects Walker facilitated this fall and other fellows previously coordinated. The Bangor School Committee at its December 19, 2005 meeting unanimously voted to adopt 'Introduction to GIS' as a permanent curricular offering.

In addition to portable modules, fellows have been organizing community outreach programs, such as the 2005 Bangor, Maine GIS Emergency Map of Bangor International Airport (BIA). Fellows Eeva Hedefine, Brad Neumann and BHS teachers and students presented the 2005 mapping project to the Bangor School Department and members of the Bangor City Council, Fire and Police departments, in May of 2005, three days before Bangor area emergency response teams tested the 2005 mapping project as part of its emergency preparedness test, a mock disaster at BIA. Because Bangor is willing to share its GIS equipment with our fellows, aspects of this project have been introduced to other school systems such as Caravel and Hampden at little or no cost.

A multi-class Global Information System (GIS) project was developed by fellow Brad Neumann with the History Department at BHS, also in the spring of 2005. The project, sponsored by Environmental Systems Research Institute, Inc. (ESRI), a world leader in GIS software development, involved creation of a digital community atlas of the historical geographies of Bangor. Known nationally as the Community Atlas Project, teachers and students were asked to define the nature of their community by creating maps, writing community descriptions, and

compiling images to be combined in a visual presentation and posted on the Internet. The project involved four World Geography classes and two Civics classes, all at the first-year level and housed in the History Department. Students created their community atlas through the use of a Global Positioning System (GPS), GIS, basic html coding, digital cameras, scanners, and computer skills. As a result, they developed research skills, spatial skills, analytical skills, technological skills, and group work skills. The final product was presented to both the City of Bangor and the Bangor Historical Society as a display on the city's website, a digital PowerPoint presentation, and a physical poster presentation. ESRI awarded the GK-12 Sensors!-Bangor High School 2005 GIS project with recognition as the best national 2004-05 model GIS K-12 educational project (<http://www.esri.com/industries/k-12/atlas/model.html>).

Working with the Bangor Fire Chief, GK-12 Sensors! Fellow Judith Walker and teacher Jim Smith of the Bangor High School (BHS) History department are coordinating an after-school Global Information Systems (GIS) mapping club program, three Senior Seminar classes (75 students) and three Computer Science classes (60 students) in designing portable presentations about emergency preparedness and homeland security. These presentations are given to classes of 2nd and 3rd graders in the Bangor area. Each lesson presents basic information on a topic (such as hurricanes) and incorporates emergency response information as well as descriptions of careers relating to the topics. Included in the description of the career is an example of a sensor encountered on-the-job. Each lesson is 'taught' by BHS mascot Sam the Ram, the Bangor High mascot.

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Working with 2005 RET-Sensors participant (hereafter written 2005 RET) Jennifer Skala of BuMS 2004 RET John Mannette of Bucksport High School and other teachers, fellow Aaron Clark has implemented hands-on modules such as introducing the concept of sensors, measuring atmospheric pressure, making fruit batteries, sensing global warming, understanding wood composites. Using the middle school's climbing wall, he also helped start the Bucksport System Climbing Club in Fall 2005.

Janice Duy began her GK-12 Sensors! fellowship in February 2006. She has worked with fellow Lester French, who introduced her to program activities in three schools, CaMAs, HMS and HHS. Janice has focused her interactions at HMS, working with 2004 RET Alan Tweedie. She has introduced a variety of sensor concepts and hands-on exercises relating to aspects of her research.

Fellow Lester French interacts with teachers at three rural schools, primarily 2005 RET Richard Burger of CaMS, 2004 RET Alan Tweedie of HMS and 2005 Joanna Lisker of HHS. At the middle schools, Les has introduced modules involving drinking water quality sensors, Global Positioning Systems, how sensors allow internet data storage such as photos from the International Space Station, and others. At the high school, Les has introduced hands-on activities involving quartz crystal microbalances to help teach concepts such as Newtonian and spring forces. Les also coordinated UM advanced research facilities tours for Caravel Middle School eighth graders.

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Edwin Nagy began his GK-12 Sensors! fellowship in February 2006. Working with 2004 RET Arthur Libby and other faculty at BrHS and BrMs, Edwin has integrated sensing systems into hands-on exercises modeling human physiological systems, using these exercises as examples of the kinds of research he performs as a civil engineering graduate student. Edwin has also shared aspects of his research through presentations describing his work with the Peace Corps in Niger, West Africa, which he has used to motivate a sensor-based module consisting of a series of hands-on activities involving woodless construction.

Fellow Jesse Parks works with Physics teacher and 2005 RET Andrew Bouchard and Environmental Science teacher Theodore Taylor, also a 2005 RET, both of BHS. In physics classes, Jesse has incorporated sensor science and engineering into major modules in Energy and in

Electronics. He has introduced sensors to Taylor's students through modules relating to plate tectonics, oceanography and meteorology.

Wade Pinkham engages 2005 RET Catherine Tilton-Davis's middle-school classrooms at CMS and 2005 RET Jane Stork's SVMS students. Starting from awareness exercises of human and everyday sensors, Wade has introduced students to sensors-related activities in techniques for biological sensing, velocity and acceleration, electricity, spectroscopy with diffraction gratings, hydro-fuel cells and Global Positioning Systems. Wade also coordinated a University of Maine advanced research facilities tour for Central Middle School eighth graders.

Ali Shareef began his GK-12 Sensors! fellowship in February 2006. He has worked with Jesse Parks to develop an electronics module for 2005 RET Andrew Bouchard's BHS physics classes. Ali works primarily with BHS participating teacher Don Erb, introducing students to both computing and electronics concepts through presentations and hands-on immersive exercises.

Judith Walker, who became a GK-12 Sensors! Fellow in July 2005, is engaged in a variety of sensor-related community-based projects with BHS students and faculty of the History Department. They have produced maps of both standard and hazardous-materials evacuation routes for Bangor; worked with Assistant Bangor Police Chief to use dispatch data in electronic format to geocode OUI data to alcohol providers; collaborated with the Bangor Historical Society to map the historical movement of area cemeteries, Jewish historical sites and Irish historical sites; used data provided by the Bangor Area Transport system to geocode Greater Bangor area public bus routes and census data. Walker also developed the classroom curriculum for a permanent BHS GIS course proposal that was adopted unanimously by the Bangor School Board in December 2005.

Contributions to Other Disciplines:

During the 2005-06 academic year, GK-12 Sensors! expanded its involvement in ninth and tenth grade Civics, History and World Geography classes; assisted in the curricular design of a new high-school level sensors-based course; engaged Social Studies classes at the sixth-eighth grade levels in participating middle schools.

Contributions to Human Resource Development:

The major goals of the project are achieved by using sensors as the vehicle to encourage students to pursue science and engineering careers. To this end the fellows act as role models as well as teachers. Emphasis toward encouraging underrepresented groups in science and technology, including females, minorities and disabled students is important to each teacher, faculty member and fellow working in the GK-12 Sensors! Program. It is anticipated that this program will significantly increase the number of high school students in Maine who will be choosing future careers in science and engineering.

Bangor School Committee adoption of a permanent course teaching Geographic Information Systems (GIS) at BHS has established a permanent footprint of GK-12, both in the school and the surrounding community. The knowledge of participating high school teachers and students has produced an ongoing working relationship between the Bangor school system and the police and fire departments of the City of Bangor. GIS-based community projects over the past three years have given GK-12 fellows the opportunity to introduce fire, police and other city officials to GIS technology, enhancing their understanding of the technology and showing them what GIS can do for the city, including improvements to emergency response and homeland security. Learning more about the power and capabilities of GIS has drawn them to large-scale implementation of these technologies for the improvement of the community. The high-school students working on projects are introduced to both GIS technology and civic engagement, encouraging some to continue involvement in community service. These projects gave students hands-on experience using GIS technology, providing them with new technical skills. Bangor city officials now view the civic contributions of participating students and teachers as an essential aspect of the City's ability to incorporate and maintain GIS technologies for security and other municipal purposes. Furthermore, the city is actively exploring ways to provide additional GIS-based resources to the high school in exchange for its ongoing efforts.

Teachings of Geographic Information Systems (GIS) at Bangor High School have increased the knowledge of participating high school teachers and helped to establish a working relationship between the Bangor school system and the police and fire departments of the City of Bangor.

In particular, through the Bangor, Maine Emergency Mapping GIS Project, GK-12 fellows introduced fire, police and other city officials to GIS technology, enhancing their understanding of the technology and showing them what GIS can do for the city, including improvements to emergency response and homeland security. Learning more about the power and capabilities of GIS has drawn them closer towards larger-scale implementation of these technologies for the improvement of the community. Working with high-school students on the project also helped introduce students to GIS technology and involved them in a community-based project. This may encourage them to continue involvement in community service. The project gave students hands-on experience using GIS technology, providing them with new technical skills.

Contributions to Resources for Research and Education:

Fellows, working with teachers at all schools we interact with, continue to develop portable sensor modules for dissemination to other schools.

GK-12 Sensors is collaborating with Gary Ybarra and Paul Klenk of Duke University to incorporate the GK-12 module library into their online engineering learning resource 'TeachEngineering.com.'

Sensor research is an interdisciplinary field with applications in all areas of science and mathematics. The students are introduced to the scientific approach to problem solving and invention.

Students in science and social studies courses to use laboratory sensors employing principles involved in the most advanced technology systems.

Development of community-based GIS projects with BHS students has encouraged the City to fund creation GIS lab at BHS.

Development of community-based GIS projects with BHS students prompted the Bangor School Board in December 2005 to unanimously adopt a proposal for a permanent BHS GIS course (the curriculum was co-designed by GK-12 fellow Judith Walker).

Fellow and participating teacher presentations of GK-12 Sensors!-related educational activities at the National Science Teachers Association Convention (March 31-April 3, Dallas, TX) provided opportunities to disseminate resources to educators from throughout the U.S., exhibiting concrete models for implementing sensors into middle- and high-school curricula.

The facilities at the Laboratory of Surface Science and Technology (LASST) are available for research opportunities. Group and individual visits to LASST have enhanced the GK-12 Sensors! classroom experience.

Contributions Beyond Science and Engineering:

Teachings about GIS and focus on community-based projects have provided the City of Bangor with emergency response-related spatial information, maps of both standard and hazardous-materials evacuation routes for Bangor, maps geocoding Greater Bangor area public bus routes and census data, geocoding OUI data to alcohol providers, maps of various historical geographies such as Jewish historical sites and Irish historical sites. These maps make possible unprecedented avenues for facilitating city planning, analysis of city resources and marketing.

GK-12 fellows have introduced fire, police and other city officials to GIS technology, enhancing their understanding of the technology and showing them what GIS can do for the city, especially improvements to emergency response and homeland security. Learning more about the power and capabilities of GIS has drawn Bangor closer towards large-scale implementation of these technologies for the improvement of the community. Working with high-school students on these projects also introduces students to GIS technology and involves them in a community-based project. This may encourage them to continue involvement in community service.

Recognizing the significance of these activities, the Bangor School Board in December 2005 unanimously adopted a permanent BHS GIS course into its high school curriculum.

GK-12 fellows involved themselves in a variety of extracurricular activities, including assisting organize an engineering technical society for BHS 11th graders, a TEAMS (Tests of Engineering Aptitude, Mathematics and Science) competition for BHS students, establishing a ham radio club at BHS, participation in BHS, DMS and CoMS science fairs as organizers and/or judges, serving as a mentor and organizer for a rock-wall climbing club at BuMS, assisting coaching the BuHS track team, co-organizing tours of university high-technology laboratories.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

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Note : A word about the format of this report.

Bold print indicates a section heading.

Bold italics indicate a subheading.

Plain italics indicate a survey question, survey scale or question asked by the evaluator.

Plain text indicates the report body.

Plain text in Arial Narrow indicates a participants’ direct quote.

Section 1: Overview of the Project

The GK-12 Sensors! program is designed to bring selected doctoral students in engineering together with local area middle and high school teachers. The project is funded through the National Science Foundation and is related to two concurrent projects: Research Experience for Undergraduates (REU) and Research Experience for Teachers (RET). The intention of the GK-12 program is for Fellows to share what they have learned in their research experience and studies in local middle and high school classrooms. During the 2005 - 2006 school year, 10 Fellows worked with 24 local science teachers, 20 classrooms and approximately 350 students.

The GK-12 Sensors! project has stated goals of bringing approximately 10 Fellows per year to the University of Maine to work with faculty members with backgrounds in biological, civil, chemical, computer, electrical, environmental, mechanical, and spatial engineering as well as physics. The Fellows' thesis topics and designs varied from participant to participant, but all included the use of sensor technologies as a central component.

Many of the participating classroom teachers in the GK-12 Sensors! project also take part in the RET project by working with mentors from the University of Maine during the summer. In this experience, teachers are able to experience firsthand the kinds of research opportunities and challenges experienced by Fellows on a day-to-day basis. The participating teachers who responded to an evaluation questionnaire regarding the performance of the GK-12 Fellows had educational backgrounds ranging from a single Bachelor's degree to multiple Master's degrees. Their years of teaching ranged from 2 to 35 years with an average of 10 years.

The evaluation instruments described in this report were designed to ascertain Fellows', teacher-participants', and faculty advisors' attitudes and beliefs about the degree to which the GK-12 Sensors! experience met the project's objectives.

Section 2: Evaluation Design

Pre- and post- program surveys of participants (Fellows, K-12 teachers, K-12 students, University faculty) attitudes were conducted during the 2005-2006 academic year, and a follow up focus group was conducted with the Fellows in April of 2006 to determine the fidelity and effectiveness of program implementation. Each questionnaire consisted of selected (Likert scale) and constructed response questions aligned to the stated grant objectives. In addition, respondents were provided multiple opportunities to give extended verbal and written responses reflecting their impressions of various aspects of the GK-12 experience. Questionnaires were administered at the beginning of the school year and again in May of 2006. These were completed in private and returned via the computer directly to the evaluator. Responses to the survey were then entered into a spreadsheet by a graduate student and accuracy was verified by the research associate directing the evaluation of this project.

