

Scientists Outside the Lab and Classroom: Can We Make a Difference?

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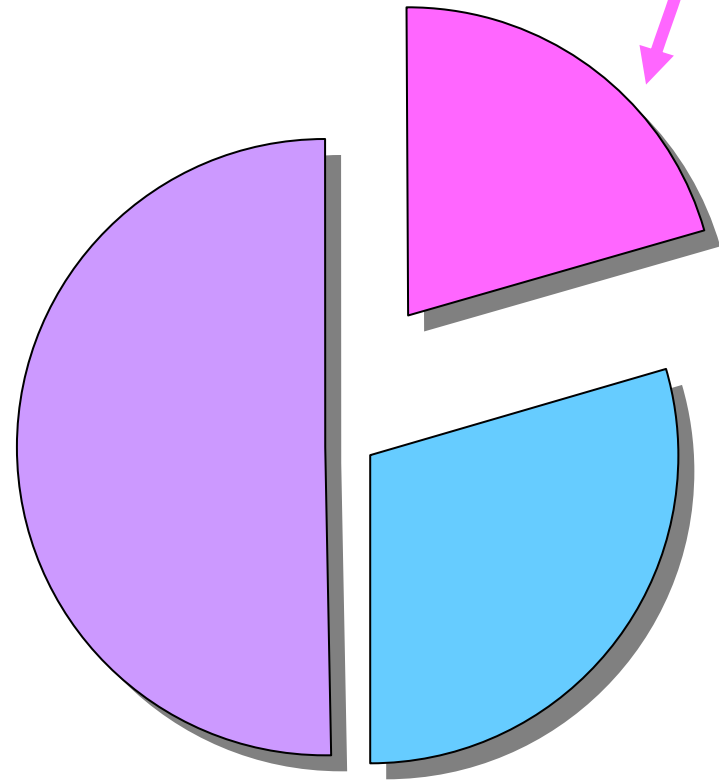
Outline

- **Motivation**
- **Steps for finding a project**
- **Can (pre-tenure) scientists meaningfully participate in K-12 education and outreach?**
 - **Some suggestion to help you make a decision and to make your decision easier**
- **Conclusions**

Outreach

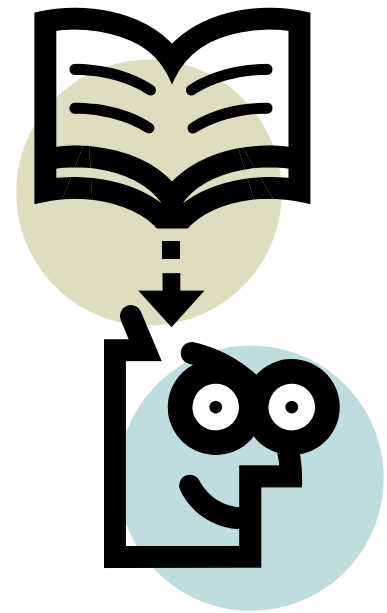
Academic Definition

**Everything that
isn't teaching or
research**



Why?

Altruism
Self-Interest



A survey of 30,000 students found that:
**the characters in the Star Trek
television program**

**had the strongest influence in
getting the students interested in
science.**

**Other interest promoters were teachers, parents and
the TV program 'Beekman's World.'**

Source: USA Today 123(2591), 15 (1994)

