Background: Engineering Outreach at UW–Madison

The K-12 Engineering Outreach Program has been in existence since 1988. It was created as part of the NSF-funded Engineering Research Center for Plasma-Aided Manufacturing. The first outreach program was based on a kit of materials that explained the states of matter and how plasma is used in manufacturing.

In 1995, Steven Zwickel, an instructor in Engineering Professional Development, became Outreach Coordinator and the program came under the auspices of the College of Engineering. In addition to the demonstration of plasma, we added new kits to showcase other engineering disciplines. The impetus for these additions has come from a wide variety of sources.

The mission of the K-12 engineering outreach program is to improve science and engineering literacy, to engage and interest school children and their teachers, to expose undergraduate students to outreach and to its rewards, and to make science and technology fun.

- FOR AREA SCIENCE TEACHERS, the outreach program offers hands-on demonstrations and in-class discussions about the state of the art in technology.
- FOR SCHOOL CHILDREN, the outreach program provides an opportunity to interact with young adults who can give them information and advice about the value of studying science and math.
- FOR UW STUDENTS, this is a chance to talk to younger people about their studies and to polish their presentation skills in front of a “real world” audience.

New Kit Development

The impetus for creating new outreach programs may come from a variety of sources. New kits for the K–12 Outreach Program have been developed by undergraduate students, by UW faculty, and by local schoolteachers. Mr. Zwickel, as Coordinator of the program, makes himself available to anyone who is interested in developing an outreach program. Every semester he makes time to consult with students (and faculty) who want to do outreach. Students’ enthusiasm and motivation waxes and wanes and they may not always have the time to implement their ideas, so Mr. Zwickel tries to be encouraging and to serve as both a sounding board and a reality check.

When Mr. Zwickel is approached by someone interested in launching a new outreach program, he arranges for a meeting to discuss our mutual goals. Mr. Zwickel gives them examples of presenter’s manuals and a copy of **The Outreach Program Creation Process**, which they go through line by line.

The Outreach Program Creation Process Step-by-step

I. Create kit to accomplish purpose(s) and meet audience needs

A. Set clear goals

1. Purpose

There is no point in doing outreach if you don't have clear goals. The main purposes of the K–12 Engineering Outreach Program are to showcase new technology and to discuss educational and career opportunities in engineering disciplines. Another important goal of the program is to encourage children (especially girls and minority group members, to stay with math and science in school, even when the subject matter becomes complex and when other activities seem more attractive.

A good outreach program can add something to the classroom experience that kids can't get elsewhere. It can expose them to new ideas and new ways of looking at things. It should not duplicate exhibits and activities that are easily accessible elsewhere. Many communities have science/technology museums suitable for children; Madison does not. However, it's wasteful to put together an outreach program that covers material already being presented by other local organizations.

You may want to consult with some schoolteachers before you design an outreach program to see how your program fits in with what the children are supposed to be learning. You need to consider the science and math curriculum being used in the schools and to go through the standards for teaching math and science in each grade.

2. Audience

We try to reach students in all the grades, from 5-year-olds in kindergarten all the way up to 18-year-olds who are ready to graduate from High School. This vast spread of ages and abilities presents quite a challenge.

Consider the audience for your outreach program—what age group will you focus on? It is very hard to develop a kit from scratch that can be used all the way from Kindergarten through 12th Grade. After a kit is developed, you can find ways of extending it to a wider range of audiences, but to start, decide on a target audience:

- For younger audiences, presentations need to be shorter, simpler, and activities more hands-on and experiential.
- Middle school children need to explore science in their lives, to understand scientific method, and to become comfortable with and personally involved with technology and math.
- At the high school level, outreach programs can be longer and often involve discussions of both theoretical science and math concepts and career choices in engineering and technology.

3. Limitations

When students go off campus to do outreach presentations, you have to make allowances for their limitations. First of these is the size and weight of kits. Our outreach kits are stored and transported in 18 Gallon hard rubber tubs. These are quite large, but not so big and heavy that they can't be carried by one person or fit easily into the back seat of most cars. (Students without cars may have to use public transportation). Museum exhibits may include airplane engines and oil wells; for an outreach kit we have to think in much more modest terms.

You and your teammates may know exactly what you want to demonstrate and how the program should be run, but those who come after you may not be quite so talented. When you develop your kit you need to keep in mind the abilities of future presenters. A presentation that calls for a high level of show-biz skills may be too difficult to maintain. Keep explanations and demonstrations simple.

Another reason for keeping things simple is the need for reliability of demonstrations. An experiment that only works 50% of the time will not make a very good impression on the school children.

Finally, we all need to remember that modern technology has limitations. The more we depend on high-tech tools, the more likely it is that these complex mechanisms will fail in the field. One museum in New York City proudly unveiled a new exhibit hall that featured 40 computers for interactive displays. Within a matter of months, fewer than half were functioning properly. Outreach programs need to be robust enough to stand up to repeated use and abuse by school children. Don't put your faith in fragile, complex technology.

B Decide how much time, energy, money are available

The process of creating a new module for outreach can be long and difficult. Good intentions are not enough. You will need to decide how much you have to give to this project before your start. Most of the kits in our program took a semester or longer to put together. They need to be carefully researched and organized so that they can be used for a long time. If you don't have the time, energy, or commitment, your project will languish and all your good ideas will go unused.