The results of these evaluation activities are by nature qualitative – any attempt to generalize the meaning of the frequencies, percentages or differences is both unwise and inaccurate. Instead, the pattern of comments and responses must be considered in their totality and interpreted as the opinions and perceptions of the responding individuals only. Interpreted this way, these responses give valuable insights into the impacts of the project on participating students, teachers, faculty, and Fellows.

The table below details the nature and frequency of the different evaluation instruments:

Evaluation Instrument	Administration Schedule
Survey of Fellows' attitudes and expectations	October 2005, May 2006
Survey of cooperating teachers' attitudes and expectations	October 2005, May 2006
Survey of students served in Fellow's middle and high school classes	April 2006
Survey of Cooperating Faculty Members	May 2006
Focus group with Fellows	April 2006

Section 3: Fellow Responses Pre-program Survey

In the fall of 2005, Fellows were surveyed to determine their overall impressions of the project to that point and seven complete surveys were returned. Questions addressed Fellows' perceptions of the utility and value of the GK-12 program for students, schools, cooperating teachers, and themselves.

Four Fellows (57%) indicated they were pursuing Ph.D. programs, while three (43%) others were enrolled in Master's of Science programs. When asked if the GK-12 experience had encouraged them to pursue a Ph.D., four of the seven (57%) responding Fellows indicated they were more likely to pursue their doctorate. Two others (29%) indicated they had always intended to get their doctorate, while only one (14%) indicated he/she still intended to stop with his/her M.S.

When asked about their level of interest in teaching, Fellows indicated the GK-12 experience had made them more interested in teaching, but not necessarily in becoming a public school teacher. While five (71%) of the seven respondents indicated high levels in interest in teaching, none (0%) of the responding Fellows said they wanted to become high school teachers.

While the GK-12 experience did not seem to impact responding Fellows' aspirations to become public school teachers, they indicated the experience had improved their teaching skills substantially, and all seven (100%) respondents expressed interest in teaching at the university level. In addition, six (86%) of the seven respondents felt they had improved their presentation skills, and all seven (100%) felt they had improved communication skills. Six (86%) of the seven responding Fellows also gained some understanding of cooperative learning strategies.

Four of the five (80%) respondents indicated they had made a positive impact on public school students' understanding of Science, Technology, Engineering and Math (STEM), while

one respondent indicated they had no impact on students' interest in these areas. When asked how their Fellowship had impacted their thesis, five of the seven (71%) respondents said it *had not* helped, one (14%) indicated it *had* helped, and one (14%) respondent was not sure.

When asked about who was most helpful to them, responding Fellows indicated that they received the most help from cooperating teachers and public school students. By contrast, respondents got relatively little help from textbooks, faculty members, and other Fellows. There was one exception to this pattern – one Fellow received the most help from a University faculty member.

The final question on the pre-program survey asked Fellows to rate how rewarding their experience with the GK-12 program had been thus far. All seven (100%) respondents indicated it had been a *rewarding* experience, and five of the seven (71%) felt it has been *very rewarding*. Detailed tables indicating the frequencies of responses follow.

Quantitative Results GK-12 Fellows Survey Fall 2005

		N	Percent
What is the highest level graduate degree you are currently pursuing?	M.S.	3	42.9%
	Ph.D.	4	57.1%
	Other	0	.0%

		N	Percent
Please indicate how much, if at all, your experience so far as a GK-12 Fellow has affected your interest in pursuing a Ph.D.	I enrolled with the intention of getting a Ph.D., and my intention has not changed	2	28.6%
	Much more likely to get a Ph.D. now	3	42.9%
	Somewhat more likely to get a Ph.D.	1	14.3%
	Somewhat less likely	0	.0%
	Much less likely	0	.0%
	I intended to stop at a M.S. degree, and my intention has not changed	1	14.3%

		N	Percent
Before becoming a GK-12 Fellow, had you ever considered becoming a middle or high school teacher?	Yes	4	57.1%
	No	3	42.9%

		N	Percent
How interested in teaching were you before this semester?	Very interested	3	42.9%
	Somewhat interested	2	28.6%
	Only a little interested	2	28.6%
	Not interested	0	.0%
How interested in teaching are you now?	Very interested	5	71.4%
	Somewhat interested	1	14.3%
	Only a little interested	1	14.3%
	Not interested	0	.0%

		N	Percent
Before becoming a GK-12 Fellow, had you ever considered becoming a middle or high school teacher?	Yes	4	57.1%
	No	3	42.9%
Are you interested in becoming a high school teacher?	Yes	0	.0%
	No	5	71.4%
	Maybe	2	28.6%

		N	Percent
Are you currently working toward obtaining a teaching certificate?	Already have a teaching certificate	0	.0%
	Yes	0	.0%
	No	1	14.3%
	No, not planning to get one	6	85.7%

		N	Percent
Do you plan to teach at the college or university level?	Yes	2	28.6%
	No	0	.0%
	Not sure	5	71.4%

		N	Percent
To what extent did your experience as a GK-12 Fellow affect your teaching skills this semester?	Greatly improved them	4	57.1%
	Somewhat improved them	3	42.9%
	They declined	0	.0%
	They are quite good already, and I did not see any more improvement	0	.0%
	They may need improvement, but this experience did not have any impact	0	.0%

		N	Percent
Has being a GK-12 Fellow helped you make better professional presentations?	Yes	6	85.7%
	No	0	.0%
	Not sure	1	14.3%

		N	Percent
Did being a GK-12 Fellow improve your communications skills?	Yes	7	100.0%
	No	0	.0%
	Not sure	0	.0%

		N	Percent
Did your experience this year as a GK-12 Fellow affect your familiarity with active/cooperative learning techniques this semester?	I was quite familiar with them before, and that did not change	0	.0%
	I became much more familiar	1	14.3%
	I became somewhat more familiar	5	71.4%
	I do not know what is meant by active and cooperative learning techniques	1	14.3%

		N	Percent
In general, how did your involvement as a GK-12 Fellow affect your students' motivation to study science, technology, engineering and mathematics?	Greatly improved their motivation	2	40.0%
	Somewhat improved it	2	40.0%
	Had little impact on it	1	20.0%
	Somewhat reduced it	0	.0%
	Greatly reduced it	0	.0%
	Do not have any classes at this level	0	.0%

		N	Percent
Has being a GK-12 Fellow enhanced your thesis research this semester?	Yes	1	14.3%
	No	5	71.4%
	Not sure	1	14.3%

Which of the following groups has been most helpful in your GK-12 experience?

		n	percent
University faculty members	Most helpful	1	14.3%
	Somewhat helpful	0	.0%
	Helpful	1	14.3%
	Marginally helpful	4	57.1%
	Least helpful	1	14.3%

		n	percent
High school / Middle school teachers	Most helpful	3	42.9%
	Somewhat helpful	4	57.1%
	Helpful	0	.0%
	Marginally helpful	0	.0%
	Least helpful	0	.0%

		n	percent
Other GK-12 Fellows	Most helpful	0	.0%
	Somewhat helpful	0	.0%
	Helpful	4	57.1%
	Marginally helpful	3	42.9%
	Least helpful	0	.0%

		n	percent
Literature and textbooks on instructional techniques	Most helpful	0	.0%
	Somewhat helpful	0	.0%
	Helpful	1	14.3%
	Marginally helpful	0	.0%
	Least helpful	6	85.7%

		n	percent
High school / Middle school students you have encountered	Most helpful	3	42.9%
	Somewhat helpful	3	42.9%
	Helpful	1	14.3%
	Marginally helpful	0	.0%
	Least helpful	0	.0%

		N	Percent
Overall, this semester, my experience as a GK-12 Fellow has been	Very rewarding	5	71.4%
	Somewhat rewarding	2	28.6%
	Neither rewarding nor disappointing	0	.0%
	Somewhat disappointing	0	.0%
	Very disappointing	0	.0%

Fellows' Pre-program Survey Summary of Qualitative Responses

If you are interested in teaching, what subjects would you like to teach?

- Social Sciences
- Physics, Mathematics, History
- Physics, Mathematics, Science
- If at the college/university level, I would like to teach GIS-Geographic Information Systems.
- Physical Sciences(Physics, Chemistry, etc)
- Physical Sciences, Physics & Chemistry
- Physics, Chemistry, General Science

Please list the titles of the high school and/or middle school courses in which you are working with a teacher under the GK-12 Sensors! program, check the boxes for the grade level information and indicate how many students are in each course.

- Senior Seminar, History Department/high school/75;Civics/high school/140;Geography/high school/40;AP geography/high school/60
- Earth Science 1&2(honors)/high school/29;Earth Science 3&4 (level II)/high school/39;Earth Science 5&6(honors)/high school/40;Physics 1&2&3(Level I)/high school/56
- G8-Physical Science/middle school/100;G8-Mathematics/middle school/100
- Physical Science (Period 1)/high school/20;Physical Science (Period 2)/high school/21;G6- Science(Period 2)/middle school/22;G6-Science(Period 5)/middle school/22;G6- Science(Period 8)/middle school/20
- Life Science/middle school/74;Chemistry/high school/20;Chemistry(Lab)/high school/35;Physics/high school/12;Physical Science/high school/15;Earth science/high school/15
- Physical Science/middle school/100
- Algebra/middle school/20;Math/middle school/20;Science/middle school/80;Honors Physics/high school/8;Physics/high school/18;Physical Science/high school/27

How did your GK-12 experiences enhance your thesis research?

- I have included more spatial relation components to my thesis research
- It broadened the way I looked at presenting material

How did your GK-12 experiences NOT enhance your thesis research?

- My thesis research area has little relevance to the teaching I do, although I was able to mention/discuss it during one of my presentations to the 6th graders. The time commitment to GK-12 also makes finding time to work on research a little more difficult.
- Very unrelated and has actually taken time from my research
- It has taken time out of my research schedule

What has surprised you about the GK-12 program and your teaching experience so far, either positively or negatively?

- The amount of "drama" and bureaucratic nonsense public school teachers have to deal with on a daily basis.
- I've been surprised by how different it is to develop first lessons on a regular basis, it can be a very time-consuming process.

- It is much easier to influence younger students (8th grade) than older ones (juniors-seniors). I feel like I'm making more of a difference this year being with younger students. This is a very positive aspect.
- I was pleasantly surprised by my experience with younger students, 6th graders especially. They are so enthusiastic and excited about having you in the classroom, especially doing activities. They are eager to participate in discussions as well. I didn't know I would enjoy working with students at all ages so much when I was just starting. It's been fun!
- I'm surprised how much I've enjoyed working with the middle school students. Last year I had a great time at the high school level but this year is far more fun and far more rewarding.
- The biggest surprise is the lower aspirations at students in one school district as compared to another

What suggestions do you have for improving the GK-12 program?

- Better communication between all of the participants.
- Get some sensors the GK-12 Fellows can share between the schools. Some of the schools have very few sensors and it takes a long time to get the sensors through the state's borrowing program. Sometimes it's too late once they come-the activity you want to do has passed by in the curriculum. Having them readily available would be very helpful.
- Expecting us to develop two new modules in one semester was not a good idea. Two modules per year is more reasonable.
- More focus on communication across all levels

Section 4: Fellow Responses to Post-program Survey

A total of eight complete and two partial questionnaires were returned for the April 2006 post-program survey. This survey was a parallel form to the pre-program survey, and while the overall pattern of participants' responses is similar, there are several important differences worth highlighting. Respondents provided similar responses to questions about their educational plans, and reasons for attending graduate school at the University of Maine. These questions were designed to detect changes in participants' aspirations to earn a Ph.D., however; this pattern of results obtained does not support that conclusion.

When asked if the GK-12 experience had changed their interest in teaching, responding participants showed increased interest which they attributed to the program. On both surveys, the majority of respondents felt this experience had increased their interest in teaching. In particular, six of the eight respondents (75%) to the post-program survey were more interested in becoming a middle or high school teacher. Paradoxically, when asked if they were interested in obtaining a teaching certificate, none (0%) of the respondents indicated they were planning to become certified to teach public school. These confounding statements are difficult to interpret with certainty. They may indicate an intellectual affinity with the concept of teaching but a lack of real interest in operationalizing that interest through obtaining a teaching license.

It is also unclear whether these individuals may enter university faculty positions at a greater rate. When asked if they planned to teach at the college level, two respondents (25%) said *Yes*, two (25%) said *No*, and four (50%) said they were *Not Sure*. Given these results, it may be important for program staff to consider paying special attention to educating Fellows about the benefits and opportunities associated with becoming a university faculty member.

The next question asked participants to evaluate the impact of the GK-12 experience on their teaching skills. The majority of respondents (75%) said they had *Somewhat improved them*, two respondents (25%) said their teaching skills had *declined* and no (0%) respondents felt their skills had *Greatly improved*. There are two concerns associated with this question: 1) most participants felt their skills had improved only *Somewhat* and 2) two participants actually felt they became worse teachers as a result of their participation. This presents another area of need and training for program staff to address in the coming year with new Fellows.

When asked how the GK-12 experience had impacted their presentation skills, all but one responding Fellow (87.5%) said it had made them better presenters. The remaining respondent was “*Unsure*” if the experience had improved that Fellow’s presentation skills. One question asked Fellows to comment on their understanding of cooperative learning techniques used in schools. The purpose of this question was to determine if Fellows became more familiar with these kinds of teaching strategies throughout the course of their teaching experience. This did not prove to be the case as similar patterns of response were detected on both the pre and post surveys of Fellows. Because several of the respondents had prior experiences as a GK-12 Fellows, this may have impacted their selections when responding to this question. This issue, in combination with the very small number of participants may impact this pattern of results substantially.

Responding participants were more positive about their perceived impact on students’ interest in studying science, technology, engineering and mathematics. All respondents felt they had a positive impact on the students they worked with, and one individual indicated that impact had *greatly improved* the student’s motivation. Finally, when asked to comment on the impact of the GK-12 experience on their own research activities, most (63%) respondents *Did not* feel

their teaching had enhanced their thesis work. One Fellow felt it *Did enhance* their thesis work, and two others were unsure of the impact. This pattern is consistent with the fall survey, and the Fellows' explanation of why it did not enhance their work was also similar. Many Fellows indicated the GK-12 work had taken up substantial amounts of time, leaving them with less time for their own studies. The complete set of Fellows' qualitative responses to this question can be found beginning on page 23.