Vocabulary of Science Cor

The Earth goes around the sun once each year

The Earth goes around the sun once per year

The Earth travels around the sun

Light travels faster than sound

Humans did not live at the same time as the dinosaurs

Cigarette smoking causes lung cancer

Antibiotics kills viruses as well as bacteria

Electrons are smaller than atoms

Lasers do not work by focusing sound waves

The father's gene determines whether the baby is a boy or girl

Light travels faster than sound

Electrons are smaller than atoms

20%

40%

60%

80%

Public Belief in Paranormal Phenomena

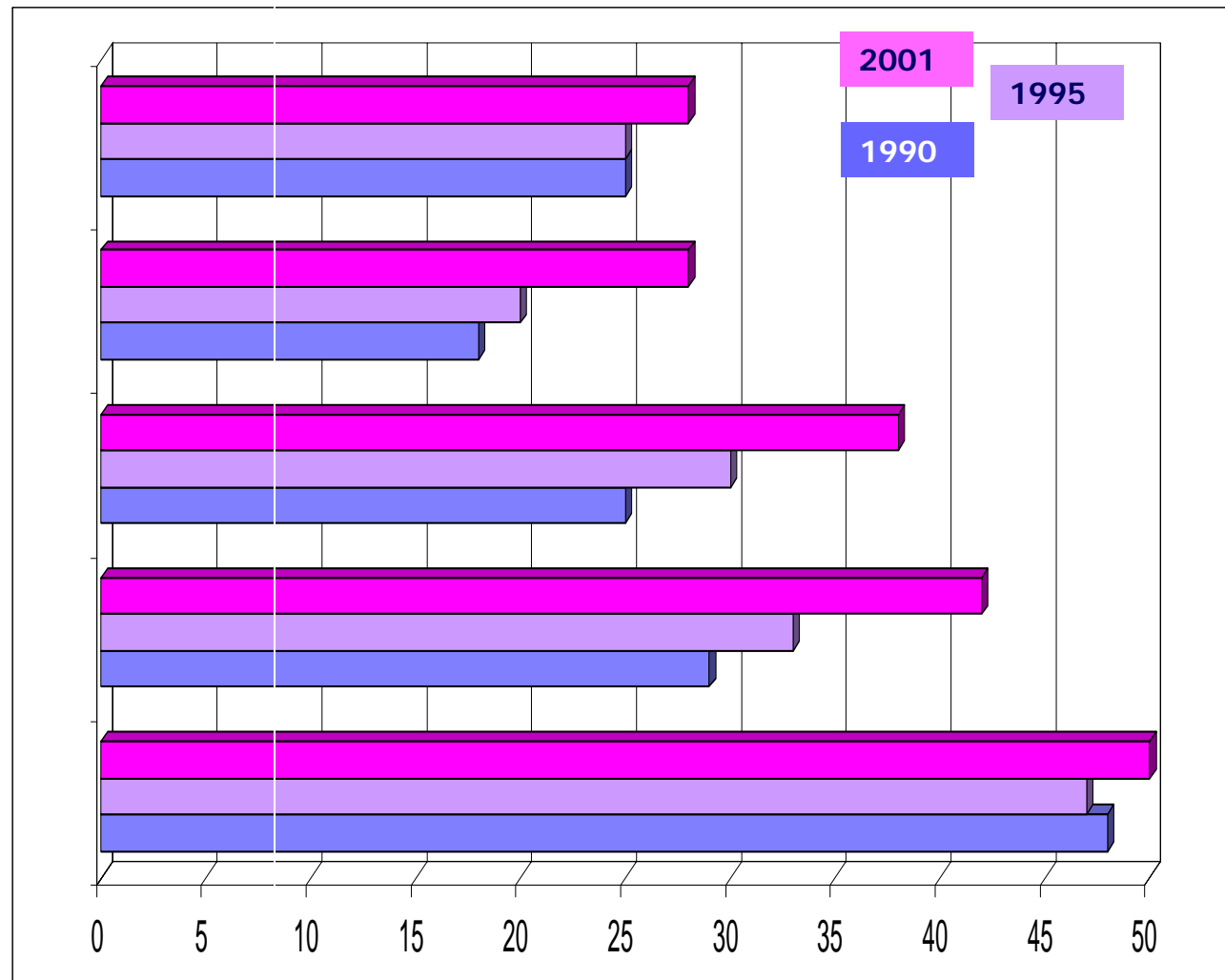
Astrology or position of stars and planets can affect peoples' lives

People can hear from or communicate mentally with someone who has died

Ghosts or spirits of dead people can come back in certain places and situations

Houses can be haunted

Extrasensory perception



“...pseudoscience is a sort of background noise, annoying, but rarely rising to a level that seriously interferes with scientific discourse...”

“...The more serious threat is to the public, which is not often in a position to judge which claims are real and which are not. Those who are fortunate enough to have chosen science as a career have an obligation to help the public make that distinction.”