I strongly recommend that kit development be done by a team, rather than by an individual. This will distribute the workload more evenly and ensure that there is enough labor to complete the tasks involved.

II Do Research

Before you start preparing your outline, you must acquire a thorough knowledge of your topic. Take some time to find out what has been done by others. The internet is a useful tool for this. Use a reliable browser and try keywords like "science education" AND your topic.

You can't simply make up an outreach program and expect teachers to welcome you into their classrooms. They need to see the outreach as enhancing the work they are already doing in the classroom. So you need to learn more about what kinds of science are being taught in the schools before you start working on your outreach program.

As of February 2001 the Madison Metro School District has adopted the Full Option Science System (FOSS) standards for teaching science. *http://www.lhs.berkeley.edu/FOSS/FOSS.html* developed at UC-Berkeley. FOSS is an elementary school science program developed at the Lawrence Hall of Science with support from the National Science Foundation. FOSS program materials are designed to meet the challenge of providing meaningful science education for all students in diverse American classrooms and to prepare them for life in the 21st century. FOSS incorporates time-honored methodologies such as hands-on inquiry and interdisciplinary projects with contemporary methodologies such as multisensory observation and collaborative learning groups. Development of the FOSS program was guided by recent advances in the understanding of how youngsters think and learn. FOSS is a project of the Center for Multisensory Learning.

To find out what the schools are teaching children about your topic, you may want to talk to schoolteachers or look at the Wisconsin Model Academic Standards, at *http://www.dpi.state.wi.us/dpi/standards/index.html*

Once you have a sense of what you want to demonstrate, come up with ideas for ways to explain your topic to kids.

III Write outline, collect materials and equipment

You will need to write an outline, explaining how the presentation is supposed to proceed. This outline can start out as a simple list of demonstrations and discussions, but you will eventually need to turn it into a presenter's manual that can be used by others after you are gone. To tie your presentation in to what the children are learning in school, consider preparing some materials to give classroom teachers. In the past, we have included lists of library books and videos, posters, pamphlets, and copies of magazines for the teachers. It is good to try to leave something behind to remind the teacher and children about your topic. Think in terms of handouts, worksheets for students, and additional readings that might be helpful for those who want to learn more.

All of our outreach presenters take standard evaluation forms with them for the teachers to fill out. With a new presentation, you may want to develop your own form to cover parts of your presentation about which you want to collect feedback.

IV Learn presentation skills

If you are not familiar with the basics of presenting technical material, you may have trouble putting together a usable outreach kit. The presenter's manuals for the existing kits contain some information about how to present the material. You may also find books and articles which may be helpful. At the UW–Madison we offer a 2-credit course called EPD275 Technical Presentations that covers Organization, Delivery, Interactions, and Evaluations. You may also learn to do presentations in EPD397 Technical Communication and ECE350 Professional Expression.

Probably the most important thing you can do to prepare for an outreach program is to spend time practicing before you go. Practice time is time well spent.

V Present outreach in classrooms

The goal here is to field test your kit to see if it accomplishes your goals. For this reason, you need to debrief and evaluate your kit after each iteration. Some things will work well and help get your point across and others that sounded so good in theory will bomb in practice.

I will help you find classes where you can run these field tests of your outreach kit. We can set up a series of test runs where you can collect data and analyze the success or failure of your kit. Then you can use this information to revise as necessary.

VI Train future presenters

Once the kinks have been ironed out of your outreach presentation, you will need to sit down and explain to future presenters what they need to do. This means turning your outline into a Presenter's Manual. If writing is not your strong suit, you may want to get help with this manual. It is, in effect, an instructions set explaining how to do the presentation. Thus, it needs to be logical, unambiguous, and fairly simple. There should be a flow chart showing what happens step-by-step and you should consider adding illustrations if you think they will help.

Another important tool for future presenters is a video showing how the presentation is supposed to unfold. I will help you create and edit this training video, which can be done in front of a real audience or in an empty classroom.

When you have finished developing a kit for the outreach program, you can feel justifiably proud of yourself. Please don't forget that, even though you will be moving on, the outreach program will continue. It would be extremely helpful to me if you leave me with notes explaining how to revise and update your handouts, worksheets, etc. I am not an expert in your field and it can be very frustrating trying to keep your outreach kit current if I don't know where to go or how to do it.

The Outreach Program Creation Process — Outline

I. Create kit to accomplish purpose(s)
- A. Set clear goals
  - 1. Audience and Purpose
    - a) Adjustable to wide variety of audiences
    - b) Goal must be to add something to classroom experience that kids can't get anyplace else
  - 2. Limitations
    - a) Size and weight of kits
    - b) Abilities of presenters
    - c) Reliability of demonstrations
    - d) Technology has limitations

II. Do Research
- A. Acquire thorough knowledge of topic
- B. Find out what has been done by others
- C. Come up with ideas for ways to explain topic to kids

III. Write outline, collect materials and equipment
- A. Prepare materials to give classroom teachers
  - 1. Evaluation forms
  - 2. Handouts, worksheets for students, and addtional readings

IV. Learn presentation skills
- A. Organization, Delivery, Interactions, Evaluations
- B. Practice presentation
- C. Field test and evaluate after each iteration

V. Present outreach in classrooms
- A. Collect data and analyze success or failure
- B. Revise as necessary

VI. Train future presenters
- A. Write manual
- B. Create training video
- C. Explain how to revise and update handouts, worksheets, etc.

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