Fellows were also asked to rate the relative “helpfulness” of different groups with their GK-12 experiences. Respondents rated faculty members, high school/middle school teachers, other Fellows, textbooks and middle/high school students. Not surprisingly, five of the seven (70%) Fellows who responded to this question rated cooperating teachers as the most helpful. Interestingly, six of the seven (86%) Fellows rated students as the next most helpful group. Respondents indicated other Fellows were generally *Helpful* to them, but not *Quite helpful* or *Most helpful*. Most Fellows found textbooks and faculty members to be only *Marginally helpful* or *Not helpful*. This raises two important points: first, students are a largely unidentified source of support to Fellows; and second, faculty members are not perceived as supporting students in this experience. Program staff should consider what sources of support and encouragement they expect for Fellows and adjust program expectations and professional development accordingly.

When asked how their GK-12 experience impacted their desire to stay in Maine, Fellows' responses were either positive or neutral. Two respondents (25%) have always intended to stay in Maine, and two others (25%) said the experience made them more likely to stay. Three respondents (38%) said they had made no change of plans of where they would work, and one (13%) indicated they never planned to work in Maine and that decision had not changed.

Finally, Fellows were asked to comment on their overall experience with the GK-12 program. All respondents indicated it had been a rewarding experience for them. This finding is important in light of the constructive criticism provided by responding participants in other parts of this survey. While participants pointed out specific needs the program should address, they were overwhelmingly positive about their experiences working with teachers and students and felt they had gained a great deal from the experience. The results of the spring focus group shows this pattern clearly – Fellows have specific suggestions to improve things, but overall, they have found the experience very satisfying and rewarding. A detailed list of tables showing the pattern of responding participants’ answers can be found starting on page 18. An overview and full text of the focus group can be found beginning on page 26.

GK-12 Fellows Spring 2006 Post-program Survey

		N	Percent
What is the highest level graduate degree you are currently pursuing?	M.S.	4	50.0%
	Ph.D.	4	50.0%
	Other	0	.0%

		N	Percent
Did getting a GK-12 Fellowship influence your decision to enroll in graduate school at UMaine?	Yes	4	50.0%
	No	4	50.0%

		N	Percent
When you enrolled in graduate school at UMaine, were you planning on getting a Ph.D.?	Yes, I enrolled in a Ph.D. program	4	50.0%
	Yes, I enrolled in a M.S. program and plan to continue to a Ph.D.	0	.0%
	Perhaps, I am enrolled in a M.S. program and may continue to a Ph.D. program	1	12.5%
	No, I plan to stop with a M.S. degree	3	37.5%
	Not sure -- I will wait until after the M.S. degree to decide	0	.0%

		N	Percent
How has your GK-12 experience affected your interest in pursuing a Ph.D.?	I enrolled with the intention of getting a Ph.D. and my intention hasn't changed	4	50.0%
	Much more likely to get a Ph.D.	1	12.5%
	Somewhat more likely	0	.0%
	Somewhat less likely	0	.0%
	Much less likely	0	.0%
	I intended to stop at a M.S. degree and my intention hasn't changed	3	37.5%

		N	Percent
Before becoming a GK-12 Fellow, had you considered becoming a middle or high school teacher?	Yes	3	37.5%
	No	5	62.5%

		N	Percent
How has your experience as a GK-12 Fellow affected your interest in becoming a middle or high school teacher?	I was sure that I was going to teach and that hasn't changed	0	.0%
	Much more interested	1	12.5%
	Somewhat more interested	5	62.5%
	Somewhat less interested	1	12.5%
	Much less interested	0	.0%
	I never expected to teach and that hasn't changed	1	12.5%

		N	Percent
Are you currently working toward obtaining a teaching certificate?	Already have a teaching certificate	0	.0%
	Yes	0	.0%
	No	2	25.0%
	No, not planning to get one	6	75.0%

		N	Percent
Do you plan to teach at the college or university level?	Yes	2	25.0%
	No	2	25.0%
	Not sure	4	50.0%

		N	Percent
To what extent did your experience as a GK-12 Fellow affect your teaching skills this semester?	Greatly improved them	0	.0%
	Somewhat improved them	6	75.0%
	They declined	2	25.0%
	They are quite good already, and I did not see any more improvement	0	.0%
	They may need improvement, but this experience did not have any impact	0	.0%

		N	Percent
Has being a GK-12 Fellow helped you make better professional presentations?	Yes	7	87.5%
	No	0	.0%
	Not sure	1	12.5%

		N	Percent
Did your experience this year as a GK-12 Fellow affect your familiarity with active/cooperative learning techniques this semester?	I was quite familiar with them before, and that did not change	1	12.5%
	I became much more familiar	2	25.0%
	I became somewhat more familiar	2	25.0%
	I do not know what is meant by active and cooperative learning techniques	3	37.5%

		N	Percent
In general, how did your involvement as a GK-12 Fellow affect your students' motivation to study science, technology, engineering, and mathematics?	Greatly improved their motivation	1	14.3%
	Somewhat improved it	6	85.7%
	Had little impact on it	0	.0%
	Somewhat reduced it	0	.0%
	Greatly reduced it	0	.0%

		N	Percent
Has being a GK-12 Fellow enhanced your thesis research this semester?	Yes	1	12.5%
	No	5	62.5%
	Not sure	2	25.0%

Please rate each of the following groups according to how helpful they have been in your GK-12 experience.

		N	Percent
University faculty members	Most helpful	0	.0%
	Quite helpful	0	.0%
	Helpful	1	14.3%
	Marginally helpful	4	57.1%
	Least helpful	2	28.6%
High school / Middle school teachers	Most helpful	5	71.4%
	Quite helpful	1	14.3%
	Helpful	1	14.3%
	Marginally helpful	0	.0%
	Least helpful	0	.0%
Other GK-12 Fellows	Most helpful	0	.0%
	Quite helpful	2	28.6%
	Helpful	3	42.9%
	Marginally helpful	2	28.6%
	Least helpful	0	.0%
Literature and textbooks on instructional techniques	Most helpful	2	28.6%
	Quite helpful	0	.0%
	Helpful	0	.0%
	Marginally helpful	0	.0%
	Least helpful	5	71.4%
High school / Middle school students you have encountered	Most helpful	0	.0%
	Quite helpful	4	57.1%
	Helpful	2	28.6%
	Marginally helpful	1	14.3%
	Least helpful	0	.0%

		N	Percent
Please rate how your GK-12 experience this year has affected your interest in working in Maine after completing your graduate degree	Had always planned to work in Maine and that hasn't changed	2	25.0%
	Much more interested	1	12.5%
	Somewhat more interested	1	12.5%
	No change	3	37.5%
	Somewhat less interested	0	.0%
	Much less interested	0	.0%
	Never planned to work in Maine and that hasn't changed	1	12.5%

		N	Percent
Overall, this semester, my experience as a GK-12 Fellow has been	Very rewarding	5	71.4%
	Somewhat rewarding	2	28.6%
	Neither rewarding nor disappointing	0	.0%
	Somewhat disappointing	0	.0%
	Very disappointing	0	.0%

Fellows' Post-program Survey Summary of Qualitative Responses

How did the award of a Fellowship affect your decision to enroll in graduate school at the University of Maine?

- Allowed me to remain at the University to pursue doctorate, I would have left otherwise
- It gave me the amount of funding to support me and my two children while I pursued a higher degree while keeping me involved with teaching
- The Fellowship provided financial security over the two years it would take to finish a master's degree. It also allowed me to get some teaching experience which is something I think I might like to do as a job later in life
- It provided the necessary financial support to allow me to attend graduate school

If you are interested in teaching what subjects would you like to teach?

- High school science
- General Science, Physics, Chemistry, Technology
- Physical sciences, chemistry and physics, math
- Mathematics, Physics, History
- Science, Math, Physics
- Sixth grade science – earth science

List three teaching modules you substantially used, developed or modified as a GK-12 Fellow this academic year.

- What is Energy?
- Understanding Half-Life
- Pandemic Avian Flu and Spatial Effects on Disease Distribution
- Torture Through Sensory Deprivation
- Introduction to Velocity, Introduction to Acceleration, Hydrogen Cars
- Runaway Jury: How TV Dramas are Affecting American Courtrooms
- Fun with Liquid Nitrogen
- Introduction to Electronics
- Intro to Atmospheric Pressure
- Intro to Sensors
- GPS Mapping of Middle School
- Potential and Kinetic Energy of a Pendulum
- Ozone in Bangor Presentations
- Paper rockets, comets, and magnetism
- Introduction to Weather and Sensors
- Roller Coaster Design Contest
- Animal Senses

If you think that your involvement improved the motivation of at least some students to study STEM, please briefly note specific examples or experiences you had that led you to that conclusion.

- Some students expressed interest in pursuing bioengineering after the Avian Flu module. The Runaway Jury module created lots of interest and discussion concerning the different avenues of forensic science.
- I've had many students approach me after class to tell me how re-awakened they are to science. They are genuinely excited and newly motivated.
- There have been two students in particular (one from Physics, one from Earth Science) who have stayed after class or sought me out between classes to ask me about different topics that interest them. I sort of gauge the level of interest by the number of questions.
- One student in particular told me that he was enrolling at EMCC in electrical engineering technology due to my involvement in his classes at the High School. Additionally, at the Middle School, some students have shown much more interest in pursuing projects that extend the lab concepts on their own time.
- The students are actively interested in what activities I would be doing that day. Where as they rarely ask the teacher.
- There were some students who didn't really seem to care what I had to say at the beginning of the year. By the end of the year those students were constantly raising their hands to answer questions.
- After I gave a presentation to the sixth graders on engineering – the different types of engineers and what they do – I asked students if they were interested in engineering and if so, which type of engineer they would like to be. There were always some students from each of the 6 classes that wanted to be engineers of varying types. These were not necessarily the students whose parents or other relatives were engineers. I had asked at the beginning of the presentation whether the students were familiar with engineering or knew an engineer. A number of them did. But I think finding out some of the specific projects that engineers work on helped to stimulate the interest of the students generally in engineering.
- Bringing the 3 sixth grade classes I work with to tour some of the engineering labs at the university may have made engineering more tangible to the students, by getting to see the equipment and labs the researchers and engineering students work in.
- I honestly have no idea whether my presence in the classes that I teach has improved or reduced the students' motivations to study STEM, since they haven't mentioned anything to that effect; however, they have been interacting very positively with me, so I think that at some level they might be less negatively inclined to think of such topics.

How has your GK-12 experience enhanced your thesis research?

- With all of the projects I've done at the high school it has greatly improved my working knowledge and troubleshooting abilities concerning the program which I'm using to supplement my other thesis research.

How has your GK-12 experience NOT enhanced your thesis research?

- My research is primarily in modeling a sensor device and does not easily fit into middle school or high school curriculum.
- It is very unrelated to my field of study.
- They have been two separate responsibilities; there's just no carry-over between what I do in the classroom and what I do in the lab.
- Time consumption
- Although I thoroughly enjoyed working in the schools as a GK-12 Fellow, it did take a lot of time away from research, which contributed to the extended length of time required to complete my degree. I have no regrets about being involved in the program, however, it does make it more difficult to complete a degree in a timely manner.
- My research is in an area unrelated to most of the classroom activities, so it didn't really bear on the research at all as far as content.
- I'm ambiguous as to whether being in the GK-12 program has enhanced my research; I don't think it has because I spend a lot less time in lab due to teaching. However, my perspective on presenting ideas has changed because I think about how I might be able to explain (very simply) to the students what I'm doing.

What surprised you most about your GK-12 experience?

- How well I fit in and worked with the other teachers in the XXXX Dept. at the High School. Also, how attached I have become to several of my students. I didn't think I was going to enjoy it nearly as much as I have either.
- I was surprised how much I enjoyed working with the middle school students.
- I did not know how I would enjoy teaching at the middle school level. It turns out that I love the enthusiasm and the energy of the students. Middle school students are far less jaded than high school students and enjoy learning for the sake of gaining new knowledge as long as the project or discussion can keep them engaged. The part of keeping them engaged can be the problem.
- It surprised how much easier it was to influence students in the 8th grade than it was to influence the seniors I worked with last year.
- As far as working with the sixth graders, I am always amazed at how enthusiastic the students are and how much they want to participate in the class. They are so glad to see you every time you visit and miss you when you're not there. Something seems to happen to their enthusiasm between 6th and 7th grade. Working with some of the same students in 7th grade science as I did last year in 6th grade, I notice a change in their attitudes. They're not as open to or excited about new ideas and activities. This seems to be true generally, as I saw the same thing among 7th graders last year in one school compared to sixth graders in another school. That window of opportunity where the students are so open and enthusiastic seems to shut a little by seventh grade. That's why I think it's so important to reach them and get them excited about science, engineering, and math as early as possible.

What could be improved about the GK-12 program?

- Better communication and feedback, especially positive feedback concerning modules. Meeting with assigned teachers earlier than two weeks before the school year starts. Accountability would be nice on the part of the Fellows concerning assignments and so forth about attendance at the school and meeting obligations to their teachers. Some students have flat out said in a meeting that they decided not to work with their assigned teacher and were going to work with this other teacher instead that already had a Fellow. It seemed to me that this was borderline unprofessional and disrespectful to the teacher that lost a Fellow. Also, considering how much we get paid, this is definitely a job and people shouldn't be able to do whatever they want at the expense of teachers and students. It is one thing if there are bad conflicts, but that should be worked out on the PI level and re-assignments should be made. Fellows shouldn't be able to make major changes just because they don't feel like working with a particular class.
- Let the GK-12 Fellows know who they will be working with as soon as possible so that they can develop a relationship with the teacher.
- Have an electronic repository with FAQ's such as the website. Have an active space on the website where new Fellows can post general pedagogy or administrative questions that experienced Fellows may answered. It can be set up as a list-serve.
- Overall I think this year has been run better than any of the years in the past. Keep improving and it will only get better
- Better communication between the P.I.'s and the Fellows. It is helpful to know what is expected from us as far in advance as possible, rather than finding out we must submit something almost immediately. I think this year the expectations were communicated in a more timely manner for the most part, but it could still be improved.
- Also, it would be nice to get some feedback regarding our activities in the schools and the modules we submit. Knowing whether these are thought to be good or bad, so we can improve next time if it's not really what the P.I.'s would like to see.