Robert L. Park, 2001

But I Don't Have *Time* for Altruism

**The Case for Self-
Interest**

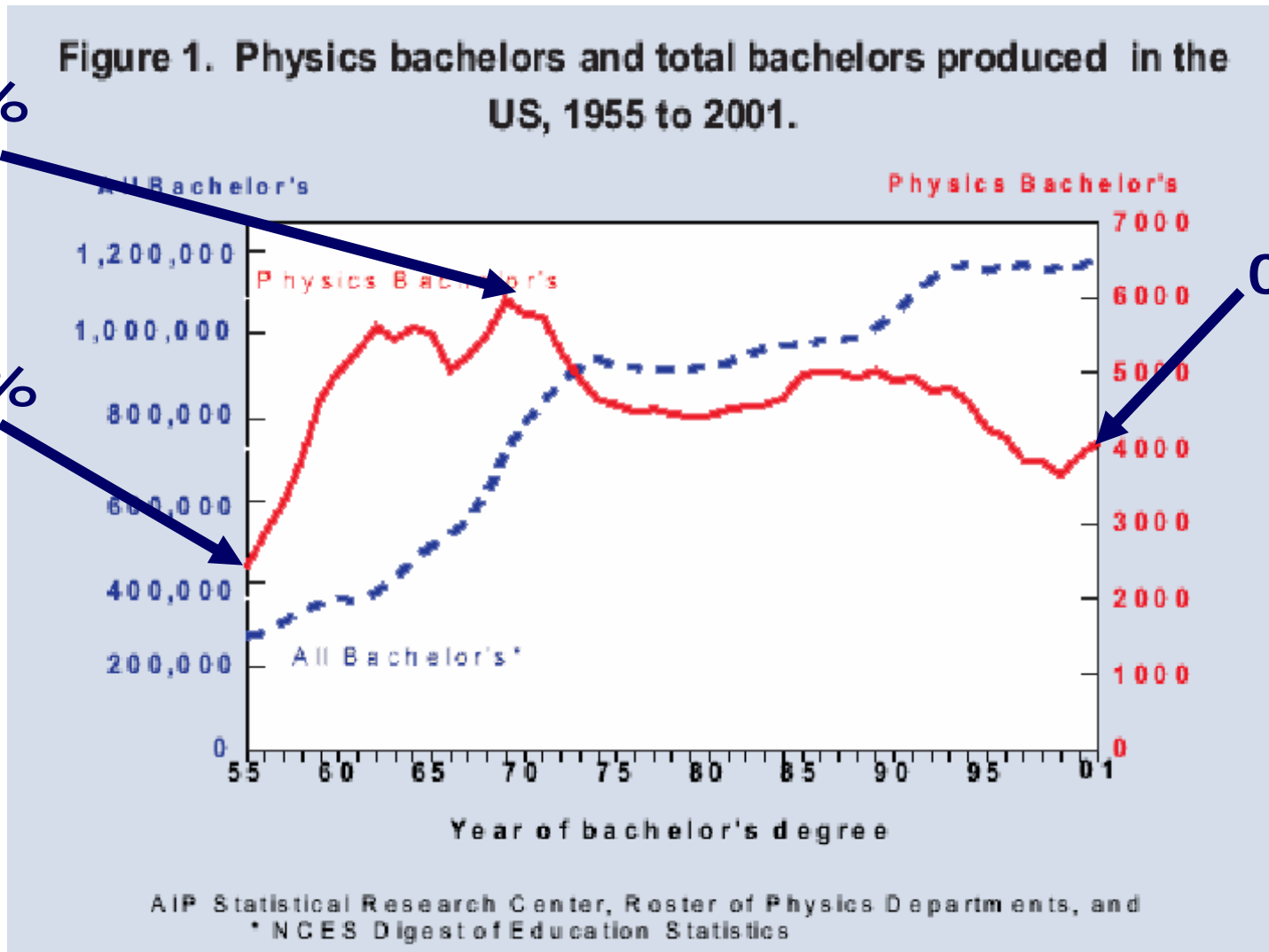
Bachelor's Degrees in Physics

Figure 1. Physics bachelors and total bachelors produced in the US, 1955 to 2001.

0.8%

0.7%

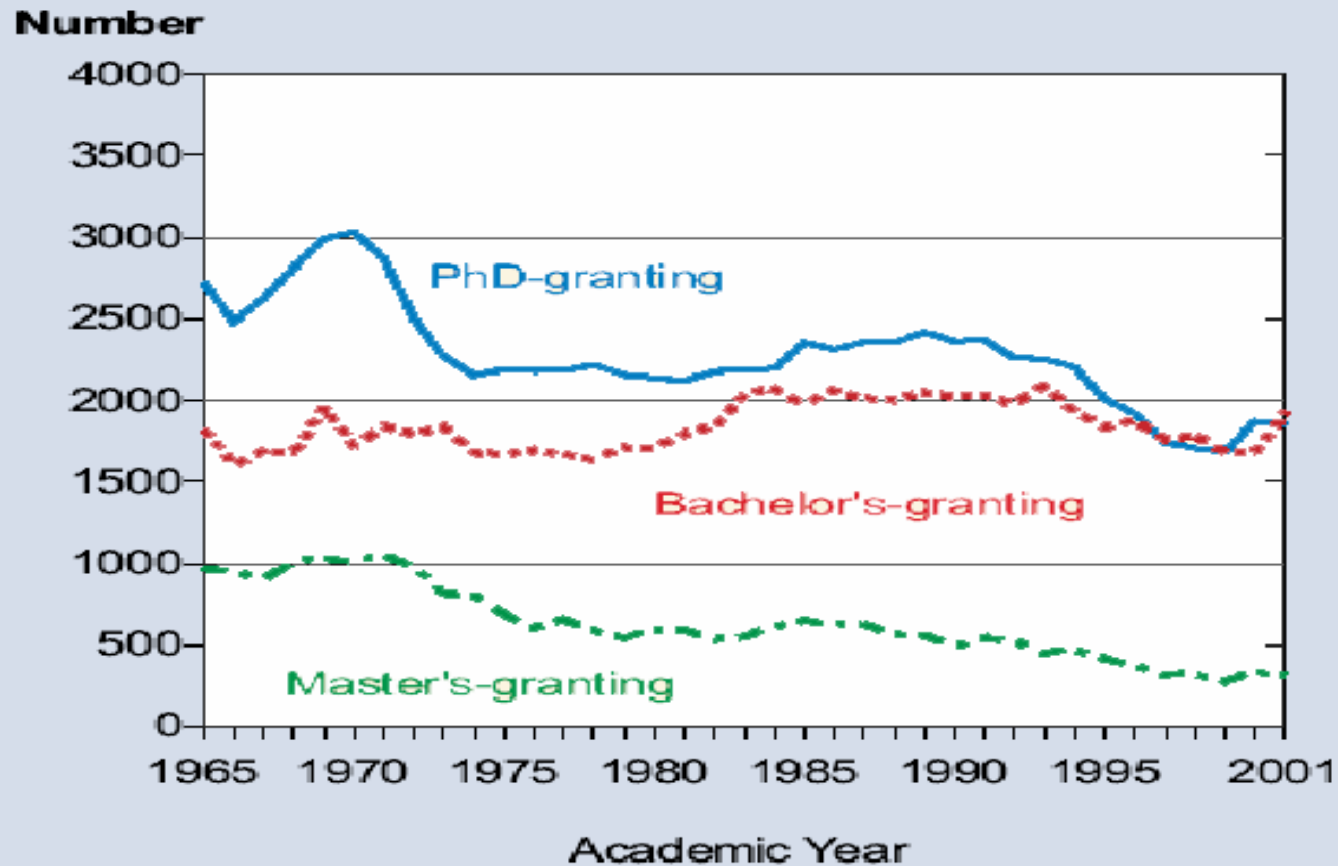
0.36%



Source: AIP

Bachelor's Degrees in Physics

Figure 2. Physics bachelor's degrees awarded by department type, 1965-2001.

