

Introducing Materials Science and Chemistry to the K-12 Community

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Abstract

We live in a high-technology world where many people do not understand the things they are using, let alone the implications of the technology they are using. It is in the engineering community's best interests to work to improve the technology literacy of society.

The health of science and engineering tomorrow depends on improved mathematics and science preparation and problem solving skills of our students today. It is our belief that part of the problem with K-12 science education is that teachers do not know how to relate the science they are teaching to real world experiences. To deal with that issue, we created a new three-hour course in engineering problem solving specifically designed for education majors. They are shown how to solve real world engineering problems and how to teach such subject matter to their own future students.

Using the theme "Our Material World", the authors integrated concepts involving the physical, mechanical and chemical behavior of materials as a means to teach engineering problem solving skills. Through the use of frequent laboratory exercises, our goal was to "demystify" for these future teachers some of the fundamental ideas of science and engineering and to heighten their interest and skill level in effectively communicating these ideas to K-12 students.

We have also had direct outreach into the K-12 community. As part of the class, our students have put on workshops for in-service teachers in our region, demonstrating the hands-on science skills that they have learned. This helps make a difference in class rooms of current teachers. Our students make presentations using simple experiments in local fourth-grade science classes. This helped have an impact on current teachers, as they observed what could be done. It also helped to have an impact on elementary school children who now have a very different attitude to materials science and engineering. The first author did a presentation at the state science teacher's association meeting to introduce more in-service teachers to what we have done.

Introduction

The health of science and engineering tomorrow depends on improved mathematics and science preparation and problem solving skills of our students today. One cannot expect world-class learning of science, mathematics, and problem solving techniques by students if U.S. teachers lack the confidence, enthusiasm, and knowledge to deliver world-class instruction¹. One way to improve K-12 science education is to improve current knowledge and preparation of the future teachers themselves.

During the 1999-2000 academic year, the authors created and offered to elementary and middle school pre-service teachers a course on engineering problem solving. This course was designed to build the knowledge base and strengthen the confidence of future teachers when working with science, engineering, and mathematics principles using laboratory-based activities as the foundation for learning. This course has subsequently been taught in the springs of 2001, 2002, and 2003.

Louisiana Tech University's undergraduate engineering program has been significantly modified during the past several years. Emphasis has been placed on creating an integrated (college-wide) program for freshmen and sophomores. A key part of this program is a three-course sequence in the freshman year that largely deals with engineering problem solving.

It is our belief that part of the problem with K-12 science education is that teachers do not know how to relate the science they are teaching to real world experiences. To deal with that issue, we incorporated what we have learned in developing our freshman engineering course sequence as a basis to create a new three-hour course in engineering problem solving. This course is specifically designed for education majors. They are shown how to solve real world engineering problems and how to teach such subject matter to their own future students. In this course we model innovative teaching techniques as well as provide mathematics, science, engineering, technological and problem solving experiences for the students.

Our problem-solving course was created through sponsorship of the NASA *Opportunities for Visionary Academics* (NOVA) program. NOVA was created out of a concern for how universities prepare new teachers. Comprising a network of 76 member institutions, NOVA partners are working to produce enhanced scientific literacy for pre-service teachers. This effort is being accomplished through the demonstration of an undergraduate science and mathematics course framework, examples of successful course models, and a mentoring support system for faculty wishing to implement new courses or modify existing courses at their universities. The framework uses interactive learning and integrates science, mathematics and technology as a means of developing a new paradigm for educating pre-service teachers.

Using the theme "Our Material World", the authors sought to integrate concepts and principles involving physical, mechanical and chemical behavior of materials as a means to teach engineering problem solving skills. Through the use of frequent laboratory exercises, our goal

was to “demystify” for these future teachers some of the fundamental ideas of science and engineering and to heighten their interest and skill level in effectively communicating these ideas to K-12 students. The course examines the physical, mechanical, and chemical behavior of materials. We emphasize how their internal structure affects their behavior. This course interacts with two of NASA’s four strategic enterprises: Human Exploration and Development of Space and Aeronautics Technology. Both of these enterprises have a materials related problem at their core. In the context of this course we examine a number of specific materials requirements. One example is the desire to use ceramic matrix composite materials in several engine components on the next generation of the shuttle. To increase engine efficiency there is a need to create engines that can run at hotter temperatures. This very crucial operating requirement embodies both mechanical and chemical aspects. This is a topic on which one of the investigators (Jordan) has directly worked during the summers of 1997 and 1998 as part of the Summer Faculty Fellowship Program at Marshall Space Flight Center. This yearly program is described on the Summer Faculty Fellowship Program web page².