Section 5: Fellow Responses to Focus Group April 2006

GK-12 Fellows Focus Group Meeting Overview:

The focus group was conducted in a single 1.5-hour meeting with all 10 GK-12 Fellows present. The meeting yielded a number of thoughtful responses on the part of participants, and their answers can be found in full in the following section. There were three major themes that emerged from this discussion, and each one presents the program staff with challenges to address. The themes were: *communication by program staff*, *support with instruction and curriculum*, and *communication with other GK-12 Fellows*.

Several Fellows raised concerns about the quality and timing of communication made by program staff. While everyone said the program manager was extremely effective in responding to Fellows' needs, he had not provided adequate time with many of his memos and requests to Fellows. In addition, several Fellows indicated there could be clearer and more detailed communication between the principal investigators of the project and the Fellows. In particular, several individuals reported they did not have an adequate understanding of the projects' direction and overall plan. One recommendation would be to establish a regular form of communication from the PI's to Fellows, teachers, and cooperating faculty. Additionally, it might be helpful for the program manager to create a regular communication (newsletter, memo, etc.) and include upcoming events and requests as far in advance as possible. This might be combined with a schedule of activities required from the Fellows and posted to a common forum accessible to all program participants.

The second area of need identified by some focus group participants was for more support in how and what to teach in the classroom. Many students indicated they could be more

effective if they had timely, thoughtful feedback on the modules they had created. There are several ways this could be accomplished. First, Fellows could meet regularly to review each other's modules, provide feedback and ideas. Second, program staff could develop a rubric to evaluate the quality, appropriateness and feasibility of Fellows' modules. Third, program staff could work with selected high school science teachers and university teaching faculty to review Fellows' work and provide feedback for improvement. These steps might effectively address several of the issues raised by participants regarding the third area: communication and instructional support. In addition to providing Fellows with ideas for improvement, this process would establish a forum for teachers, program staff, and faculty to discuss ways to improve the GK-12 experience and identify potential paths to sustain the project after NSF support has ended. The full transcript of the focus group follows.

April 2006

Note: Evaluator's questions and comments appear in italics.

What comments do you have about the acceptance process?

It was quick. There was a 4 day turnaround. I applied late and got in fast – fast track.

I don't think it was that quick, but it was only a few weeks later.

What were the program responsibilities as described?

They said very little. I don't think we were given a whole lot of direction when we came in. In my case, I was told these were the teachers I was going to be working with and that I should be in the classroom 10 hours a week and that was it. And take it from there.

What did other people hear?

When I started they said you are going to be in the classroom about 10 hours and there is going to be some prep time.

When I started I think it was a little more clearly defined. I think we had a couple three weeks – it wasn't a whole lot of guidance other than you were going to take sensors into the schools. At least in my case it was a topic I was comfortable with, so that made it easier.

I feel that the added time commitments, like attending evaluation meetings, filling out weekly journals, which we could have anticipated that there would be some of that, but that was completely ignored in my interview.

There are these mandatory meetings that happen now and again, and we could have expected that it would happen but it would have been nice to have been made aware of that.

Would that collectively be something you would identify as an issue?

When I came in, I had been exposed to the other GK-12 Fellows and I knew what to expect.

When I came in, I talked to one of the previous Fellows, so I knew what I was getting myself into.

Would it have been better if they had clearly delineated what would be expected from you?

Of course.

It couldn't hurt.

I think it means that we don't resent having these events.

Sometimes they are not real good with adequate notice. That is my only real pet peeve, you know you have to do it right away. Or the wrath of God will come down upon you.

How often does that happen?

More often than not. Although it has gotten better than since the beginning. It has gone from a day notice to maybe two or three.

The last meeting we had we had a lot of notice.

Often it is an information request, like, we need a bio tomorrow, or we need to know how many students there are in a particular class,

What about the communication with the program staff? What are the positive and negative aspects of this communication?

I know that last semester the program manager gave us a schedule of when everything was due, but that didn't happen this semester.

Probably Friday we will get a notice at 3:00 that there is a journal due at 4:00.

Is that reality or an exaggeration?

It's reality.

On the other hand, there was an expectation laid out that we had to do these every 2 weeks. So it's not really a surprise when they are due.

I was wondering about these heavy handed e-mails that come out asking for this or that, or asking us to all be at a meeting.

I'm not sure if it is the program manager or the PI that is sending these really.

I think that sometimes these are sent as a way to say "no, I really mean this is the deadline this time" because people have not responded to earlier messages.

So, is there a level of non-compliance on your [the Fellows] part?

Yeah, I guess that is what I am saying. I think in the past there was a student that didn't attend meetings.

On a positive note I had always gotten fast feedback –

Is that for administrative kinds of things?

For whatever, like how is this survey process going to work, or what is the deadline for this paperwork etc.

I really appreciate that we know when the modules are due.

I think the communication has improved this year from last year.

I like that things are laid out more up front.

It seemed to be more make it up as you go before, the last meeting we had about 4 month of notice. I liked that.

We were told about this [the focus group] about a week ago and that was good.

Like the summer meeting that they always have, that always seems to be kind of last minute. You know everyone is planning their vacations, and it's really hard to plan when you don't know when you are supposed to be there.

Yeah, they could just say, it's going to be the first or second week of August and then everyone including the teachers could plan for it.

I want to ask you about some specific roles:

Program manager:

I think he is very good about answering questions and getting back to you quickly.

He is really good on the reactive side and not very good on the front side. That may be his philosophy that we are supposed to figure it out and ask for help if we needed it. That was part of the goal for us to figure out what to do and to do it as opposed to having someone tell us what to do.

Once again if that is their philosophy then it would be good to tell us, if that is not what their philosophy is, then they should act according to whatever their philosophy is.

He is very good on the reactive side and almost nothing.

Is there a legitimate claim that he laid out a schedule for what was due and when?

He did that for last semester and it was helpful.

No, he gave us a list of dates for this semester too.

Oh that's right he did do that.

A little in his defense, I think a lot of these last minute things he doesn't know about either. He is very organized and likes things planned out if he can.

My experience has been nothing but positive. I want to make it clear that the program director has been very helpful and he has done a very good job. I understand that there may have been issues in the past, but I think they have been worked out.

For me, I feel like I have been at this long enough so that it doesn't bother me to have to respond to things at the last minute. I think after a while you have to learn to run with it.

I think some of us are used to it, we have been doing this for a while. I usually presume that if things come to us at the last minute it is coming from the PI and not from the program manager.

This is the second program manager that I have been involved with and he is much better than the first one. That program manager would send out everything at the last minute, not just those things that he knew about at the last minute.

I think we are moving in the right direction.

I don't really know the PI well, but if this is true, then the program manager has done a great job in his role because there has never been even a hint in any of his emails that something that was last minute wasn't his fault. As his role as a program manager is a good trait to take responsibility [for these things].

What about the PI's?

Sometimes it seems like it is a secret group that is meeting and doesn't want us to know what is happening. Basically any information that I have gotten I have sought. Other than that, it has been "what's going on?"

My experience has been even when I ask I don't always get information.

I have a working relationship with one of the PI's so I have a better idea of what is going on than other people.

So, how important is it to you to know what is going on?

So what kind of stuff? Well it is hard to know if we need to know what is going on when we don't know what that is. It would be nice, and I guess we do to some extent have some idea of the broad goals of the project.

What do you think those are? What is the point of this project [GK-12], in your own words?

I think there are two points, one is to get us Ph.D.'s and the other is to get students to the college that wouldn't otherwise attend or go into engineering.

I think the importance of the female going into the sciences, to be a role model for these...

I think just to go on to college in general, it is important to be a role model. For example I had some really nosy freshmen asking what I had to do and how much I got paid, and even though their questions were really inappropriate, I shared with them so they could maybe have aspirations to go on to do this too.

I told them so they could understand why in the world would a person want to do this.

Are there other comments about the PI?

When we presented specific issues that required the input of the PI to make a decision, they left it hanging.

I think they are treating us like Ph.D. students when we go out to these schools. We are treated like Ph.D. students not like Master's students.

Is it a plus or a minus?

In the long term, I think it is a plus.

For me it is a plus because I prefer to not have others too involved in what I am doing. If things are going well, then let's keep them going well.

I haven't had a lot of contact with them either, except for the Fellow meetings, but then I haven't felt the lack of support either. The fact that I haven't had more contact with them, I really haven't felt the need to.

One thing I would like is more feedback as to the these reports we do every two weeks and then it is just gone and we never hear about it again. I would like to hear "good job, bad job, don't do that again, and so on. Because we may be Ph.D. students but I am not a Ph.D. yet and I sure as hell don't know everything yet." If they have any opinions.

Who would evaluate these?

I think the best ones to evaluate these are the students and the other Fellows.

Do you ever do that?

Sometimes informally, like I might share a lab with another Fellow, but we don't have a group meeting, I don't actually think we need one, but I think we all know each other well enough to go to one another and ask for feedback.

Most of these people I never see.

For example, at the last meeting we each talked to the PI one at a time where no one else talked. It was kind of like having a series of individual meetings in front of everyone. It might have been better if there could have been some group input.

Would this be constructive for you?

I think some feedback on the modules would be helpful, because we are just told “sensors” that’s it, so my mind just goes all over the place and sometimes it is hard to focus. It would be good to get feedback, instead it just get posted and there is no feedback for improvement.

What have your school experiences been like?

Fantastic, I totally love everyone at the school I work with. I have some issues with getting too much put on my plate, but I wouldn’t want to be anywhere else.

Does it go beyond the 10 hours?

Definitely, there have been some weeks that I have spend thirty hours trying to get everything working, and that is on top of the teaching and everything else.

I would concur, overall my experiences have been very positive. I think any teacher is going to take as much as they can get. The only negative that I have is that sometimes teachers want to change things at the last minute. Like, no, I have a test I am going to give today, we’ll have to do that lab another time. I’ve been coming this day for three months! But, like is like that, there are snow days or block schedules and these things are a challenge. When you are in once a week.

I found the teachers to be really enthusiastic about us being there, when they are enthusiastic, the attitude they have, and then the kids tend to be more enthusiastic as well.

As long as the teacher you are working with really buys into the whole idea and the whole program then it is really positive experience for myself and the kids and the teacher.

It sounds like you have worked with different kinds of teachers?

Most of the time my teachers have been really into it. One of the teachers was really busy and wasn’t into having me come in and do different things. Overall it was a positive experience even for that teacher.

I’ve worked with several different teachers and to me the experience depends greatly on just the chemistry between the me and the teacher. If we really hit it off then it is really exciting and then there are others who we are never on the same wavelength with. It depends on how well you are both looking at things the same ways, if you have the same goals. It depends on who you are paired with. For me the subject area isn’t as important as the personality of the teacher. You are going to work in their classroom and they are going to dictate when you are there and how long and so you really have to be on the same page.

Most of the teachers I have worked with have allowed me to bring an idea in that isn’t the primary focus of their class. For example, I was able to present some physics in math because there was graphing. I’ve heard other people say that their teachers are not very flexible, but for me, it is really important to have this flexibility. They are good about they want you to do something, but they are not good about other things.

Most of the teachers I have worked with have things planned out, some people are just better at planning.

I’ve had teachers who would sit in the classroom and take notes so that they could learn to run the program, and I have had others who said “oh great, I get to go to the coffee room for the day.”

When you work with someone who really cares it makes such a huge difference.

There is this synergy that happens. That was probably the best your that I have had, you know that the module is going to be used. That is a good feeling.

There is this one teacher that I work with who has everything that any Fellow has ever developed in his classroom.

What about the impact on the kids?

I think it is positive. In my experience they have been positive, they get excited when I am there, and they want me to stay beyond the time I am supposed to be there. One high school student is going to a 2-year EE program,

I think you are looking at some few kids who were on some borderline and you help them get across that line.

I think there are one or two that are more sparked, and that is all that I would ask for.

Do you think you are making an impact?

Yeah, I don't know.

I think most of the time people don't want you to know how much of an influence you have had on them, that you have made them change their minds about something. They might not even realize it. I guess the surveys will tell us.

I know how I get along with them, but on a personal level, I don't know.

I've wondered if our goal wouldn't be better served by taking students out for a half an hour and chatting with them one on one. As opposed to doing educational modules which teachers do every day. I think that we do give a different slant because we are not in there 40 hours dealing with all of the stuff teachers have to deal with. That's all good, but I have wondered if it is the best way for us to encourage students to go to engineering school.

If nothing else I think being in there is being a positive role model. Some of the kids you can tell they don't have a positive role model in their life. If you can come in once a week and just show them that people can go on to go to college and do other things, just having that influence in the classroom makes a difference sometimes.

I was thinking that the program should get a Ferrari and we could pull into the parking lot and rev the engine and then come inside and say hey, I'm in college, it's great, and this could be you.

I think I want to show them that science is not all lab coats and pocket protectors. You know, they don't have to feel as though they have to sacrifice their coolness just because they are interested in science.

I don't see this as changing every student, but for most of the kids that I have dealt with any small positive impact, even if it is just walking down the hall and asking what are we doing today is in this day and age, it can't hurt, there is just no way that it can hurt.

That's why I like the enthusiasm, at least if they are excited then they are not bored, science is a class they are not dreading going to – at least once a week they like it.

It would be nice if we could tailor things more. You come in and you give a module for the whole class, and some portion of them are sleeping or daydreaming, some portion of them are going to not care, and they are never going to be scientists and nothing you could say is ever going to change that and some of them are already interested in science and a lot of times those are the ones that are more fun to work with. Like the other person said, sometimes it seems like the scattered approach is missing more of them. I haven't figured out, short of trying to get kids to stick around after school, and I don't even know how appropriate that would be the way things are today, I don't know how appropriate it is to seek out any kind of interaction with the students outside of the class. I don't even know if that would be smiled upon, I don't know what our guidelines and boundaries are there. In the class you have to deal with everybody but you could do more fun stuff with the kids who are interested in what you are going to do without having to drag along the ones that just don't care.