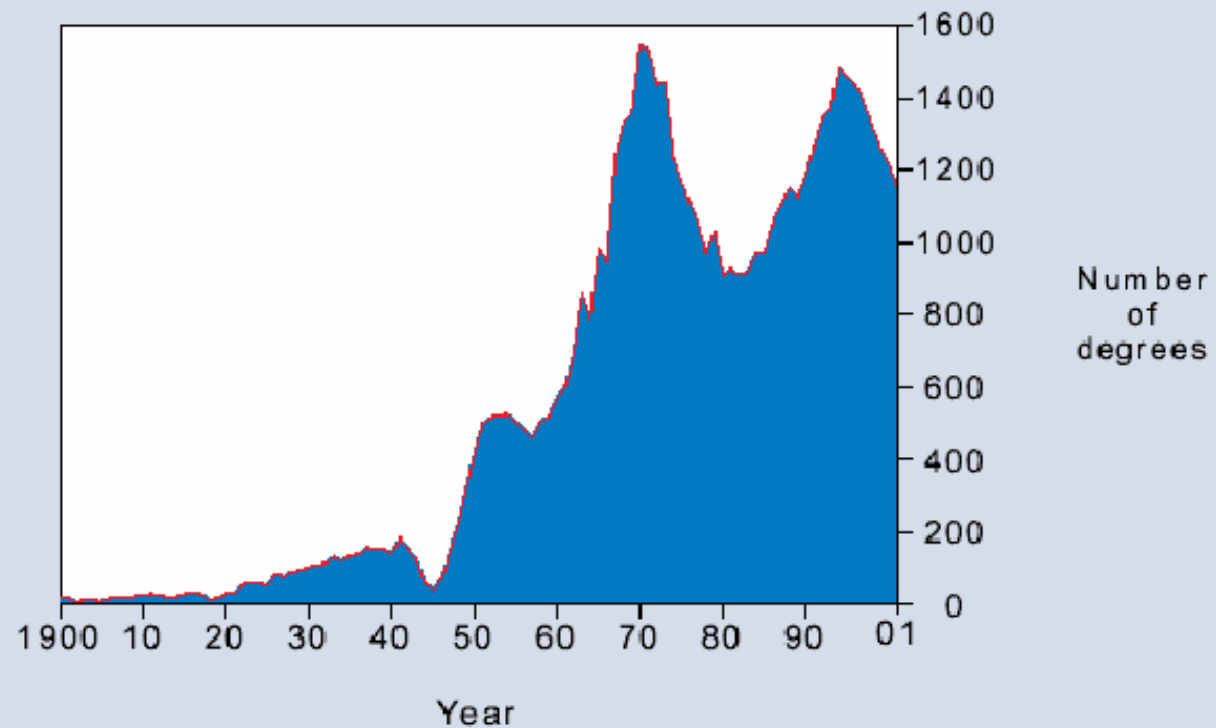


AIP Statistical Research Center, Enrollments and Degrees Report.

Source: AIP¹

Ph.D.s in Physics

Number of physics PhDs conferred in the United States, 1900 to 2001.



Sources: ACE (1900-1919), NAS (1920-1961), AIP (1962-2001)
AIP Statistical Research Center, Enrollments and Degrees Report.

Source: AIP

Motivation



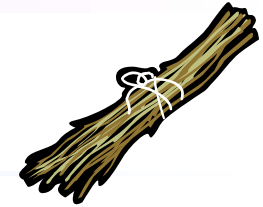
NSF: Integration of Research and Education

“One of the principal strategies in support of NSF's goals is to foster integration of research and education through the programs, projects and activities it supports at academic and research institutions.”



NSF - GPG

Motivation



NASA: To Inspire the Next Generation of Explorers

"In 1995-1996 the Office of Space Science developed and implemented a strategic plan to more effectively engage and involve the space science community in support of the nation's future interests and needs in science education. ... call for education and public outreach to become an integral part of the space science community's professional activities."



Mission Statement

*To understand and protect our home planet,
To explore the Universe and search for life, and
To inspire the next generation of explorers,
...As only NASA can.*

Motivation

- Large research centers (MRSEC, NSEC, ERC) require significant education/outreach components



To CAREER or Not to CAREER?

Pros

- Not competing against established scientists
- Prestigious
- 4-5 year grants carry you through tenure
- 'Regular' grants requiring education portion, too

Cons

- Giving reviewers two targets
- Weight of education/ outreach activities varies among programs
- Have to do both if you get funded

What Do I Do?