We initiated the process of “engineering problem solving” with laboratory-based activities by first forming teams to promote collegiality among the pre-service teachers and to provide a supportive framework for their entrance into potentially unfamiliar territory of problem solving from an engineering standpoint. Team formation was accompanied by a strong commitment to regular “teaming” activities providing ample opportunities for students to literally put their “hands to the task” of experimenting with the new concepts to be learned. Mixed with a lively interaction among the faculty members (and the students themselves) this quickly broke down many barriers to students’ actively and cooperatively learning new concepts.

The course was taught in a cooperative learning environment, integrating numerous hands-on activities with brief lectures coordinated to provide “just-in-time” information for current team activities. By *doing* rather than merely observing, students engaged in “constructivist” instructional techniques.

In the spirit of NOVA’s mission, we have developed this course with four specific goals in mind:

- To improve the science and engineering problem-solving skills of pre-service teachers
- To model effective teaching methods to the students
- To provide opportunities for the students to create their own problem-solving strategies and modules and practice communicating them to others.
- To have outreach into the K-12 community through
 - workshops for in-service teachers taught by our students
 - presentations by our students in actual elementary class rooms
 - a workshop on the Louisiana Tech campus for engineering/science/education faculty in our region
 - presentations at regional and national engineering or education conferences

Course Content

Problem Solving in Engineering Science for Teachers follows the guidelines set forth in the National Science Teachers Association's (NSTA) position statement on Science Teacher Preparation Standards³. While focusing on understanding and developing the major concepts and principles of properties of matter, it helps students conceptualize the inter-connectedness of the sciences, mathematics, and technology. Students relate the study of matter and materials to contemporary, historical, technological, and societal issues. Students are able to locate appropriate resources; design and conduct inquiry-based, open-ended investigations in science; interpret findings; communicate results; and make judgements based on evidence.

Course learning objectives focus on four areas. Students first learn how to solve problems in engineering science. They then use the skills they have been taught to solve problems dealing with materials. Innovative teaching methods are modeled to the students by the faculty team. Finally, the students create lessons based on what they have learned and teach them to others. We have had them teach the lessons to each other, to groups of in-service teachers, and to groups of fourth-grade students at a local elementary school. The last two groups are part of a deliberate outreach program to reach people beyond the boundaries of our university with what we are doing.

The students learn about the atomic structure of metals, ceramics, polymers, and composite materials. They learn how this internal structure affects the physical and chemical properties of the materials. They also learn how this internal structure affects the mechanical properties of the materials. Specific examples that are used include materials-related problems with space transportation systems and with the International Space Station.

Experiential learning is an important part of this course. The need for this is described in the National Science Education Standards: "Conducting scientific inquiry requires that students have easy, equitable, and frequent opportunities to use a wide range of equipment, materials, supplies, and other resources for experimentation and direct investigation of phenomena".⁴

A significant aspect of this course is the extensive involvement of our students with experimental work. Our goal is to introduce pre-service teachers to principles, applications, and technologies that can readily be implemented in their future classrooms. This is shown in more detail in the laboratory section of this paper.

During the development of the course considerable care was used in the planning of instruction, use of instructional materials, and evaluation of practices suitable for teaching elementary and secondary school students. Methods for teaching science, mathematics and engineering content to elementary and secondary students were evaluated for appropriateness. Strengths and limitations of a variety of teaching methods were considered. These methods and practices were then modeled and assessed through the conduct of the course in classroom, laboratory, and in-service experiences. Methodologies included lecture, small group activities, whole group

activities, individual participation, reflective writing, alternative assessments, cooperative learning, demonstrations, and technology-based assignments.

Laboratory Portion of course

A significant aspect of this course is the extensive involvement of our students with experimental work. Our goal is to introduce pre-service teachers to principles, applications, and technologies that can readily be implemented in their future classrooms. Through these experiments, students not only learned or reinforced science, math, and engineering principles; they also practiced skills such as data measurement and analysis, graphing or tabulation, and fundamental statistics. Details of this have previously been reported by the authors⁵.