But really you are trying to target the ones that don't care.

I think we should all be going to English classes. If we really want to make a difference we should go to English class and gym class and music class.

That brings up a good point, I talked to one kid who said, I don't want to be a scientist, I want to be a journalist. I said, well, think about what's a hypothesis? What's the scientific method, it's not that different from the Journalists, from doing a research article from a research point of view, that's where it is related. Science isn't something that exists by itself out in some corner of the universe.

Yeah, journalism is the only one that I could come up with. But obviously there is physics in sport and in music and anything that is physical has science involved in it. Research in journalism and social studies or whatever, that might almost be a more interesting place to go in some cases.

Are any of you working in any interdisciplinary classes?

No.

I have talked about it for next year, but I am not doing it now.

What is the impact on you? What difference has this made to you personally? What are you going to bring from this going forward?

A lack of debt.

It's given me a really good insight as to why the undergrads are so much further behind than I think they ought to be. Seeing the students in 9th grade and 11th grade and where they are at, gives me a new appreciation for where the undergrads are at when they get here. It's not as surprising to me where they are. I think to me, in terms of teaching undergrads is a good thing. I think having a better idea of where they were three years ago is definitely helpful.

Many of you are looking to go on to finish your degrees and become a faculty member?

Yes (several students)

What else are you going to get from this?

Time management skills, just having three: research, my own classes and teaching, having three completely distinct but equally important things going on at the same time, is a struggle to juggle but it is something that you need to learn to do. Nothing that you do for one is really going to help you in the other. Three separate aspects and they all have to be done. For me I think it is easier to just have one thing to focus on, but that's not the reality.

I'm a lot better with PowerPoint than I was. You need to be able to communicate. You have a better appreciation for kids. I guess I thought of myself as still pretty young, until you realize, oh it's been 11 years since I was in high school. The students don't look at you as young anymore.

I definitely think I am a better presenter and I can definitely control a group of 14-year-old kids. I was absolutely exhausted at the end of the class, but the teacher was like, "put that on your resume because anyone will hire you."

Communication skills for sure. Going in my first year, I didn't really know how to get through to the students, how to talk to them, just presenting something at the board was nerve racking for me, now it's nothing, now it's normal.

It's communication too with the teachers, dealing with all different types of personalities, you know whatever you are going to do in life, in your job, that is definitely going to help you. For me too, presentation skills, being able to get up in front of a group of kids or whoever, and be able to do a much better job than I used to do.

Yeah, the communication, stripping down the topic to its essence – whatever level you are teaching. I have gotten rid of a lot of jargon when I am presenting stuff. That's a danger that a research has when going to a technical conference. You say, oh, there is a bunch of tech people here so I am just going to talk in jargon, but you know what? They aren't always in the same field

as you. So it has made my technical presentations better it has helped me get at what is really important when discussing something because 50 minutes really flies by.

What else are people going to carry from this?

There is a certain reckless abandon that you get used to operating in. Things come up and it might be something that I have never researched or looked at before, and you just sort of throw yourself at it and trust that it is going to come out all right. Usually it is pretty open ended. Which is still a source of anxiety, but things just change much more at the high school than they do here. Here [at the university] things pretty much stay the same, but there, [at the high school] every week is pretty much something different. I think it helps to keep things fresh. It helps to keep you on your toes.

I think the willingness to take on something new. When I agreed to do this, I hadn't been in a high school classroom in 10 years. I had no idea what to expect and no idea of how it was going to go, you just toss yourself into it and trust.

I take that sense of accomplishment, maybe I am naive but I really think that I am making a difference.

How?

One of the students that I worked with came here and went into EE and maybe he would have done that, but for me it was just seeing a kid that I worked with come into the program.

I think it also increases your confidence in yourself, you can get up and start talking about things and when someone asks you a question, you can answer that question, and be able to shift and talk and think about things that you haven't thought about that much. Also, to be able to explain things in a way that people understand.

I think I got a lot more out of this than I get out of our usual meetings.

You want to have a focus group every week [kidding].

It certainly wouldn't be bad if we had the chance to sit down and talk about "are your kids bad at fractions too," or whatever.

I would say it would be beneficial for all of us. For example, I have a certain specialty, when it is time to do something with a class that is outside my area of expertise it would be good to be able to use the experience of people that know more about those topics. Just to pull on other people's expertise, that would be helpful to me. I could help out other people too.

It's kind of like we are independent contractors, and maybe that is better than us being a total collective, but maybe somewhere in between is better. For example, I had no idea that some people were having particular problems until today. I don't know what is going on with anyone except for a couple of people.

How often and how long should you get together?

I think it would have been great to have it when the Fellows come on. It's like here you go, here is your school and that's it.

For example, one of the new Fellows was just brought into the lab and was told "here's a new Fellow, tell them what is going on."

Where is the division between being told too much of what to do and being treated like the Ph.D.'s you mentioned earlier?

I feel as though as long as I am getting something productive out of the meeting then I don't mind being there. If I feel like I am waiting and I am just biding my time through a meeting then I resent it. I don't know if it is about how often or how long they are, so much as what happens and what are the results being used for. But there is no way to know that in advance.

Would it be beneficial for you [Fellows] plan and facilitate a meeting?

I think if we could have an agenda for the meeting and then have the opportunity to add items to the agenda that we thought were important to talk about.

Like our research meetings if these were more about discussion, and less like, you go then you go, then you go... we just don't know the order. It would be good to have a Fellow meeting that was just the Fellows.

Remember the time we called the meeting where we got the program staff out of there? We got more done in 15 minutes than we did in three days of meetings?

Some of you have not talked today, and can we continue this discussion on email?

End of meeting.

Section 6: Summary of Fellows' Suggestions for Establishing Periodic Meetings

During the April focus group, Fellows were particularly interested in having a regular forum where they could come together and talk about concerns and issues without the program staff. Several of the participants enjoyed the focus group and felt it gave them an opportunity to speak more freely and communicate in ways not possible (as perceived by these individuals) during regularly scheduled meetings conducted by the program staff. As a result, a discussion happened over email between the Fellows and the evaluator to determine when they wanted to meet, how often, and what they wanted to talk about. Their complete responses to these questions follow.

What might work for a meeting structure?

- A roundtable discussion so that Fellows may bounce ideas and experiences with each other.
- I suppose one or two meetings like yesterday's each semester would be a productive use of our time. Of course we've never met without program staff before so it was interesting to hear Fellows' various opinions. I was a bit disappointed with some of the comments that were made and I had to bite my tongue on a few occasions but allowing people to vent their frustrations without repercussion is the point of the meeting I kept reminding myself.
- The roundtable format is a good idea, my only suggestion for improvement would be to obtain feedback from each Fellow before moving on to the next topic. The open format of yesterday's meeting encouraged the discussion to be dominated by the three or four Fellows who most enjoy hearing themselves speak.
- I would say meetings at the beginning of the semester and maybe once every 2 months would be appropriate. Meeting topics could be what is working and what is not working. What topics need to be covered at the schools. What kind of presentations methods are best for these topics.
- Basically things that will help us in our teaching would be the topics of these discussions. As far as time, it would be best if everyone sent their schedules ahead of time and then the most appropriate time was selected for the meeting. As far as who would organize the meetings, I don't know. Maybe a group of people could organize it and then a different group would organize it the next meeting.
- Informal is good, but someone should probably take the lead to get the discussion going and kept it going. If one of the Fellows was willing to do that, or if the program manager wanted to, either would work. If the meeting is too informal though, for instance meeting over dinner somewhere, I don't think as much would be accomplished. If standing, people tend to break off into groups, and if sitting, you can't necessarily hear what's going on at the other end of the table, especially in a crowded restaurant. So some structure - meeting informally, but perhaps at a table setting - would probably work best.

What times would be best?

- Afternoon, after 3:00 so that it is after the school day.
- I thought the length of the meeting was appropriate, early afternoon is a good time for meetings, and I think we should have at least one of these types of meetings each semester.
- I would say that late afternoon is good. Evenings could also work, but if it gets too late in the day, people are more inclined to want to go home and not want to spend the time discussing things. By late afternoon the Fellows would be done with the schools for the day, and unless some of them had classes, they would probably be available.

How often?

- Two times a semester; once before the start of a semester and toward the middle of the semester. If the Fellows find the meetings productive, three a semester can be scheduled.
- Every month might be a little much, but several times a semester would be good.

How long?

- One to two hours.
- Anything less than an hour, and nothing will really get accomplished. But much more than that is also too long. So somewhere between an hour and an hour and a half.

What would be on the agenda of the first several meetings?

- Modules what works well and why
- Classroom challenges and how they can be overcome
 - regarding students
 - regarding teachers
- Feedback and brainstorming on modules and other educational aspects of introducing technology into the classrooms
- I think the idea of getting to know the other Fellows is a good idea. I know a few of the Fellows that I have either worked with personally or who have been around on the grant as long as I have. Since I don't ever see the other Fellows, I don't really know them much at all. At least finding out what their area of expertise is and what types of classes they are working in - whether chemistry, earth science, etc. - would let me know who I might go to for help on certain subjects or where I might look for resources when I am creating modules. I wouldn't spend a lot of time going over exactly what modules we have all created, since we can go look at other Fellows' modules on the website. When I am looking for a possible activity on a subject I am not that familiar with, I check the GK-12 website for modules the other Fellows may have put together. I think if we got to know the other Fellows better there would be more of a tendency to approach each other for help or ideas.
- Discussing problems we have encountered or things that worked well for us might also be beneficial, especially for new Fellows. Getting an idea of how the program works from other Fellows' points of view and knowing how different teachers integrate the Fellows into the classroom would be helpful I think.

Section 7: Cooperating Teachers Pre-program Survey (also the RET Post-program Survey)

The pre-program survey asked cooperating teachers to comment on the potential impact of the Fellow assigned to work with them, their perceptions of the difficulty in supervising that person, and the quality of support they had received from the program. In general, teachers were quite enthusiastic about the program and especially about the Fellows. They raised concerns about the usefulness of the *Introduction to Sensors* course as well as communication with the program staff and Fellows.

Most (63%) of the eight teachers who submitted complete questionnaires indicated the (RET) experience would give them excellent or good ideas for teaching in the fall. Five (63%) responding teachers rated their ability to get questions answered as excellent or good. Four (50%) of responding teachers rated the instructions they received from program staff as good or very good. Finally, six teachers (75%) rated their opportunities to interact with GK-12 Fellows as fair or poor.

Most teachers indicated the work they were doing in the summer was interesting and important with 62% of respondents rating the experience as high and very high. Six (75%) respondents also indicated the Fellows' presentations were both interesting and useful, and the same number felt that they would be able to incorporate some of these projects into their curriculum in the fall. Seven (88%) teachers felt the GK-12 Sensors! Fellows' modules had a very high or high probability of making a positive difference for their students and in their classrooms that fall. Finally, six (75%) teachers indicated there was a very high or high potential for them to apply some aspects of the summer program in the fall.

The first several questions asked teachers to comment on the *Introduction to Sensors* course taught during the summer of 2005. Of 13 responses to these questions, 2 teachers (15%)

indicated this class had been *Very Useful* to their teaching, another 5 (38%) said it was *Somewhat useful*, 4 (30%) said it was *Not very useful* and 2 (15%) felt it was *Not at all useful*. The course had more value to teachers personally, as 5 (38%) felt it was *Quite useful* or *Very useful* and another 4 (33%) said it was *Somewhat useful* to them personally. When asked about the style of presentation for this course, most (75%) respondents felt it was *Quite* or *Very effectively* presented.

When asked how to improve the GK-12/RET experience, teachers offered the following suggestions: have clearer expectations, more training in sensors, a better organizational plan, earlier and more frequent contact with the Fellows, and more interaction with other teacher participants. Despite these suggestions for improvement, four (50%) of the responding teacher participants felt the RET experience exceeded their expectations, and another three respondents (37%) suggested it met their expectations. Only one participant (13%) indicated the GK-12/RET program fell short of their expectations.

When teachers were asked how useful their participation in the GK-12 / RET research experience was to their teaching, all responding teachers said it had been *Quite* or *Very useful*. Teachers were equally enthusiastic about the value of this research in their own professional development, with seven (64%) of the responding teachers saying it was *Very useful* to their own professional development.

Teachers also made a series of qualitative responses about the program, which are included in detail beginning on page 44. Most significantly, they wrote about the importance of getting to meet and work with their cooperating Fellows sooner. Several teachers expressed frustration that they had too little time to get to know their Fellow, and that instructional time was lost in the fall because of this. One teacher also expressed concern over the utility of the

Sensors course, however; this perspective was unique among the responding teachers' qualitative responses. Other responding teachers were either neutral or positive about the course.

Table of Frequencies of Responses, Teachers' Pre-program Survey

	Not at all		Not very		Somewhat		Quite		Very	
	n	%	n	%	n	%	n	%	n	%
How useful for your teaching was the course <i>Introduction to Sensors</i> ?	2	15%	4	30%	5	38%	0	0%	2	15%
How useful to your own professional development was the course <i>Introduction to Sensors</i> to you personally?	1	8%	2	17%	4	33%	4	33%	1	8%
How effectively was the course <i>Introduction to Sensors</i> presented?	1	8%	1	8%	1	8%	7	58%	2	17%
How useful for your teaching was your participation in a research project?	0	0%	0	0%	5	45%	3	27%	3	27%
How useful to your own professional development was your participation in a research project?	0	0%	0	0%	0	0%	4	36%	7	64%
How important was your contribution to the research project you worked on?	0	0%	1	9%	5	46%	3	27%	2	18%
How helpful for your teaching was your research project mentor?	0	0%	2	18%	1	9%	3	27%	5	45%
How helpful for your own professional development was your research project mentor?	0	0%	1	9%	1	9%	3	27%	6	54%
How useful for your teaching was preparing and delivering your presentation?	0	0%	1	9%	2	18%	4	36%	4	36%
How useful for your own professional development was preparing and delivering your presentation?	0	0%	1	9%	2	18%	5	45%	3	27%
How useful for your teaching was it to hear the presentation of others in the program?	1	9%	1	9%	1	9%	4	36%	4	36%
How useful for your own professional development was it to hear the presentations of others?	1	9%	0	0%	2	18%	4	36%	4	36%

	Yes, a lot		Yes, some		Yes, a little		No, have not been able to		Not this semester, but plan to next semester		Probably will not be able to	
	n	%	n	%	n	%	n	%	n	%	n	%
Have you been able to incorporate information or teaching you learned last summer into the classes you are teaching this fall?	0	0%	5	45%	4	36%	1	9%	1	9%	0	0%

Summary of Qualitative Results GK-12 Sensors! Fall Teacher Survey

What could be improved about the GK-12 Sensors program?