Finding a Project

Within the Institution

Graduate

Content

- Professional Masters
- Interdisciplinary Courses
- Mentoring Research

Prof. Development

- Communication Skills
- Grant-writing skills
- Paper-writing skills
- Recruitment and Retention
- Underrepresented Groups
- Careers

Undergraduate

Majors

Content

- Programmatic changes
- Interdisciplinary courses
- Improve teaching
- Research

Prof. Development

- Communication Skills
- Recruitment and Retention
- Underrepresented Groups
- Careers

Non-majors

Content

- Improve teaching
- Curriculum development
- Targeted courses (journalism)

Prof. Development

- Exposure to what scientists do
- Science and society issues

Future Teachers

Content

- Targeted courses
- Joint courses with Ed College

Prof. Development

- Practicums
- Workshops
- Invite education-related speakers for colloquia
- History and nature of science
- Research experiences

Outside the Institution

K-12 Education

Students

- Physics Van
- Lend materials and training
- Visit classes
- Judge science fairs
- Help students with science fair projects
- Develop materials
- Lend materials and training
- Ask-a-scientist website
- Develop curricula
- Involve students in research

Teachers

- Workshops
- Training on using materials
- Research experiences
- Web resource
- Develop curricula

General Public

Policy Makers

- Volunteer as resource for elected officials
- Lead letter-writing campaign
- Congressional visits
- Invite representative to give a talk for your department

Informal Science

- Volunteer as docent at science museum, zoo, etc.
- Series of lectures at science museum or planetarium
- Design exhibits for science museum

Everyone

- Talks for the public
- Family viewing nights
- Review science websites for accuracy
- Coordinate a science badge for boy/girl scouts.
- Review science books for your local newspaper
- Start a newspaper column or website to answer science questions

What Do You Feel Strongly About?

- Scientific illiteracy of the public
- My third grader's teacher doesn't teach science
- None of our high school physics teachers are certified in physics teaching
- Politics dictating science without input from scientists
- I'm tired of people thinking I must be a geek because I'm a scientist
- My lectures are brilliant -- why aren't my students learning anything?

One Day by The Coffee Machine...

Your colleague approaches you excitedly. A local, predominantly Hispanic, middle school was on the news last night because too many students are failing the standardized tests in math and science. Your department has a large number of Spanish-speaking graduate students. Your colleague suggests that you enlist their help and develop a unit on optics (your area of specialization).

What is your response?

What Are Your Goals?

- Entertainment
 - Demystification
 - Education
 - Change Attitudes
 - Change Policy
-
- *How will you know if you've achieved your goals?*
 - *What do you have to achieve to have made the effort 'worth it'?*

Who Is The Target Audience?

- Is the audience there?
- Is the audience interested?
- Is the idea appropriate for the level and circumstances of the audience?
- What else exists that is already targeted to that audience?



What Do You Want To Do?

- What are the needs of your target audience?
- How will your project meet those needs?
- Is someone else already doing it (or something similar)?
 - Can you learn from them?
 - Can you work *with* them?

Special Considerations for K-12

- Have you involved teachers in planning?
- Is your idea aligned with state and national standards?
- How does your idea impact NCLB testing?
- Do you have a way to compensate teachers for their time?
- Do you need permission from anyone?
- Are you overlapping someone else's project?

The Next Day at the Coffee Machine...

- **Your colleague talked to an 8th grade teacher at the school. They have an upcoming unit on Chemical Building Blocks. All of the 8th grade science teachers at this school are new to the grade and none of them have taught the Chemical Building Blocks unit.**
- **Do you modify your plan and, if so, how?**

Who Needs to Be Involved?

- What aspects of this project *can* you do?
- What aspects of this project do you *want* to do?
- Who can do the other things?
 - Are they interested?
 - What will it cost?
 - How do they need to be prepared?
 - When do they need to get involved?
- Who needs to be involved from a political standpoint?

Do You Need Funding?

Pros

- \$\$\$
 - Overhead
 - Resources
- **Infrastructure**
- **Demonstrates ability to**
 - Write grants
 - Organize large-scale projects
- **If it's a really bad idea, probably won't get funded**

Cons

- **Have to write the grant**
- **Can't decide to just stop doing it**
- **May be constraints on who must be involved**
- **Reports**
- **PI meetings**
- **Everybody expects you to do it for them**

You've Started Bringing Coffee From Home...

But your colleague finds you in your office.

What else (people, money, good will) do you need to make your idea work?

The Need for Evaluation

A Case Study

Scientists as Role Models: Are We Really Having Any Impact??

*Eisenhower Professional Development Program
National Science Foundation*

Pilot Study

Graduate students work with 4th/5th graders at a Title I school

- **Do student attitudes toward science and scientists change?**
- **Does student content knowledge increase?**
- **Do teachers change the way they teach science?**

Experimental Setup

- 8 weeks of Magnetism/Circuits
- 80 fourth/fifth graders
 - Title I school
 - Large ELL population
- 2 hours/week
- 4 teachers
- 3 science graduate students



How Would You...

... evaluate the effectiveness of the project for any one of the stated goals?

- **Do student attitudes toward science and scientists change?**
- **Does student content knowledge increase?**
- **Do teachers change the way they teach science?**

Assessment Details

- **Pre-surveyed students about their attitudes toward science and scientists**
 - Image of Science & Scientist Scale (Krajkovich, 1982)
 - Student Opinion Survey (McMillan, Simonetta, Singh, 1994)
 - Student Interviews
- **Teachers provided measures of the students' prior and current performance in science**
- **A selected sample of students was interviewed every two weeks**



Psst....