This is being accomplished, in part, by the use of the Calculator Based Laboratory™ (CBL)—an integrated system of measurement sensors or probes, a data acquisition unit, and a graphing calculator. The system we've selected for use are products of Texas Instruments and Vernier Software. The choice for this system was governed by relatively modest cost, a fast “startup” for new users, and wide variety of options for measuring parameters in physical, chemical, and biological processes. Experiments under consideration include parameters such as temperature, pressure, light, voltage, pH, conductivity, and calorimetry.

We focus on strengthening the links between verbal descriptions, numerical data acquisition, and graphical representation as means of understanding physical phenomena. The identity and application of functional relationships between independent and dependent variables will be addressed through expression of mathematical models illustrated with experimental activities.

For example, one critical element in scientific inquiry is the fundamental understanding of rates of change in systems. The CBL system provides a clear approach to setting up an experiment for evaluating a process change with time (e.g. pH or temperature), collecting data at a desired frequency and range, and representing the process change graphically. Further processing of data sets, such as statistical analysis, may be accomplished either through use of the graphing calculator or by importing data sets to a computer. Each of these aspects of experimentation and analysis will be presented to the students in a simple, hands-on approach to provide them with training and skills development.

We have also used video probes, computers, the Internet (including NASA's Strategic Enterprises resources), telecommunication technology, and software designed to enhance learning and presentation skills. Eventually it is hoped that the compressed video program that Louisiana Tech already has in place can be used to offer this course and its outreach programs to classroom teachers and university faculties in other geographic locations.

Some of the laboratory experiences are described below:

- Examine how materials respond to temperature changes by recording the rates at which

aluminum, glass, and polymeric soft drink containers cool down when placed in an ice chest.

- Examine crystal structure of metals by making models of unit cells using styrofoam balls and wooden sticks.
- Examine structural stability by making and testing structures made out of straws and masking tape.
- Examine temperature effects on metal behavior by doing Charpy impact tests on aluminum and steel samples at room temperature and the temperature of liquid nitrogen (-320 °F).
- Examine how metals respond to loads by doing tensile tests on aluminum and steel tensile samples.
- Examine the concept of fatigue by performing fatigue experiments on paper clips. This experiment is also used to illustrate a number of statistical concepts.
- Examine viscoelastic behavior of materials by making and observing the behavior of a “silly putty” type material.
- Measure diffusion rates of different dyes onto filter paper
- Learn about rates of change through studying pH, temperature, and humidity in specifically designed experiments.

The details of several of our laboratory exercises serve to further illustrate the experiences developed in the course.

Crystal Structure

Students were introduced to the basic crystal structures of metals by making models of the different structures using styrofoam balls and wooden sticks. An example of this is shown below:



Figure 1—students making models of crystal structures

Structural Stability

Students were introduced to the concept of stability through the design and building of a structure composed of straws and masking tape. Their task was to build the tallest structure possible within a given time period (about one hour). The winning team was the one with the tallest structure that could hold up a soccer ball. When the structures failed at loads far below their actual strength levels, the students learned that strength is not the only issue to be concerned with when designing structures. This was used to introduce them to the concept of stability, and how it differs from strength.



Figure 2–Building a structure

Fatigue

Students were introduced to the concept of fatigue, and how repeated loading of a part can cause failure at stresses below the yield strength of the material. This was illustrated by having each student do fatigue experiments on two different sizes of paper clips. This example was chosen since it is something that almost everyone has done at some time in his life—bending a paper clip until it breaks.

This experiment illustrated some of the problems involved in interpreting fatigue data. In particular, the wide range of results was used in two ways. We examined the results and discussed which lifetime should we use: the minimum lifetime or some statistical type of average? This included such issues as whether using the minimum value would require too much material, for it greatly underestimates what the actual lifetime might be. On the other

hand, using only a mean value of lifetime means that half of your parts will fail before you would have expected them to. What is the best representation of the fatigue life is not a simple question.

We used this fatigue experiment to introduce the students to several aspects of statistics. They determined the mean, median, mode, and standard deviation of the lifetimes. One of the paper clip types had a smaller standard deviation on its lifetime and this was used to illustrate that its data was more uniform.

Since the first offering of this course (spring 2000), most of the class material has been placed on the web (www.latech.edu/~jordan/NOVA/index.htm). This will enhance student access to ideas and concepts with the next course offering and, with further development, can provide the course to “in-service” teachers at locations remote to the Louisiana Tech campus.