- Further contact with mentors each summer
- Research would be good
- Periodic get-together (There was one this fall) on a time table set in advance at the university to discuss what is/has happening
- Drop the Sensors! class. Other than teaching us how NOT to teach, it was a total waste of time. Please find another class to teach teachers that will make them better teachers
- We need to have a master plan for Sensor-curriculum. We need to schedule graduate students for the year. Graduate students need to stay with RET teachers for 6 weeks
- In the summer pair teachers up with a Fellow right away-that way they can begin a working relationship and really understand and get to know each other. Also, if the teachers can do research in the same area as the Fellow, this would be helpful for teachers to know/understand what the Fellow's research area is

Section 8: Cooperating Teachers Post-program Survey

Teachers were surveyed again in May of 2006 and several of the questions from the fall survey were repeated to detect shifts in participants' attitudes and perceptions. When asked how difficult it was to supervise the Fellow(s), all responding teachers indicated it took *Little to No time and effort*. Most (90%) of responding teachers felt the program would improve their teaching effectiveness, and eight (80%) indicated the program would assist them to some degree in aligning their curriculum to state standards. Similarly, eight (80%) of responding teachers said their involvement would help them further integrate technology into their classrooms. Three respondents (30%) suggested the presence of the Fellows would *Greatly improve* the motivation of their students to study STEM, and another six (60%) indicated it would *Somewhat improve* their students' motivation. Finally, when teachers were asked to characterize their overall experience with the GK-12 program, nine of the ten responding teachers said it was a *rewarding* experience. Only one teacher indicated it was *neither rewarding nor disappointing*, and no respondents said it was a *disappointing* experience.

When teachers were asked to write about their experiences with the GK-12 Fellows, they shared many positive experiences. Several teachers wrote at length about the positive difference the Fellow had made for students in their classes. Other respondents mentioned the quality of the instruction and ideas the Fellow brought with them. Still other respondents referred back to the positive summer research experiences they had. One respondent was not positive about the program, and indicated the only benefit received was the stipend. This response is not in agreement with the majority of teachers' perceptions, but signals a potential breakdown in communication, conflict, or issue to be resolved.

GK-12 Sensors! Teacher Survey Summary of Results May 2006

		N	Percent
Have you been able to incorporate information or techniques you learned last summer into the classes you are teaching this year?	Yes, a lot	0	.0%
	Yes, some	3	37.5%
	Yes, a little	2	25.0%
	No, haven't been able to	1	12.5%
	Not this semester, but plan to next semester	1	12.5%
	Probably won't be able to	1	12.5%
How much time and effort do you think it took to mentor the graduate Fellow(s) you work with to improve their teaching skills this year?	Considerable time and effort	0	.0%
	Little time and effort	5	55.6%
	No time and effort	4	44.4%
To what extent did your experience with the RET/GK-12 Sensors projects this year improve your own teaching effectiveness?	Greatly improve my teaching effectiveness	0	.0%
	Somewhat improve my teaching effectiveness	9	90.0%
	No change in my teaching effectiveness	1	10.0%
	Decline in my teaching effectiveness	0	.0%
To what extent do you think participation in the RET/GK-12 programs this year helped you align (or maintain the alignment of) your curriculum with state, local, or national standards?	Will help significantly	1	10.0%
	Will help somewhat	4	40.0%
	Will help only a little	3	30.0%
	Will not help at all	2	20.0%
To what extent do you expect participation in the RET/GK-12 programs this year to help you integrate (or further integrate) technology into your teaching?	Will help significantly	2	20.0%
	Will help somewhat	4	40.0%
	Will help only a little	2	20.0%
	Will not help at all	2	20.0%
In general, what do you think the impact of the GK-12 teaching Fellows was on the students in your classes this year?	Will greatly improve students' motivation to study STEM	3	30.0%
	Will somewhat improve students' motivation to study STEM	6	60.0%
	Will have little impact on students' motivation to study STEM	1	10.0%
	Will reduce students' motivation to study STEM	0	.0%
Overall, how would you characterize your experience with the RET/GK-12 Sensors programs this year?	Very rewarding	6	60.0%
	Somewhat rewarding	3	30.0%
	Neither rewarding or disappointing	1	10.0%
	Somewhat disappointing	0	.0%
	Very disappointing	0	.0%

Teachers' Qualitative Responses Post-program Survey:

How much time and effort did it require to mentor the graduate Fellow(s) you worked with to improve their teaching skills?

- The grad student was very organized and personable with the students
- I did no mentoring.
- My graduate student worked really well with my students. The grad student's teaching skills improved as the grad student became more comfortable being with the students.

To what extent did the Fellow improve your own teaching effectiveness?

- I did get some good ideas from the Fellow.
- My graduate student provided me with some excellent resources.

How did your participation in the GK-12 project help you align your teaching with the STEM curriculum?

- There was a great demo that fit with our Physical Science benchmark.

What do you think the impact of the GK-12 Fellow(s) has been on the students in your classrooms?

- My students liked my graduate student and looked forward to the activities they did with them. The Fellow made science a little more exciting for them.

Overall, how would you characterize your experiences with the GK-12 program this year?

- Students really enjoyed the days that the Fellow was in our classroom. He always had something interesting to share with them.
- It was rewarding in only the monetary facet of my life.
I did work in the lab setting with some really great people.
- We did some awesome things this year (ex. EARTH KAM and a field trip to various labs at UMO.)

What should be improved about the GK-12 program?

- Utilize some technology in the class room.
- The GK-12 and the RET should work together in the summer, perhaps on the GK-12's research project. This would build a better and stronger working relationship.
- It would also enable the GK-12 and RET to begin designing ideas and plans for the upcoming school year.
- There needs to be more structure for the RET's at the start of the program; what are the expectations, who will the RET be working with (faculty and GK-12), what project will the RET be working on - can the RET have some say in what they do during the summer.
- The class was ridiculous.
- Ensure a match between content the teacher teaches and the focus of the Fellow's research.
- Be consistent. Allow the Fellows to stay at their site for more than a year. Every time we get some consistency it is taken away. It takes a considerable amount of time for the students to feel comfortable with the Fellows.

Section 9: Cooperating Teachers Additional Comments and Suggestions

Additional teacher feedback on GK-12 Fellows 2006

- The GK-12 experience has been great for both the students and me. The Fellow has added a great deal to the curriculum as well as included new aspects of science and engineering. I have been fortunate to have a GK-12 Fellow who not only enjoys talking and teaching about the many aspects of engineering and sensors, but someone who also cares about the students.
- Modules that we have focused on include a general introduction to sensors, human and biological. A great deal of time was spent on liquid nitrogen and its many uses. The Fellow added a lot to the Global Warming/ Pollution Unit that I teach with some great real world examples and explanations. A module on electricity was conducted during the winter; during this time students tested fruits and vegetables for their potential current. The end of the year has focused on bridge design and construction using toothpicks. Many of the modules that we have done this year have enabled us to take field trips to the Penobscot Narrows Bridge as well as to the University of Maine. The Fellow has also become very involved with the students. He helped me start a climbing wall group that meets once a week to use the schools climbing wall. He has also been joining our track program and assisting students with the fundamentals of sprinting. The Fellow has even attended field trips that have been unrelated to his GK-12 Fellowship. I feel that the reason I was able to have such a successful year was because the Fellow and I met throughout the summer to plan the upcoming school year. I shared the curriculum with him and together we decided what we wanted to do and when we wanted to implement the modules. Communication between he and I has been the key all along and encourage future RET's and GK-12 to plan time to meet and get to know each other in the summer.
- The year has been extremely rewarding and working with the Fellow was great. First he is a natural at working with the kids and prepared lessons and spoke at a level that was perfect for their understanding. I am not sure that happens with all Fellows but this Fellow was exceptional.
- Something I might suggest would be have some funding to get the students that work with the Fellows to the University for a tour of the facilities. I had great intentions of doing this but quite frankly the funding was not there for the busses. Maybe the program could split the cost or help out.
- I would say overall the experience has been successful for the following reasons. 1. The Fellow and I arranged a simple and consistent schedule that involved him coming in to my class and teaching all five of my classes at least once per week throughout the year. 2. Over the course of the year the students looked forward to the Fellow coming in to class. 3. The lessons and activities that the Fellow engaged the students in were well connected to my curriculum and reinforced many of the concepts that I was teaching throughout the year. His deep content knowledge and expertise helped students to expand their understanding of the concepts that I was teaching. The Fellow often drew on his engineering background and used "real life" examples of scientific concepts in action. 4. He was a valuable resource for student during the planning and carrying out the Invention Convention project.
- Module involving concepts of magnetism, geomagnetism, and a student led activity focused on the creation of compasses and the tracing of magnetic lines.
- Module involving phases of matter (liquid, solid, gas) and phase changes. Excellent and dramatic demonstrations involving liquid nitrogen and solid CO₂.
- Module involving the "creation of comets"
- Some areas for growth involving the program are: 1. More opportunities for the students to have contact with GK-12 Fellow outside of the classroom (online blog or first class account where students could ask the Fellow questions involving scientific concepts being discussed in class) (online assignments that could be emailed to the Fellow that could be graded and results could be emailed back to students)

Section 10: Supervising Faculty Responses Post-program Survey

Faculty Feedback on Fellows GK-12 2006

A survey of Fellows' supervising faculty members was conducted to determine the perceptions of these individuals about the GK-12 program and its impact of their advisees. A total of five complete responses were returned. In general, faculty members were positive about the value of the program overall and to their graduate advisees. When asked to rate the overall value of the Fellowship, all responding faculty members said it was *Good* or *Very good*. They mentioned teaching experience and financial support as the two most positive contributions of the program for their advisees. All responding faculty identified the substantial time demands of the GK-12 program as a drawback, but felt it was a fair amount of work in return for the stipend. Responding faculty members identified communication as a significant problem. Two faculty members indicated the survey was the first communication they had received from the program this year. Several respondents suggested program staff initiate a regular form of communication to keep supervising faculty abreast of program news and developments.

Responses from Supervising Faculty Members, May 2006

Describe any positive impacts of the GK-12 program for your student(s) (collectively if you have more than one.)

- The financial aid provided is very helpful to his graduate studies here. Now he has one short paper accepted for publish by an IEEE international workshop.
- The teaching requirements force the student to take a step back and consider science or engineering problems from a much broader perspective. In order to teach concepts to K12 students, the Fellow must himself have a good vertical understanding of the subject. This type of contemplation has value for the Fellow at many levels.
- Positive peer-group effects for students - interaction with a diverse set of students and faculty from University of Maine as well as the staff and students at the local high school
- Provides teaching experience
- Graduate student was enthused about the program and with working with young students. I think it built her confidence in her own skills and expertise.
- Good teaching experience, reasonable workload.

Describe any negative impacts of being a GK-12 Fellow for your students (again, collectively if applicable.)

- NONE
- Time burden of teaching and other Fellow responsibilities can detract from academic and research responsibilities.
- None.
- Considerable drain on time in accomplishing her thesis work.
- The program has great time demands.

How would you rate the value of this Fellowship compared to other opportunities for graduate students? Why did you assign this rating?

- Good: Good funding level, reasonable workload expectations.
- Very Good: The program provides a unique experience to master's students and facilitates strong relationships among the university and local schools.
- Good: Overall the benefits were very positive compared to the drawbacks.

What other impacts have you seen as a result of this program? (e.g. For the University? For the state of Maine? For scientific education? For higher education? For your discipline?)

- The impacts are many:
 - expanded science opportunities for the K-12 students
 - fresh program ideas for the K-12 faculty
 - an improved pipeline between the university and the K-12 schools
 - the potential to draw more students into science and engineering disciplines (hopefully at UMaine!)
 - a potentially stable source of funding for the Fellow.
- For the University - positive role helping local schools and perhaps recruiting students.
For Higher Education - rewarding innovative faculty at local schools

- As a young faculty member here, I also gain significant help for having a graduate student working with me.
- Didn't pay too much attention to it. It was a source of graduate funding for a student who seemed pleased with the tasks she was being requested to perform. Will it help attract other students into our discipline? Hard to say at this point.
- None yet.

Describe the quality of communication between the GK-12 program and yourself: What about this communication made you rate it that way?

- Poor: My only communication with the program was through informal comments by my graduate student.
- Poor: This [survey] is my first contact with the program.
- I cannot rate this. There has been no communication until now.
- Good. The only reason it is not a "Very Good" is that it is not clear to me what programmatic expectations there are for the student. This may represent a communication problem between the Fellow and the faculty advisor, not a program problem.

What would improve this communication?

- A briefing at the beginning of the semester for the faculty whose advisees were to be engaged in the program. I happened to be present at such a briefing at the very end of the semester.
- Maybe a monthly or quarterly e-mail update on program progress.

Section 11: Middle School Student Responses Post-program Survey

Fellows' classes were surveyed in May of 2006 to determine the impact of the GK-12 program on students' interest in STEM, and future aspirations to study STEM at the college level. A total of 173 middle school students completed the questionnaire. In general, students' responses were positive with regards to the Fellows' presence in the classroom.