*... You know, the
kids don't believe
you're scientists*

Addressing Role Models

- **Emphasize graduate students as *scientists* from the university**
- **Have students talk about their research**
- **Videotape**
 - **Lead graduate student**
 - **In her lab, explaining her research**
 - **Shown in week #4**

Results

Students did not accept that their visitors were scientists

- **87%** described the visitors as 'teachers'
- When asked whether the visitors were scientists, **75%** explicitly said **NO**

Results

The visitors didn't look like scientists

- 'They were too pretty to be scientists. Only women who aren't pretty enough to be in the movies would be scientists'
- 'Scientists would be wearing white coats with glasses, have grey hair and be old'

Results

The visitors didn't act like scientists

- 'They showed expressions'
- 'They let us do fun things'
- 'Real scientists talk about complicated things'
- 'They are trying to make things easier for us to understand'

Results

The parents didn't get it either

- 'When will the real scientists show up?'
- 'It was really nice of the scientists to let their wives do this'

Conclusion

- Students started with common stereotypes about scientists
- The scientists in the classroom did not fit these stereotypes
- Not only did the students not change their stereotypes, they rejected the visitors as scientists because they didn't fit the stereotypes

*Buck, Leslie-Pelecky and Kirby,
J. Elem. Sci. Educ. 14(2), 1-10 (2002)*

Breaking Stereotypes

- Introduce scientists via videotape *first* to establish identity
- Have scientists start by dressing like stereotypes, then gradually becoming 'themselves'
- Have scientists start by doing 'shows', and then have them move into working with students in a 'teaching' mode.
- Ensure that scientists are always referred to as 'scientists', not 'grad students' or 'teachers'

Role Model Project

- Don't allow scientist to work with students until after videotape is shown
- Teacher does short unit on scientists & what they do
- Changed title from 'Fellow' to 'Resident Scientist'
- Wear nametags: "Scientist"
- Role Model Project:
 - Diverse faculty, grad students, industrial scientists
 - Relate to content matter
 - Scientists talk about why they are in science, etc.

Role Model Project Results

- At midterm, majority of students believed their Fellow *was* a scientist
- By end of year, majority was back to believing he/she was a student teacher
 - Definite gender dependence
 - *Very* scientist-specific
 - In some cases, image of a scientist went *down*
 - Passive F scientists/strong M or F teachers
 - Different results for girls/boys

Evaluation

- **Don't assume you know how to do it yourself**
- **Don't Duplicate Existing Materials**
 - Lit search education databases
 - Check large project review websites (i.e. QuarkNet)
 - NSF
- **It is easy to ask questions that give you the answer you want**

Evaluation

- **Observations (someone who knows how)**
- **Journals**
- **Surveys**
- **Portfolios**
- **Pre-Post**
- **Interviews!**

Back at the Coffee Machine...

- **What kind(s) of evaluation might you need to evaluate the project you are planning with your colleague?**

What Can You Learn?

**Question Conventional
Wisdom**

Graduate Teaching Fellows in K-12 Schools

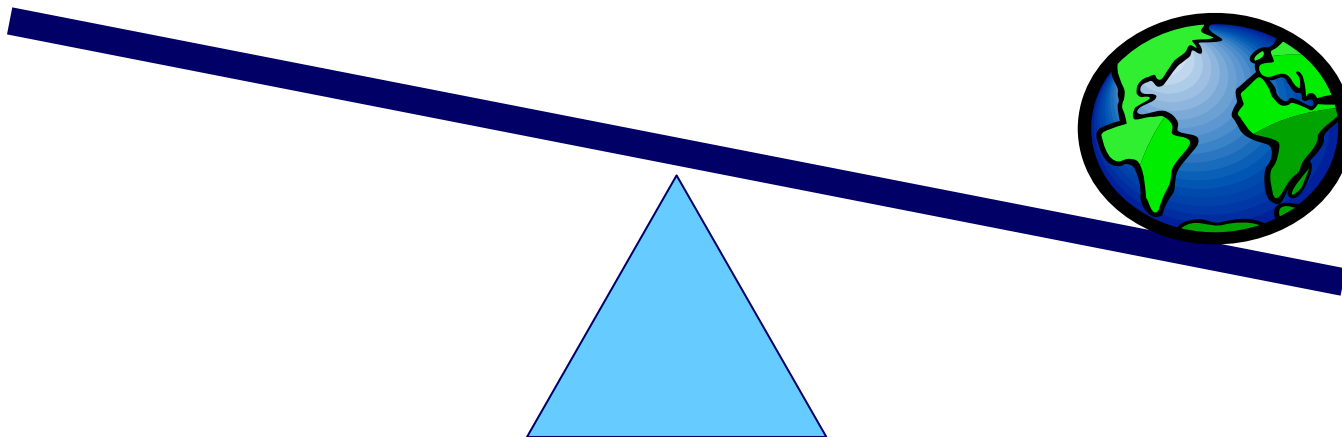
NSF's Primary Goal

Produce scientific research
leaders who are aware of and
sympathetic to the challenges
addressing K-12 education

Project Fulcrum – Year 4

– Give me a long enough lever and a place to stand and I can move the Earth –

Archimedes



Women and Outreach

- The increasing rate of women entering graduate school is not producing a commensurate increase in women Ph.D.s.
- Nationwide, 55% of GK-12 Fellows are female
- Significantly larger than the pool – why?
 - Women => nurture, interdependence, etc.
- Is it a good thing?
 - Can GK-12-type activities be a retention tool for women in math/science?
 - How does participation in a GK-12 program affect participants?