Outreach from Within the Class

Outreach to In-Service Teachers Through a Workshop

One of the goals of this course was to create a workshop for area teachers that would be led by our students. All of our students participated in a half-day in-service training—designed and led by the students. In small groups the students guided teachers through problem solving activities that they in turn could use in their classrooms. Students modeled the same pedagogical techniques that they had experienced in their class.

An example of a lab created by the students for the teachers involved measuring density of different liquids. An example of this is shown below.



Figure 3–In-service teachers performing density experiment in workshop

Participating teachers were delighted with the results. Here are a few of the typical comments made on their evaluations of the workshop:

- *This was a wonderful experience! The students have demonstrated their learning in very interesting ways. Many activities will be extremely useful and fun to use in my classroom. I know my students will love each activity. These are very useful both to demonstrate scientific principles and to use as activities when students want to do FUN activities.*
- *The students did a wonderful job, and their lessons were demonstrated in a very professional manner. Each one of these students will be a great teacher. PLEASE have more workshops. I would love more opportunities to explore new ideas and to get motivated to use these activities in my classroom.*
- *This was a wonderful opportunity for the Tech students to build their skills. The presentations were well prepared as were the lesson plans. I would love to see all of the presenters again. The material will be easy to use in the classroom. PLEASE do this again.*
- *I thought this was an excellent educational opportunity. The students were well prepared; there were a wide variety of activities presented. It gave the students experience and teachers were exposed to new content and methods.*

Outreach to Elementary Students and Their Teachers

In addition to the experiments performed in our class, our students were required to create a hands-on laboratory teaching lesson that was presented in two different settings. The first one was to a workshop of in-service teachers. The second one was to groups of fourth-grade students at a nearby elementary school. In this setting both the fourth grade students and their teachers got to observe what we were doing.

The students had to create complete lesson plans that could be used to teach this to others. Many of these lessons seemed “easy” to the engineering faculty involved but were not easy for the teachers nor their elementary-age students. It is a challenge to create experiments that demonstrate science and the scientific method to students of elementary age. Many of these concepts were new to our students (education majors, most of them were sophomores).

We wanted to have our students internalize what they have learned. One way to do this is to have them present what they have learned to others. We wanted to communicate to the K-12 students and in-service teachers that science and engineering could be fun. We also wanted to communicate this to our own students. Many of them were very nervous about doing science and engineering things when the class began.

Examples of the Student-created Labs Included:

1. Measured effect of small amounts of caffeine on pulse rate by having students drink different liquids and then measure their pulse. Students measure their pulse after having had a small drink. Some drinks had no caffeine, others had differing amounts of caffeine. The effect of caffeine on increasing pulse rate could be clearly seen.
2. Illustrated polymer behavior by making a silly putty type material and then evaluating it. When a similar experiment was done in our class, this was done to introduce the concept of viscoelastic behavior of polymers. Our students did not use term viscoelasticity when this was presented to the fourth graders, but still introduced the concept of time dependent material behavior.



Figure 4–Making a viscoelastic material

Both the students and their teachers enjoyed the presentations. The following teacher comments were typical:

- *Students loved the activities and trying out the experiments.*
- *Presenters were very enthusiastic. Students enjoyed the activities and the lesson.*
- *Great experiment! Very appropriate for this age group.*

Outreach as a Result of the Class

Louisiana Tech has now received a second phase grant from the NOVA project. We have two main goals in this second phase. We will continue to teach our course and make further refinements. The main aspect of this second phase is to disseminate what we have done. We believe that the course we have created and the way we have taught the course can be models for similar efforts in other universities. As such we have had deliberate outreach efforts this past year. Some of them are discussed below. These are in addition to the outreaches described above which were part of the class itself.

Presentations at Science Teacher's Conferences

One of the author's made a presentation at the 2001 Louisiana Science Teachers Associate meeting in December 2001⁶. We shared a couple of our hands-on laboratory problems, and demonstrated how they can be used in a middle-school classroom. The presentation was very well received by the teachers who were in the workshop.

Presentations at ASEE Conferences

The authors would like to see more engineering faculty incorporate active learning into their classrooms. We would also like to see more engineering faculty become involved with teacher education and outreach to the K-12 community. As a result of this goal, we have made presentations about the content and teaching methods of this class to the 2000 and 2001 ASEE National Conferences^{5,7}.