The responding students were enrolled in sixth through eighth grade, with a handful of respondents enrolled in other grades. Most respondents (70%) indicated they planned to attend college, and 19% indicated they intended to pursue an advanced degree. When asked whether they would like to study STEM in college, 41% indicated they would, 28% would not, and 30% were not sure. Interestingly, over 85% of these respondents expected to do *Well* or *Very well* in the STEM courses they were enrolled in. Program staff may want to consider this gap between perceived ability to perform in STEM courses and students' interest in taking them in the future. Part of the answer may lie in participants' feelings about STEM courses. Only 28% of responding students said STEM courses were their *favorites*, while 55% said they were *OK*, *not my favorite*, and 17% expressed a general dislike of STEM courses. Program staff may want to provide specific professional development to Fellows to help them counter these students' perceptions.

Students were very positive about the degree of impact the Fellows had on them personally. Approximately 60% of responding students indicated they became more confident in their STEM class because of the GK-12 Fellow while only 1.2 % suggested they were *less* confident. Another 55% said they liked the class more because of the GK-12 Fellow, while only 7% said they liked the class *less*.

Middle School Student Responses Post-program Survey

GK-12 Sensors! Middle School Student Survey Summary of Results May 2006

		N	Percent
Which year of school are you in now?	6th grade	19	11.0%
	7th grade	50	28.9%
	8th grade	101	58.4%
	9th grade	2	1.2%
	Another grade	1	.6%
How far do you think you will go in school?	Probably will not finish high school	2	1.2%
	Get a high school diploma	30	17.3%
	Graduate from college	88	50.9%
	Go on to more education after college, such as medical school	33	19.1%
	Do not know	19	11.0%
Would you like to study more science and mathematics after you get out of high school?	Yes, probably	71	41.0%
	No, probably not	48	27.7%
	Do not know	52	30.1%
How well do you usually do in mathematics and science in school?	Very well	37	21.4%
	Well	111	64.2%
	Not very well	13	7.5%
	Not well at all	1	.6%
	Varies a lot	10	5.8%
In general, do you like mathematics and science courses?	Yes, a lot	48	27.7%
	They are OK, not usually my favorites	95	54.9%
	Do not usually like them	22	12.7%
	Never like them	6	3.5%
Did the university students in this class help you learn the subject you were taking?	Very helpful	76	44.2%
	Yes, a little	74	43.0%
	No	7	4.1%
	I do not know	14	8.1%
Do you feel more confident about the subject because of the class?	I always was very confident. I did not change	29	16.8%
	I got a lot more confident	30	17.3%
	I got a little more confident	75	43.4%
	I got a little less confident	0	.0%
	I got a lot less confident	2	1.2%
	I never was confident. I did not change	2	1.2%
	I do not know	32	18.5%
Do you like the subject in this class more, or less, after you took the class?	I always liked this subject a lot. I did not change	28	16.2%
	I liked it a lot more now	36	20.8%
	I liked it a little more now	62	35.8%
	I liked it a little less now	4	2.3%
	I liked it a lot less now	5	2.9%
	I never liked it much. I did not change	14	8.1%
	I do not know	22	12.7%

Section 12: High School Student Responses Post-program Survey

A survey similar to the one described in the preceding section was given to high school students enrolled in STEM courses taught by GK-12 Fellows. A total of 158 high school students returned the questionnaire. The pattern of results on this survey is strikingly similar to those on the middle school survey. The high school students exhibited similar levels of interest in attending college. Slightly over 80% of respondents indicated they planned to complete at least 2 years of college, and approximately 75% intended to complete at least a 4-year degree. Encouragingly, almost 30% of responding students said they wanted to complete an advanced degree. Also encouraging was the proportion (44%) of students interested in studying STEM as their major in college. Both of these sets of numbers were up slightly from the proportions found in the middle school survey. Paradoxically, when asked if STEM courses were their favorites in school, only 29% of respondents indicated they were.

Similar to the middle school students, the high school respondents were very positive about the presence of the GK-12 Fellows in their classes. A majority of students (89%) said the Fellows were *Quite helpful* or *Very helpful* in helping them learn the material for their STEM class. Only 7% of responding students indicated the Fellows were *Not helpful* in this respect. This same pattern was also true when students were asked about how the Fellows' presence impacted their confidence in learning STEM. On this question, 62% of responding students indicated their confidence had increased because of the Fellow, while only three students (1.8%) said their confidence had *decreased*.

The final two questions on the high school survey asked students to rate the degree to which their interest in their specific class and in STEM had changed as a result of the GK-12 Fellow working with their teacher. Over half of all responding students (53%) felt they liked

their class more because of the Fellow, 26% already liked the class a lot, and 14% never liked the class. Only 6% of responding students suggested they liked the class *Less* because of the GK-12 Fellow. When asked to comment on how the Fellow had impacted their interest in STEM in general, most students (76%) were more interested in STEM because of the Fellow. This includes 27% of responding students who indicated they were *always interested in getting more STEM*.

In sum, students – whether middle or high school – were positive about the presence of the GK-12 Fellows in their classes. They indicated these graduate students had increased their knowledge in their classes, increased their interest in their classes, and made them more likely to study STEM in the future.

High School Student Responses Post-program Survey

GK-12 Sensors! High School Student Survey Summary of Results, May 2006

		N	Percent
Which year of high school are you in now?	First Year	107	67.7%
	Sophomore Year	5	3.2%
	Junior Year	23	14.6%
	Senior Year	23	14.6%
	Other	0	.0%
How far do you think you will go in school?	Probably will not finish high school	2	1.2%
	High school diploma	11	6.5%
	Trade or vocational school	4	2.4%
	Some college, but no degree	2	1.2%
	Get a 2-year degree or associate degree	12	7.1%
	Get a 4-year degree or bachelor degree	77	45.8%
	Master degree, Ph.D. degree, professional degree, or similar	48	28.6%
	Other	3	1.8%
If you go on to any kind of training, school, or college after high school, what do you plan to study?	Do not know	9	5.4%
	Mostly subjects in the mathematics and/or science area	70	44.0%
	Some mathematics and/or science, but it will not be my major	59	37.1%
How well do you generally do in mathematics and science courses?	As little mathematics or science as I can	30	18.9%
	Very well	45	26.9%
	Reasonably well	90	53.9%
	Not very well	21	12.6%
	Not well at all	2	1.2%
In general, do you like mathematics and science courses?	Varies a lot	9	5.4%
	They are usually my favorites	47	28.5%
	They are OK, not usually my favorites	87	52.7%
	Do not usually like them	20	12.1%
How useful was having these university students in this class in helping you learn the subject you were taking?	Never like them	11	6.7%
	Very helpful	60	36.4%
	Quite helpful	87	52.7%
	Not helpful	12	7.3%
Did having these University students working in your class change your confidence about doing the subject you were taking in this class?	Do not know	6	3.6%
	I always had a lot of confidence in my ability in this area,	43	25.7%
	I got a lot more confident	24	14.4%
	I got a little more confident	79	47.3%
	I got a little less confident	2	1.2%
	I got a lot less confident	1	.6%

	I never had much confidence in this area, and it did not change	18	10.8%
Did having these University students working in your class change how much you liked or didn't like the class.	I always liked this subject a lot, and it did not change	43	26.2%
	I liked it a lot more because of the University students	27	16.5%
	I liked it a little more	60	36.6%
	I liked it a little less	8	4.9%
	I liked it a lot less	2	1.2%
	I never liked it much, and it did not change	24	14.6%
Did having the University students in your class change your interest in getting more education in science, technology, and mathematics subjects after high school?	I was always interested in getting more STEM	44	26.8%
	I am a lot more interested because of the University student	15	9.1%
	I am a little more interested	65	39.6%
	I am a little less interested	6	3.7%
	I am a lot less interested	2	1.2%
	I never was interested, and it did not change	32	19.5%

Section 13: Conclusion

The GK-12 program has been successful in meeting its goal of bringing graduate Fellows into public school classrooms to encourage students to study Science, Technology, Engineering and Mathematics. These Fellows have made a measurable impact on students' interest and aspirations to further their STEM education in the future. Fellows have also impacted their cooperating teachers by providing instructional modules that have enhanced these teachers' STEM instruction. Finally, Fellows have reported improved skills in communication, presentation and teaching.

These accomplishments are impressive, and should be kept in mind when considering the areas of improvement identified by program participants. GK-12 staff should consider the constructive feedback provided by respondents to the evaluation activities outlined in this report. In particular, the issue of communication should be examined carefully. All project participants identified this as the area most in need of improvement. A list of specific recommendations to improve this issue appears in the following section.

In addition to communication, the Fellows may need additional guidance and feedback about their teaching activities. This is especially true for new Fellows. There are several specific ideas listed in the next section, but the core need identified is the creation of some formal process to provide feedback about modules, curriculum and instruction. As described elsewhere in this report, the establishment of such a process would facilitate other program needs simultaneously. Such a forum would improve communication, publicity and possibly lead to increased sustainability for the GK-12 program.

Recommendations:

Based on the feedback from a variety of sources, the following recommendations are suggested for careful review by program staff:

- Establish a regular form of communication from the PI's to Fellows, teachers and cooperating faculty (in addition to the one listed below).
- Create a regular communication (newsletter, memo, etc.) and include upcoming events and requests as far in advance as possible. This might be combined with a schedule of activities required from the Fellows and posted to a common forum accessible to all program participants (e.g., a listserve).
- Seek feedback from Fellows as to why they felt the impact of the program on their teaching skills was relatively less in the second semester, and why some Fellows felt their teaching skills had declined. Based on Fellows' comments, design program changes to address the need for additional professional development related to teaching skills, especially in the spring semester.
- Develop a rubric to evaluate the quality, appropriateness and feasibility of Fellows' modules.
- Have Fellows meet regularly throughout the academic year to discuss modules, instruction and their own research. These meetings should be conducted without program staff, except by invitation.
- Bring together selected high school science teachers and university teaching faculty several times a year to review Fellows' work, provide feedback for improvement, and identify ways to sustain this project beyond NSF funding.
- Pair teachers and Fellows much sooner and provide multiple, structured opportunities for them to get acquainted and design a work plan together.
- Create a more cohesive plan for the inclusion of Sensors into the STEM curriculum.
- Identify benchmark modules would assist Fellows in the creation and design of new units of instruction.
- Provide specific professional development to Fellows to help them counter some students' perceptions that STEM courses are not interesting.
- Establish a more streamlined process for Fellows to obtain technology to bring into the classroom.
- Program staff should consider what sources (faculty, teachers, peers, others?) of support and encouragement they expect for Fellows and adjust program expectations and professional development accordingly.
- Educate Fellows on the benefits and opportunities of becoming a university faculty member.

Section 14: Evaluation Instruments

Dear Colleague:

Now that you have been working this academic year as part of the GK-12 Sensors! and RET programs, we would like you to answer some questions about your experience as a teacher participating in the program. This will help the Principal and Co-Principal Investigators to understand better the impacts of the program on teachers and others involved in the program. Please answer the following questions honestly. Your answers will be kept confidential. We ask for your name only so we can tell who has responded. Your name will not be used in the evaluator's report to the Principal and Co-Principal Investigators, and results will be reported in the aggregate and without information that would identify a teacher, school, GK-12 Fellow, or school student. It should take about 20 minutes to complete this questionnaire.

There is very little or no risk to you from participation in this evaluation research, but there will be benefits for all in terms of program improvements. Of course, you may choose not to answer any questions in the survey. If you have any questions about this survey, please contact the evaluator, Research Associate Brian Doore, of the Center for Research and Evaluation (CRE), College of Education and Human Development, at The University of Maine (581-2370 or email brian.doore@umit.maine.edu).

Thank you for your cooperation.

1. Have you been able to incorporate information or techniques you learned last summer into the classes you are teaching this year?
 1. Yes, a lot
 2. Yes, some
 3. Yes, A little
 4. No, haven't been able to
 5. Not this semester, but plan to next semester
 6. Probably won't be able to (Please briefly note why not in the comment box below.

2. How much time and effort do you think it took to mentor the graduate Fellow(s) you work with to improve their teaching skills this year? (Please circle the number of, or put an X beside, one answer)
 1. Considerable time and effort
 2. Little time and effort
 3. No time and effort

3. To what extent did your experience with the RET/GK-12 Sensors projects this year improve your own teaching effectiveness? (Please circle the number of one answer)
 1. Greatly improve my teaching effectiveness
 2. Somewhat improve my teaching effectiveness
 3. No change in my teaching effectiveness
 4. Decline in my teaching effectiveness

4. To what extent do you think participation in the RET/GK-12 programs this year helped you align (or maintain the alignment of) your curriculum with state, local, or national standards? (Please circle/X the number of one answer)

1. Will help significantly
2. Will help somewhat
3. Will help only a little
4. Will not help at all

5. To what extent do you expect participation in the RET/GK-12 programs this year to help you integrate (or further integrate) technology into your teaching? (Please circle/X the number of one answer)

1. Will help significantly
2. Will help somewhat
3. Will help only a little
4. Will not help at all

6. In general, what do you think the impact of the GK-12 teaching Fellows was on the students in your classes this year? (Please circle/X the number of one answer)

1. Will greatly improve students' motivation to study science, technology, engineering and math
2. Will somewhat improve their motivation to study science, technology, engineering and math
3. Will have little impact on their motivation to study science, technology, engineering and math
4. Will reduce their motivation to study science, technology, engineering and math

7. Overall, how would you characterize your experience with the RET/GK-12 Sensors programs this year? (Please circle/X the number of one answer)

1. Very rewarding
2. Somewhat rewarding
3. Neither rewarding nor disappointing
4. Somewhat disappointing
5. Very disappointing

8. What recommendations do you have for improving the GK-12 Sensors programs?

The University of Maine
GK-12 Sensors! Graduate Teaching Fellows Year-end Questionnaire
Spring 2006

As part of the program evaluation, we ask that you complete this questionnaire about your background and your experiences with the GK-12 Sensors! program. This evaluation questionnaire is being distributed by the Center for Research and Evaluation (CRE) of the College of Education and Human Development at The University of Maine.

Completing this questionnaire is voluntary. You may skip any question you wish, or not fill it out at all. Individual responses will remain confidential. Results will be reported in the aggregate and will not disclose individual Fellows' identities or those of participating teachers or schools.