Attrition of Women in Math/Science

- Lower amount/quality of interaction w/advisors
- Isolation
 - Few to no female faculty members
 - Lack of a critical mass of females at the peer level
- Demands and routines that ignore safety considerations (i.e., walking alone to a car in the middle of the night)
- Conflict with family responsibilities
- Overemphasis on science and scientific learning that emphasizes competition and intellectual inquiry for its own sake rather than for the benefit of society.
- Lack of administrative response to climate issues
- Exclusion from collegial networking and social events

What Motivates Women to Participate?

- **Want to inspire students**
- **Generate student interest in science/math**
- **Improve their own teaching abilities**
- **Want interactions with younger students**
- **It's not a TA**

Results

- Participating women overwhelmingly felt experience was positive
 - 5/7 eligible to re-apply did
 - Addresses their need to feel 'of use', 'wanted', 'missed'
 - Increased self-confidence
 - Increased motivation to complete degree
- GK-12 takes same amount of time as TA, but nature of duties causes additional role conflicts
- Integration Issues
 - Is being away from the department a negative in terms of 'joining the profession?'
 - If the department environment is bad and PF is supportive, maybe being away from the department is a positive

Sharing Your Work

- **Talks, Colloquia, Seminars**
 - APS Meetings, AAS Meetings
 - MRS – Symposia on Materials Education Fall 2004
 - AAPT Meetings
 - National Science Teachers Association, Local Science Teachers Meetings, Local AAPT meetings
- **Publish**
 - Science Education Journals: J. Materials Education, Physics Teacher, J. Chem. Eng. Ed., Astronomy Education Review
 - Many disciplines are having special issues or special sections on education (Genetics, Cell Biology)
 - Collaborate with an education colleague and try education journals
 - Collaborate with a teacher and try a practitioner journal

Institutional Review Boards

- Your institution will require you to get informed consent from your participants for anything you want to publish
- Some require informed consent for *any* surveys or studies you want to do

Hallmarks of Successful Programs

- A scientist is fully involved in planning and execution and is rewarded
- The program's primary goal is meeting the needs of its audience
- For K-12: Teachers are involved from the beginning
- Real partnerships
- Thoughtful evaluation
- Commitment to dissemination
- Materials are used by people outside the original project
- Program is not vested in a single person

It's About *Them*, Not You

20 engineering students volunteer to teach elementary students

"The reason why you fell down and why it was harder for you to hold on with the backpack was – I paused momentarily to add more drama – 'gravity'

I sounded like Beakman.

'Gravity pulls things down and gravity is what makes things feel heavy. Remember this word because you're going to hear it every time I am here – gravity', I concluded proudly."

S.G. Hagerott "Physics for First Graders, Phi Delta Kappan, 78(9), pp 717-720

First, Do No Harm

“Reading *Physics for First Graders*” was disturbing in a familiar way, similar to what I’m sure I would have felt watching the author... plugging a speaker into a wall outlet”

D. Hammer, “Physics for First Graders?”, Science Education, 83 (6), 797 (1999)

Keys for Working with K-12 Teachers

- **Collegiality**
 - respect educators' expertise in education
- **Communication**
 - do not condescend
 - be aware of scientific jargon
 - don't always be negative first
- **Collaboration**
 - this is not a competition
 - project goals come first
 - explicitly define roles

***Should Scientists Try
to Make a Difference
in K-12 Education &
Outreach?***

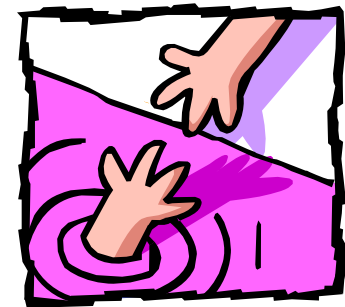
Should Pre-Tenure Scientists Try to Make a Difference in K-12 Education & Outreach?

$$\frac{\text{Impact}}{\text{Effort}} \rightarrow \text{LARGE}$$

Risk Assessment

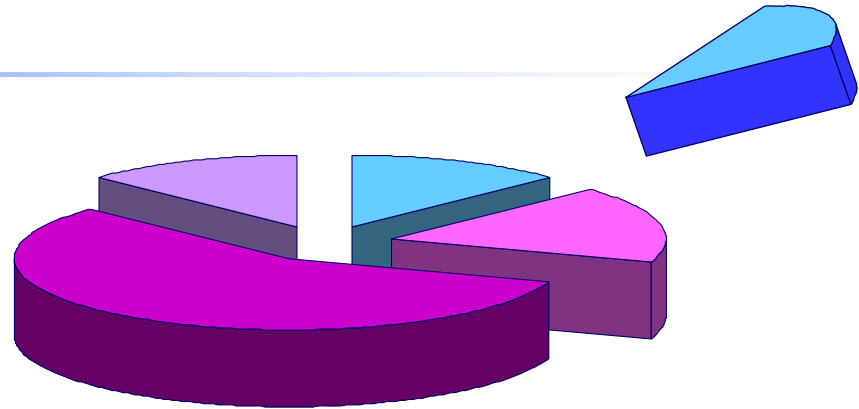
- Ask dept. chair if these efforts will be valued – *in a tangible way*
 - Will it count toward tenure?
 - Does your idea dovetail into existing departmental programs/priorities?
 - Can your idea provide visibility to help the department?

You can always start
AFTER tenure



Negotiate!

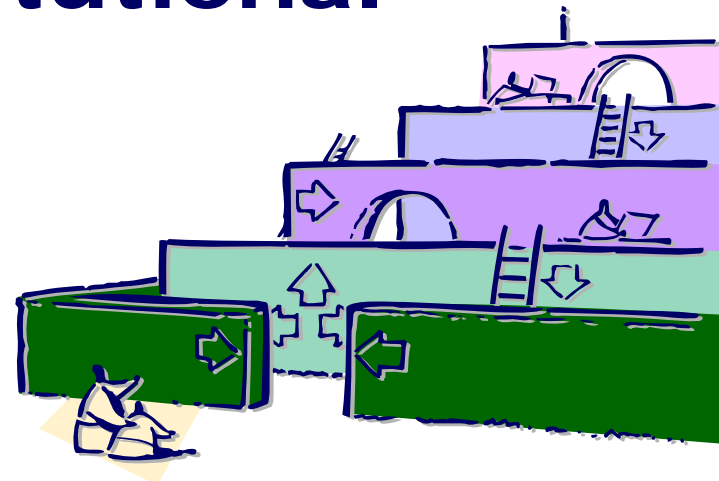
When something is added, something else *has* to give



- Not just outreach – Anything beyond standard expectations
- Can it be counted as part of your teaching or service load?

Institutional Support

- Use **existing** institutional structures
 - Secretarial
 - Organizational
 - Logistical
 - Managerial
 - Outreach Professionals



Invest your time in things that really require *your* skills.

Piggyback

PF as a framework for faculty who would like to (or must) include an education component in a proposal

- *We know what works*
- Contacts with Lincoln Public School District
- Developed a cadre of teachers who *want* to work with scientists

Example: All MRSEC participants are pledged to do 20 hours/yr outreach

Doing Both

Pros

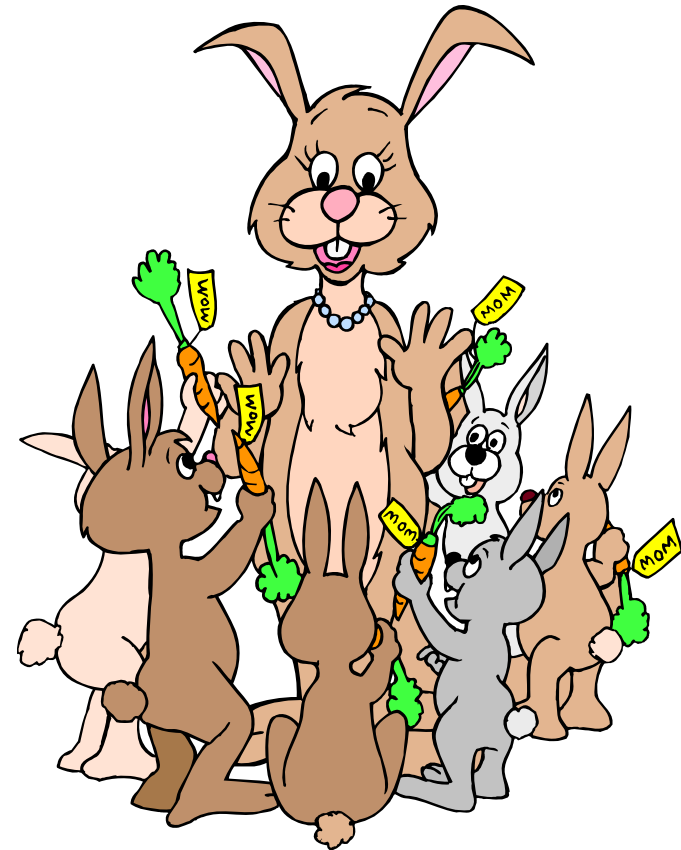
- More invited talks
- More papers
- More \$\$
- More visibility
- More invitations to review grants

Cons

- More refereeing of papers and grants
- More travel to give talks
- More papers to write
- Real need to efficiently divide your time

Balancing

Decide how much time you're going to devote to your outreach (teaching, family, etc.) and **STICK TO IT.**



**Can Scientists
Make a Difference
in K-12 Education?**

Yes.

From a Teacher

“Thank you for caring enough about science and children to invest like you have... this opportunity has given me the chance to self-examine/mindfully improve my quality of teaching on a daily/weekly basis. It feels like I'm in 'seminar' every week - and what a great way to keep fresh and keep learning.”

Is it a Waste of Time?

If you do it, you may not make an impact.

If you *don't* do it, you definitely won't make an impact

-Tom Weber

Conclusions

- Do things you feel passionate about
- Listen to the needs of the people you want to “help”
- Investigate what has already been done – and whether it worked
- Involve specialists
- Infrastructure!
- Stay optimistic



Project Fulcrum:
www.physics.unl.edu/~fulcrum

fulcrum2@unl.edu