Presentations at NOVA Conferences

The NOVA project has regional conferences where math/science/engineering faculty can get together with education faculty to discuss ways to improve K-12 math and science education. At the November 2001 Regional Conference we made a presentation as a successful example program.

We have also made presentations at the national NOVA conferences in 2000⁸, 2001^{9,10}, and 2002¹¹. These conferences are different in scope than the regional ones. The regional ones are an outreach to faculty who have not participated in these educational reform activities. The national conference is composed of universities that have been involved in the program. Here we are sharing with each other what we have learned. Since Louisiana Tech University is one of the few universities which has engineering involvement in the NOVA program, we are able to learn about a wide variety of methods and outreach activities that can be done in other science areas.

Louisiana Tech University NOVA Workshop June 2002

We hosted a workshop at Louisiana Tech University in early June 2002. This workshop was aimed at both content (math/science/engineering) as well as education faculty. During this workshop, the attendees received hands-on experience in ways to teach engineering science to non-engineers. It is hoped that the attendees will go back to their home universities and start similar courses/programs of their own.

Outreach You Can do on Your Campus

There are a variety of approaches you can take to begin an outreach program. One possibility is to follow our example and create a new course. This may be too big a step for some faculty to

take all at once. An alternative step would be to incorporate outreach in other classes. For example, in our Mechanical Engineering senior seminar, we have the students prepare and give a technical presentation during the course. Occasionally we have had these senior seminar students make presentations about science related topics in junior high class rooms. This fulfills their class requirement of learning how to make presentations and also exposures junior high students (and their teachers) to the world of engineering.

Similar outreach programs can be developed through your engineering professional societies. This is something that might be supported by your admissions program as part of their outreach activities.

Course Assessment

One of our goals for this course was to promote reform-based teaching and assessment strategies among pre-service teachers by immersing them in instructional techniques that modeled a constructivist approach. The focus was on *doing* science rather than merely acquiring isolated facts of content knowledge. Students were asked to construct information in ways that were meaningful to them. The instructors encouraged students to connect new learning to previous experience, to ask questions, to explore a wide range of possible answers to their own questions, and to construct their own conclusions. Incorporated in this context were certain aspects common to other teaching models such as cooperative learning, thinking inductively, nondirective teaching, teaching to multiple intelligences, and efficacy of instruction for all learners.

Publications from NSF¹², NSTA^{3,13}, AAAS¹⁴, and NCEE¹⁵, have called for certain curriculum strategies that go right to the heart of the teaching/learning experience. Anderson¹⁶ synthesizes the perspective and recommendations of these publications by national science education organizations as ". . . 1) integrating themes in subject matter, 2) teaching for understanding, 3) making connections between subject matter and its applications, and 4) reaching all students--not just the elite--with rigorous content and attention to critical thinking". Thus it can be seen that the methodologies used in teaching this course had a well researched and broad base of support.

Yager¹⁷ stipulates that most constructivist teachers promote group learning, where students in small groups discuss approaches to a given problem and work together to solve problems. Inquiry lessons should be highly interactive so that teachers and students take on equal roles where ideas are concerned. Students learn best in an environment that combines dialogue with other students, experimentation, and discussion with the teacher.

McIntosh¹⁸ states that: "We need to give students the opportunity to practice problem solving that is more realistic and requires them do to more of the work. I think this type of activity combined with meaningful post-lab discussion about what happened, what thinking processes

were used, and what skills the students need to practice is a good way to give students good problem-solving experience.”

In each of our lessons we used small group problem solving activities which were followed by discussions of not only the results, but the implications involved. Most lessons included the five essential elements to a constructivist lesson.

These basics include¹⁹ :

- activating the prior knowledge of the learner,
- having the learner acquire knowledge through direct interaction with materials and/or other learners,
- conceptually developing the acquired knowledge,
- applying the new knowledge, and
- reflecting on the new knowledge.

It was our hypothesis that students in this class would make gains in positive attitudes towards doing and teaching problem solving in engineering if we used a curriculum design that capitalized on the students’ natural curiosity. Siversten²⁰ reports, "Studies have shown that the new curricula [i.e. constructivist oriented] were generally more effective than traditional programs in improving student performance on cognitive measures and raising attitudes about science" (p. 1). We found this to be true in our case.

On a comparison of mean scores from a pre- and post- *Survey of Attitudes About Problem Solving in Engineering for Teachers* students showed a significant positive attitude shift on 17 of the 20 test items dealing with their perceptions of the field of engineering, their ability to do engineering problem solving, and their ability to teach problem solving in the classroom within an engineering context. Our students clearly gained an appreciation for the field of engineering along with a newfound confidence in their ability to solve real life problems having to do with engineering.

Their gains were not only reflected quantitatively on the attitude survey, but also qualitatively in their daily journal writings. Typical entries from the students were these:

- *The things that I like most about this class were the experiments we did. From the silly putty to the sponge [creative thinking] activities. . . . I also found that I do have a little bit of science knowledge. From discovering that the scientific name for plastics is polymers to actually going to an engineering lab [I am now] able to relate to conversations that my friends are having. Before that I would just listen. Now I can offer my two cents. After finishing this course I have a new found interest in science related areas.*
- *I thought it was so much fun learning and doing activities that we can do with our students when we become teachers. I also liked how we learned about chemical*

engineering and materials engineering and how the understanding of these made the activities not only fun, but also a learning experience!

- *I enjoy many things in this class. Learning how to incorporate problem-solving techniques into the classroom was especially interesting. I enjoyed learning about cooperative learning. It provided me with valuable insight to how to incorporate cooperative learning and problem solving techniques.*
- *Everything we did was “hands on!” It was great. This is the best fun I’ve had in any class in my entire 4 ½ years in college.*
- *[My favorite things about this class were] hands-on activities, interaction among students, interaction with teachers, and the comfort level in the classroom which made it so easy to ask questions. The combination of professors was just cool and greatly added to the learning.*
- *[What I liked about this class was] the cooperative group settings. The “laid back” environment approach in learning some of the different engineering concepts of this course material. I loved the sponge activities in the beginning of the class. They were fun and very relative for future use in our classrooms. Great motivators! I enjoyed the enthusiasm, the “down to earth” approach, and the “serious side.” All three combined instructors made this course a SUCCESS! It was great, and I recommend this course to all education majors!*

Another goal we had for our course was to create a workshop for area teachers that would be led by our students. All of our students participated in a half-day in-service training—designed and led by the students. In small groups the students guided teachers through problem solving activities that they in turn could use in their classrooms. Students modeled the same pedagogical techniques (cooperative learning, indirect teaching, constructivism, etc.) that they had experienced in their class. Participating teachers were delighted with the results, as reported earlier.

One long term goal of this project would be to follow the students’ future performances as they begin teaching, to see if this course made a difference in the way that they teach. This is a difficult task to do, and we might or might not be successful in tracking them.

Benefits of these activities to engineering professors

There are four significant benefits to engineering faculty members who become involved in activities such as has described in this paper. First, these sorts of activities will help increase the technological literacy of our society, which will make it easier for engineers to do the things they really want to do. Secondly, exposure of engineering concepts to K-12 students may encourage some of them to pursue engineering when they get to college age. This can only be a benefit to

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our engineering profession. Some faculty may object to the suggestions in this paper, because they have the attitude that this is not real engineering. We would assert that our class, while not traditional engineering, certainly fits the category of pre-engineering. We are using this class to present engineering in a way that can excite others to join our profession.

A third major, though indirect, benefit to the engineering professor who begins to do the sorts of things we have described in this paper, is in the improvement of his teaching. The authors have been exposed to what are new ways of teaching (at least new to us). The first author has incorporated many of these teaching techniques into several traditional engineering courses such as materials engineering and a combined statics/strength course. Our engineering students are benefitting today from our more creative teaching styles.

A fourth benefit is the personal and professional growth of the engineering faculty member. We have found our involvement in these activities to be one of the more the more rewarding and enjoyable things we have done since we became professors. We have seen this benefit in other faculty who have also become more creative in their profession.

Conclusions

We have reported on what we believe are successful outreach efforts, presenting engineering concepts to faculty, college students, in-service teachers, and K-12 students who otherwise would not have learned such concepts. This has been done at relatively low cost. Financial support from NASA's Project NOVA has been very important in getting this process started. However, many universities could create similar programs without the outside support.

These sorts of activities are new to most engineering faculty members. We encourage other engineering faculty members to think outside the box and become involved in similar activities.

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