If you decide to answer these questions, and of course we hope you will, please either email it back as an attachment or seal your completed questionnaire in an envelope and mail it back to the evaluator at the address shown at the end of the questionnaire. If you have questions about the evaluation or how the resulting data will be used, please contact the evaluator, Research Associate Brian Doore (telephone 581-2370, or brian.doore@umit.maine.edu).

This is a Microsoft Word document. If you plan to use it to enter your responses and send back as an attachment to an email, please put an X in front of the number of your answers where there is an answer list provided, and type in the spaces provided if the question asks for a narrative response.

1. What is the highest level graduate degree you are currently pursuing? *(Please circle the number of, or put an X beside, one answer)*

- 1 M.S.
- 2 Ph.D.

2. What will be the title of your graduate degree? *(Please write your answer in the space below)*

3. Did getting a GK-12 Fellowship influence your decision to enroll in graduate school at UMaine? *(Please circle/X the number of one answer)*

- 1 Yes
- 2 No

4. If you answered yes to question 3, please briefly explain how getting the GK-12 Fellowship affected your decision. *(If this question does not apply to you, leave it blank and go to the next question).*

5. When you enrolled in graduate school at the University of Maine were you planning on getting a Ph.D.? *(Circle/X the number of one answer)*

- 1 Yes, I enrolled in a Ph.D. program
- 2 Yes, I enrolled in a M.S. program and plan to continue to a Ph.D.
- 3 Perhaps. I am enrolled in a M.S. program and may continue to a Ph.D. program
- 4 No, I plan to stop with a M.S. degree
- 5 Not sure—I will wait until after the M.S. degree to decide

6. Please indicate how much, if at all, your experience as a GK-12 Fellow has affected your interest in pursuing a Ph.D. *(Circle/X the number of one answer)*

- 1 I enrolled with the intention of getting a Ph.D., and my intention hasn't changed
- 2 Much more likely to get a Ph.D.
- 3 Somewhat more likely
- 4 Somewhat less likely
- 5 Much less likely
- 6 I intended to stop at a M.S. degree, and my intention hasn't changed

7. Before becoming a GK-12 Fellow, had you ever considered becoming a middle or high school teacher? *(Circle/X the number of one answer)*

- 1 Yes
- 2 No

8. How has your experience as a GK-12 Fellow affected your interest in teaching at the middle or high school level? *(Circle/X the number of one answer)*

- 1 I was sure that I was going to teach, and that hasn't changed
- 2 Much more interested
- 3 Somewhat more interested
- 4 Somewhat less interested
- 5 Much less interested
- 6 I never expected to teach, and that hasn't changed

9. If you are interested in teaching, what subjects would you like to teach? *(If this question does not apply to you, leave it blank and go on to the next question.)*

10. Are you currently working toward obtaining a teaching certificate? *(Circle/X the number of one answer)*

- 1 Already have a teaching certificate
- 2 Yes
- 3 No, but plan to start soon
- 4 No, not planning to get one

11. Do you plan to teach at the college/university level? *(Circle/X the number of one answer)*

- 1 Yes
- 2 No
- 3 Not sure

12. Please list the titles of the high school and/or middle school courses in which you worked over the past current academic year. Please list all your placements in the table below and check the boxes for the semester and grade level information.

Course title If you taught multiple sections or classes with the same title, indicate in parentheses after the course title the number of sections or times the class was offered.	Semester		Grade level	
	Fall 2005	Spring 2006	Middle school	High school
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

13. To what extent has your experience as a GK-12 Fellow improved your teaching skills?

(Circle/X the number of one answer)

- 1 They were very good before, and they haven't changed
- 2 Greatly improved
- 3 Somewhat improved
- 4 Declined
- 5 They weren't very good before, and they haven't changed

14. Do you think being a GK-12 Fellow has helped you make better professional presentations?

(Circle/X the number of one answer)

- 1 Yes
- 2 No
- 3 Not sure

15. Has being a GK-12 Fellow improved your communications skills? *(Circle/X the number of one answer)*

- 1 Yes
- 2 No
- 3 Not sure

16. Has your experience this year as a GK-12 Fellow affected your familiarity with active/cooperative learning techniques? *(Circle/X the number of one answer)*

- 1 I was quite familiar with them before, and that hasn't changed
- 2 Much more familiar
- 3 Somewhat more familiar
- 4 I don't know what is meant by "active/cooperative learning techniques"

17. If you used active/cooperative learning techniques that you found to be particularly useful, please note them briefly in the space below. *(If this question does not apply to you, leave it blank and go on to the next question.)*

18. List below up to three teaching modules you substantially used, developed, or modified as a GK-12 Fellow this academic year. *(If this question does not apply to you, leave it blank and go on to the next question.)*

19. In general, how would you characterize the impact your involvement as a GK-12 Fellow on the middle and high school students in your classes? *(Circle/X the number of one answer)*

- 1 Greatly improved their motivation to study science, technology engineering, and mathematics (STEM)
- 2 Somewhat improved their motivation to study STEM
- 3 Had little impact on their motivation to study STEM
- 4 Somewhat reduced their motivation to study STEM
- 5 Greatly reduced their motivation to study STEM

20. If you think that your involvement improved the motivation of at least some students to study STEM, please briefly note in the space below specific examples or experiences you had that led you to that conclusion. *(If this question does not apply to you, leave it blank and go on to the next question.)*

21. If you think that your involvement did not improve the motivation of some students to study STEM, or it reduced their motivation, please explain why in the space below. *(If this question does not apply to you, leave it blank and go on to the next question.)*

22. Has being a GK-12 Fellow enhanced your thesis research? *(Circle/X the number of one answer)*

- 1 Yes
- 2 No
- 3 Not sure

23. If you answered yes to question 22, please explain how in the space below. *(If this question does not apply to you, leave it blank and go on to the next question.)*

24. If you answered no to question 22, please explain why not. *(If this question does not apply to you, leave it blank and go on to the next question.)*

25. Please **rank** from **most helpful (1)** to **least helpful (5)** each of the following groups of participants in the GK-12 Sensors program in terms of the extent to which they helped you improve your teaching skills. *(Put a number from 1 (most helpful) to 5 (least helpful) in the blank in front of each item.)*

- University faculty members
- High school and/or middle school teachers
- Other GK-12 Fellows
- Literature and textbooks on instructional techniques
- High school and/or middle school students you encountered

Any other? Please specify: _____

26. Please rate how your experience this year as a GK-12 Fellow affected your interest in working (including, but not limited to teaching) in Maine after completing your graduate degree.

(Circle/X the number of one answer)

- 1 Had always planned to work in Maine, and that hasn't changed
- 2 Much more interested
- 3 Somewhat more interested
- 4 No change
- 5 Somewhat less interested
- 6 Much less interested
- 7 Never planned to work in Maine, and that hasn't changed

27. Overall, my experience as a GK-12 Fellow has been: *(Circle/X the number of one answer)*
- 1 Very rewarding
 - 2 Somewhat rewarding
 - 3 Neither rewarding nor disappointing
 - 4 Somewhat disappointing
 - 5 Very disappointing

28. What surprised you most about the GK-12 program and your teaching experience this past year? Please briefly describe in the space below.

27. What suggestions do you have for improving the program for future GK-12 Fellows?
Please write your recommendations in the space below.

Thank you for your time and your thoughtful answers.

If you have completed this questionnaire on your computer using a word-processing program, please return it as an attachment to an email addressed to brian.doore@umit.maine.edu . If you decide to print it out and mail it conventionally, please send it to Brian Doore, Center for Research and Evaluation, 5766 Shibles Hall, University of Maine, Orono, Maine 04469-5766.

The University of Maine
RET/GK-12 Sensors!
Questionnaire for Teachers—Fall 2005

Dear Colleague:

Now that you have been working this academic year as part of the GK-12 Sensors! and RET programs, we would like you to answer some questions about your experience as a teacher participating in the program. This will help the Principal and Co-Principal Investigators to understand better the impacts of the program on teachers and others involved in the program. Please answer the following questions honestly. Your answers will be kept confidential. We ask for your name only so we can tell who has responded. Your name will not be used in the evaluator's report to the Principal and Co-Principal Investigators, and results will be reported in the aggregate and without information that would identify a teacher, school, GK-12 Fellow, or school student. It should take about 20 minutes to complete this questionnaire.

There is very little or no risk to you from participation in this evaluation research, but there will be benefits for all in terms of program improvements. Of course, you may choose not to answer any questions in the survey. If you have any questions about this survey, please contact the evaluator, Research Associate Suzanne Hart, of the Center for Research and Evaluation (CRE), College of Education and Human Development, at The University of Maine (581-2400 or email shart@maine.edu).

Thank you for your cooperation.

Your Name:

The school(s) in which you had a GK-12 Fellow placed with you this semester (Fall 2005):

We would like some background information about you

Your undergraduate degree major subject:

Undergraduate degree year:

Undergraduate degree college/university:

Graduate degree major subject(s):

Graduate degree year(s):

Graduate degree school(s):

Years of teaching experience at this school:

Total years of teaching experience:

For how many semesters, including this one, have you worked with a GK-12 Fellow in at least one of your courses? *(Please enter the number of semesters here: _____)*

Please list the titles of the high school and/or middle school courses you are teaching this semester (Fall 2005) in which you work with GK-12 Sensors! Fellows, check the boxes for the grade level information, and indicate how many students are in each course.

Course titles If you teach multiple sections or courses with the same title, please list each section or course separately (you can use ditto marks) and indicate the grade level and number of students in each of the sections or classes.	Grade level		Number of students
	Middle school	High school	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	

The next questions are about your experiences with the **summer program in 2005**

	Not at all	Not very	Somewhat	Quite	Very
The course <i>Introduction to Sensors</i>					
1. How useful for your teaching was the course <i>Introduction to Sensors</i> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. How useful to your own professional development was the course <i>Introduction to Sensors</i> to you personally?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. How effectively was the course <i>Introduction to Sensors</i> presented?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The research project					
4. How useful for your teaching was your participation in a <i>research project</i> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. How useful for your own professional development was your participation in a <i>research project</i> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Your mentor	Not at all	Not very	Somewhat	Quite	Very
6. How important was your contribution to the <i>research project</i> you worked on?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. How helpful for your teaching was your <i>research project mentor</i> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. How helpful for your own professional development was your <i>research project mentor</i> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The presentations					
9. How useful for your teaching was preparing and delivering your <i>presentation</i> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. How useful for your own professional development was preparing and delivering your <i>presentation</i> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. How useful for your teaching was it to hear the <i>presentations</i> of others in the program?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. How useful for your own professional development was it to hear the <i>presentations</i> of others?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

13. Have you been able to incorporate information or techniques you learned last summer into the classes you are teaching this fall?

1. Yes, a lot
2. Yes, some
3. Yes, A little
4. No, haven't been able to
5. Not this semester, but plan to next semester
6. Probably won't be able to (*Please briefly note why not:* _____)

The next questions are about your experiences with the RET/GK-12 Sensors projects this semester (Fall 2005)

14. How much time and effort do you think it will take to mentor the graduate Fellow(s) you work with to improve their teaching skills this semester? (*Please circle the number of, or put an X beside, one answer*)

1. Considerable time and effort
2. Little time and effort
3. No time and effort

15. To what extent do you expect your experience with the RET/GK-12 Sensors projects this semester year improve your own teaching effectiveness? (*Please circle the number of one answer*)

1. Greatly improve my teaching effectiveness
2. Somewhat improve my teaching effectiveness
3. No change in my teaching effectiveness
4. Decline in my teaching effectiveness

16. To what extent do you think participation in the RET/GK-12 programs this semester will help you align (or maintain the alignment of) your curriculum with state, local, or national standards? *(Please circle/X the number of one answer)*

1. Will help significantly
2. Will help somewhat
3. Will help only a little
4. Will not help at all

17. To what extent do you expect participation in the RET/GK-12 programs this semester to help you integrate (or further integrate) technology into your teaching? *(Please circle/X the number of one answer)*

1. Will help significantly
2. Will help somewhat
3. Will help only a little
4. Will not help at all

18. In general, what do you expect will be the impact of the GK-12 teaching Fellows on the students in your classes this semester? *(Please circle/X the number of one answer)*

1. Will greatly improve students' motivation to study science, technology, engineering and math
2. Will somewhat improve their motivation to study science, technology, engineering and math
3. Will have little impact on their motivation to study science, technology, engineering and math
4. Will reduce their motivation to study science, technology, engineering and math

19. Overall, how would you characterize your experience with the RET/GK-12 Sensors programs this semester so far? *(Please circle/X the number of one answer)*

1. Very rewarding
2. Somewhat rewarding
3. Neither rewarding nor disappointing
4. Somewhat disappointing
5. Very disappointing

And finally...

20. What recommendations do you have for improving the RET and/or GK-12 Sensors programs?

Thank you for your time and your thoughtful answers.

If you have completed this questionnaire on your computer using a word-processing program, please return it as an attachment to an email addressed to shart@maine.edu . If you have completed a printed version, please mail it to Suzanne Hart, Center for Research and Evaluation, 5766 Shibles Hall, University of Maine, Orono, Maine 04469-5766.

GK-12 Sensors! Focus Group:

Agenda:

- 1) Overview: purpose of evaluation, increased attention from NSF, confidentiality of answers – evaluator’s first duty is to the participants’ privacy.
- 2) Permission to tape record
- 3) Section 1) “The Fellowship of the Sensors”
 - a. What worked well with the process of getting into the program? What didn’t?
 - b. Talk about the administrative aspects of the program:
 - i. Program Director
 - ii. Principal Investigators
 - iii. Support Staff
 - c. Reporting requirements of the program (journals, reports, submission of lessons & activities)
 - i. How would you describe these?
 - ii. What could have been improved?
- 4) Section 2) “The Two Roles”
 - a. Talk about the dual responsibilities of the two roles: teaching and research.
 - i. How did you balance your time? What do you wish you had done differently?
 - ii. What did the schedule of your year look like? Was it consistent? Were there patterns of activity?
- 5) Section 3) School Experiences: What were the cooperating teachers like?
- 6) Challenges, benefits, things to improve?
- 7) Other: