The KIDS Program:
TEACHING THE SCIENCE IN EVERYDAY LIFE

A Project To Develop Inquiry-Based Science and Engineering Education In Arkansas Middle Schools

Institution: University of Arkansas
PI: Art Hobson (Physics);
Co-PIs: Gay Stewart (Physics), Denise Airola (Middle School Science Coordinator), Ronna Turner (Evaluation/testing), Greg Salamo (Physics), Caroline Beller (College of Education), Lynne Hehr (K-12 Outreach), Ken Vickers, (Microelectronics & Photonics Graduate Program), Sarah Faitak (K-12 Outreach)
Participants: 9 graduate fellows per year and 9 to 12 K-12 teachers per year
Target Audience: Middle School (6th and 7th grades)

The National Science Foundation has awarded a grant that, with matching funds from the University of Arkansas, provides $2.75 million to develop inquiry-based science and engineering education in Arkansas middle schools over a six-year period. **KIDS** (**K**-12, **I D**o **S**cience) is an interdisciplinary program focused on electronics and optics that will initiate a new effort to teach mathematics, science, and technology in middle schools in Arkansas. It is based on the "learning through doing" paradigm--the premise that students who explore their own curiosity, reach for their own ideas, and engage in their own experiments, are experiencing inquiry and innovation and are *learning* science. It specifically addresses the integrated teaching of mathematics, science and technology in the context of everyday life. It is presented to middle school teachers and their students by practicing scientists and engineers. Graduate students, guided by their major research professor and trained to work in partnership with middle school teachers, bring an approach to the classroom that emphasizes student learning through their "wonder" of how things work. Graduate students will partner with middle school teachers to teach science, mathematics and engineering while transmitting their own passion to solve the mysteries of nature and to use that understanding to improve human well-being. Using a theme of ***optic and electronic concepts in everyday life***, students will identify an interesting question or puzzle, propose their own ideas or answers, identify what they perceive is needed to make a feasibility test of their answer, set up experiments to carry out that test, team together to gather data from experiments, analyze data, and evaluate the results.

The outcome of the KIDS program will be middle school teachers who have learned the value of, and developed the skill to implement inquiry-based instruction in mathematics, science, and engineering. Their effort will bring a new generation of middle school students who are self-confident and motivated to learn science, have a thriving curiosity, see a direct connection between learning and everyday phenomena, work successfully in teams, communicate and present their ideas skillfully, and are excited and prepared to further their knowledge and interest in science, mathematics and engineering.

And last, but not least, the KIDS program will begin an effort in Arkansas to develop and graduate fellows into scientists who will begin their careers with a deeper understanding of their science, a greater ability to express it to others, and an abiding passion to engage with and improve K-12 education in their new communities.

Planned Education and Training Activities

For a summary of the schedule, see "Project Schedule" on page 3, below.

The planned KIDS training program begins during the summer with academic advising of the graduate fellow cohort group by Professor Ken Vickers. Professor Vickers is the Director of the microElectronics-Photonics Graduate Program and the Physics FIPSE program, both designed to develop student creative and interpersonal skills in parallel with technical skills. Likewise, the K-12 teachers cohort group will be guided by Co-PI Denise Airola. Denise is the Science Coordinator of the Fayetteville School System and already has a working relationship with Springdale and Winslow

teachers. Although both Ken and Denise will provide continuous guidance to the cohort groups at weekly meetings, they will meet for an intensive discussion of the KIDS program and its interface with fellow and teacher career goals during the first week of the summer training program.

The advising period is followed by a separate workshop for the graduate fellows and for the middle school teachers, which will be held for one week at the start of the summer training program. Co-PI Lynne Hehr, the K-12 Outreach Director for the University of Arkansas, who has many years of experience helping K-12 teachers throughout the state, and Co-PI Denise Airola, who has extensive experience with workshops for K-12 teachers on inquiry based teaching, will both coordinate these workshops. The workshop for the graduate fellows will focus on "teaching" skills and include discussion of state math and science standards, current middle school curricula, the short-comings of the current middle school classroom, and the KIDS approach to strengthening the middle school teachers' science content knowledge and ability to teach through inquiry. During the same week, a similar workshop for middle school teachers will focus on "content" and include discussion, comparison, and demonstration of inquiry based teaching methods, as well as invited speakers from successful programs. (K-12 teachers will receive 6 course credits for the 8-week summer program).

Having introduced and prepared both cohort groups to the KIDS program they will then *join together* to participate in two courses recently designed for pre and in-service (grades 5-12) science teachers through a grant from the Arkansas Department of Higher Education in conjunction with PhysTEC. Each morning for three weeks they will attend an interdisciplinary class taught by the Co-PI, Professor Caroline Beller from the College of Education, during which they will discuss and explore various inquiry-based science-teaching methods. The professional development of science teachers requires learning science content through the perspectives and methods of inquiry, and these perspectives and methods will be the focus of the training activities in the morning class. In the afternoon they take a corresponding inquiry-based physics laboratory course taught by PI Professor Art Hobson and Co-PI Professor Gay Stewart, of the physics department. During this afternoon laboratory session, graduate fellows will be paired with a middle school teacher and work together on selected "known-to-work" inquiry based experiments. They will each have an opportunity to recognize the potential of merging their respective strengths of "science and technology content" and "communication and teaching skills" and to become comfortable and trusting of each other. They will dissect the experiment, discuss the objective, investigate how to implement it into the classroom, and examine "how" and "if" it accomplished the goal. This will allow the graduate fellows and middle school teachers to realize that their goal is not simply to bring inquiry based activities into the classroom but rather to create an inquiry based "mindset", where new inquiry based experiments and activities will become the natural course of learning everyday.

Finally, during the last three weeks of the summer, the fellows will team together with their major professor and their middle school teacher: nine teams in all, at the five participating schools. Each team will then develop <u>two</u> inquiry-based experiments, along with a written description of the corresponding step-by-step laboratory procedure that will be introduced into the 6^{th} or 7^{th} grade curriculum during the academic year. As a result, eighteen experiments will already be in the planning stage at the start of the school year. Under the guidance of the PI Professor Art Hobson and the science advisor Professor Greg Salamo (who will also mentor several graduate fellows), the teams will discuss and evaluate the experiments together, and the needed equipment will also be acquired so that the experiments can be built and tested at the start of the academic year. For the first nine weeks of the school year, the team of fellow, professor, and middle school teacher will meet, construct the planned inquiry based experiments, and develop the skill to implement the first set of experiments into their 6^{th} or 7^{th} grade class. During the same nine-week period, the graduate fellow will attend the middle school class in order to develop both a comfort level as well as intuition about the students in the class. They will also use their extensive knowledge of new digital technologies to help the middle school teacher integrate them into the classroom. In this way, teachers can enhance student projects with new media, including web publishing, digital sounds and pictures, graphs and simulations, and on-line educational resources. During the second nine-week period the first set of built and practiced experiments will be implemented in the classroom. This is repeated during the third nine-week period with development of the next set of experiments and correspondingly implementation during the last nine weeks. At the end of the year, the PI will bring the

entire KIDS staff together to discuss, report, and tune the program for the next year. The resulting report will act as the start of a KIDS program guide to be fully developed by the second year. The same format (although modified via end-of-the-year feedback) will be followed each year but with a new cohort of graduate fellows and middle school teachers.

In addition to the training of graduate fellows and middle school teachers, the proposed program will also provide a training experience for parents and administrators. Knowing that some parents will have difficulty in supporting their children's interest and development of science, math, and technology skills due to their own limited training, we propose to hold a "parent hour" at least one night each month. During this time the graduate fellow and middle school teacher will discuss the science and math skills that their children are learning, so that parents can choose to make an even greater difference. To further provide opportunity to parents they will also creatively design lessons on the web as well as a "live" question and answer web page while keeping parents informed of such activities through newsletters.

Administrative support can be vital to sustaining programs that step outside the "usual" ways of teaching. Although school administrators have welcomed participation in this program, gaining their full understanding and appreciation of inquiry-based science will increase the likelihood of the development of policies that will help create the desired long-term change in culture in science classrooms. To this purpose, graduate fellows will periodically engage participating administrators in a learning experience similar to the students', but with a narration of the elements that make the inquiry-based lesson valuable to the school and how the national and state teaching standards are addressed by the KIDS program.

Summary of Project Schedule

During the 6-week summer session:
- Week 1:
  - 1 day orientation (conducted by Vickers, Airola)
  - 2-day "summer camp" (Vickers, Airola, Faitak)
  - 3-day simultaneous workshops (a) for fellows stressing teaching skill (Airola, Hehr), (b) for K-12 teachers stressing science content (Hehr, Airola)
- Weeks 2, 3:
  - Mornings: Courses in inquiry-based science pedagogy (Stewart, Beller).
  - Afternoons: Courses in inquiry-based science laboratories (Stewart, Hobson)
- Weeks 4-6:
  - Team-based identification of inquiry-based laboratory experiments for middle-school students (Salamo, Hobson).

During the regular school year:
- 1st 9 weeks: Fellows, professors, and K-12 teachers will construct and develop experiments,
- 2nd 9 weeks: Implement the experiments.
  - 3-day chip workshop in which students build and characterize an electronic chip.
- 3rd 9 weeks: Develop remaining experiments following the format of the 1st 9 weeks,
- 4th 9 weeks: Implement the 2nd group of experiments.
  - 3-day laser workshop in which students build and characterize a small He/Ne laser.

Also:
- Monthly parent hours, in which fellows give demonstrations to parents.
- Fellows will show examples to administrators throughout the school year.

Organization and Management

The KIDS management and implementation team is comprised of recognized experts in different areas of the educational community that will participate in, and be impacted by, the tactics contained in this proposal. These different areas include K-12 education and administration, University, K-12 coordinated programs, K-12 science resource material management, K-12 science teacher education,

graduate student research education and development of inquiry based experiments, graduate student soft skill development, management of a distributed organization, and program measurement and evaluation.

Co-PI Denise Airola, the K-12 Science Coordinator for the Fayetteville School System, was chosen by the administrations of the three participating school systems to represent the *K-12 education and administration* perspective on the KIDS management team, a perspective that is needed to develop a strong connection between the graduate fellows and the K-12 teachers. Ms. Airola is in charge of science curriculum development for the Fayetteville School District, has been a teacher herself earlier in her career, and provides the communication link to the school administrations that encourages the enthusiastic adoption of the KIDS program by the three school districts.

The KIDS program has tapped into expertise in *coordinated university K-12 programs and science resource material management* provided by **Co-PI Lynne Hehr**. She is the University of Arkansas Outreach Director for the all Arkansas K-12 school systems, is Director of the UA Center for Mathematics and Science Education, and is also Director of the Arkansas NASA Educator Resource Center. As part of her broad K-12 responsibilities, she manages the Northwest Arkansas Regional Science and Engineering Fair for Jr. High and High School students. She developed the Arkansas AEGIS (Academic Enrichment for the Gifted In Summer) program on campus, and manages the science and engineering demonstration day on the University campus in the spring for K-12 teacher enrichment. Through these multiple activities with our state's K-12 teachers, she has developed "trusting" relationships throughout the state. She will use that existing network to disseminate and implement the inquiry based teaching experiments developed by the KIDS program.

K-12 science teacher education is represented on the management team by **PI Art Hobson, Co-PI Caroline Beller, and Co-PI Gay Stewart**. **Dr. Hobson** is Emeritus Professor of Physics whose research has been focused for the last twenty years on teaching science concepts, including its connections to society and to everyday life. **Dr. Beller** is an Assistant Professor of Education in the College of Education and has extensive experience in inquiry based teaching methods in K-12 education, as well as in the training of the K-12 teachers graduating from our University. **Dr. Stewart** is an Associate Professor of Physics at the University in the research field of Physics Education. Dr. Stewart has led the redefinition of freshman physics education on this campus, has created a Master of Arts in Teaching Physics for graduate students preparing for high school physics education, and is one of the national leaders in the advanced placement physics testing of high school students. Under her leadership, the University of Arkansas has been selected as one of the six Primary Program Institutions in the PhysTEC program.

Co-PI Greg Salamo is the Science Advisor for the KIDS program, and brings his national reputation in photonics and microelectronic research to the graduate fellows' *research education and development of inquiry based experiments*. Dr. Salamo has been selected by the faculty at the University to the rank of University Professor, and is a Fellow of the Optical Society of America. Drawing on his experience in incorporating state-of-the-art research into undergraduate education, Dr. Salamo will organize and lead the mentoring faculty to create fascinating experiments for use by the KIDS program.

Graduate *fellow soft skill development* is the expertise of **Professor Ken Vickers**. Prof. Vickers is currently a Physics/Engineering Research Professor at the University of Arkansas, but was in Engineering Management at Texas Instruments for seventeen years before returning to the University to create and be the Director of the NSF IGERT award winning microelectronics-photonics (microEP) interdisciplinary graduate program. He will use his extensive engineering management experience to guide the core educational and "soft skill" development of the graduate Fellows using the same techniques as in the IGERT program and the Physics FIPSE program. He attributes his strong interest in education to his graduate student experience, when he taught Physical Science for Elementary Teachers for 3 semesters.

Ms. Sarah Faitak had extensive daily operations experience in the commercial health care industry as well as in operational management of a state-wide health research initiative. This operations management resource is available to the KIDS program as part of Ms. Faitak's primary work assignment as the K-12 Outreach Director of the NSF MRSEC Center for Semiconductor Physics in Nanostructures.

Co-PI Ronna Turner will bring her talent and track record of assessment techniques to the KIDS program to implement extensive *program measurement and evaluation* tactics. Dr. Turner is Co-Director of Office of Research, Measurement, and Evaluation (ORME) in the College of Education. ORME is the provider of the State of Arkansas' K-12 student assessment database and software, and is already working closely with Dr. Salamo and Prof. Vickers to provide the graduate student evaluation and assessment for the microEP IGERT award and the Physics department FIPSE award.

This group of experts, along with a to-be-elected graduate Fellow representative and Teacher Representative, will form the Board of Directors of the KIDS program. The Board of Directors is responsible for setting program policy and evaluating and directing the progress toward the goals of the program. PI Professor Art Hobson will chair the Board of Directors and have full responsibility and accountability to the NSF for effective grant administration.

Evaluation Of Progress Toward Goals

We will evaluate the effectiveness of the **KIDS** program along four directions:

- **Increasing the interest of all students in studying science and engineering**, with a specific focus on females, minorities, and students with disabilities.
- **Increasing the use of inquiry-based teaching** methods in K-12 schools for learning about science, math, engineering, and technology with an outcome expectation of
- **Increasing achievement levels** in science, math, engineering, and technology, of K-12 students and,
- **Helping parents contribute** to developing the science, math, and technology career interests and skills of their children.

The evaluation plan includes the obtainment of longitudinal quantitative and qualitative data from the majority of stakeholders including middle school students in both treatment and "control" groups, graduate fellows, participating and non-participating K-12 teachers, and parents.

We expect the evaluation to show significant evidence of changes in interest level, attitude about, and participation in coursework in science, mathematics, and technology for students as a whole as well as for females, minorities, and students with disabilities. If this occurs in combination with scientific evidence of increases in academic interest and performance in science and mathematics, then we will have helped build a foundation from which to improve K-12 math and science education throughout Arkansas. In six years the proposed KIDS project will impact 2000 K-12 students and potentially as many parents, 60 middle school teachers, 60 graduate fellows, 20 to 60 University faculty, and six to ten school systems. In addition, we expect the KIDS program to provide a model of how effective partnerships between middle school educators and practicing scientists and engineers can significantly enhance science education and career interest for students in the most challenged schools. The KIDS project will ultimately have an impact on future policy between the public school, higher education and local communities, statewide.