Contents

GENDER EQUITY COMMENTS – JULIA A. THOMPSON

1 Objectives and Philosophy

1.1 Introduction

These comments are an extract of a proposal to the NSF (written in 2001). This one happened not to be funded because it was not closely enough aligned to the specific goals of the program to which it was submitted (not really focussing on physics and practical work). I have edited out the extraneous things, but thought the general comments might be of use the group working on gender equity.

1.2 Personal Context of Work

The P.I., Julia Thompson, has been introduced briefly in the summary, and more details are in her attached C.V. She is a native of southern Illinois and an elementary particle physicist. Both to use her physics experience as an example to encourage others in following a scientific career and in order to support and enjoy her extended family, she has, over the past few years, been meeting teachers and students in the southern Illinois area, in order to find how best to match her skills and interests to local needs. She has developed contacts within pre-college schools from Jacksonville to E. St. Louis, and those contacts expand each year. She has prepared computer infrastructure (at her own expense) to allow her to continue her collaborative elementary particle physics work from her parents' home. In fall, 2000, she started as half-time at the University of Pittsburgh, to allow her to pursue her plans in working with K-12 teachers in southern Illinois, as a replacement academic activity comparable to one term of University level teaching. The combination of the University of Pittsburgh, her DOE research funding (present rare kaon decay physics and prospective participation in the MINOS neutrino oscillation experiment at FNAL), her directorship of REUP-FOM, an undergraduate NSF Research Experiences for Undergraduates program with a focus on minorities, and her outreach work [note: Quarknet added in summer of 2001] comprise her research, teaching, and outreach activities.

It may seem odd to begin a grant proposal with such a personal statement. But the constant tug between professional and personal responsibilities is one known well by many women scientists [1, 2] and is one of the leaks in the "leaky pipeline" of talented young women, many of whom stop well before their abilities are fully developed and displayed. Many women have found informal solutions to this tug, but we need to make the solutions more possible, available, and visible if we wish to attract and retain women to our ranks. Thompson's outreach activities, including informal discussions of her own family along with her scientific work, demonstrate the existence of at least partial solutions to this tug of loyalties.

A fringe benefit of being a senior woman scientist is the knowledge that many of one's own experiences, which may have been rather inconvenient at the time, are in the end of some use in giving an example or changing the environment for one's junior colleagues. A parallel pleasure is to see those junior colleagues developing in strong, individual, and yet connected directions. This sense of having made a difference (together of course with the sense of excitement and discovery of our research) is part of what holds those of us who stay in our fields. While this proposal focusses on high school and middle school outreach, it weaves a web from senior academic women scientists, thread by thread and step by step, down to middle school students. At each step, women who have achieved can look forward to more senior women and backward to encourage more junior women. at SIUE in summer 2001.

1.3 Philosophy underlying our general outreach work.

The disparity of educational opportunity for different students, depending on where they live, is a glaring problem in our country [3]. The solution involves money – its availability and intelligent use. In many situations, local teachers already have good ideas but are unable to execute those ideas because of the lack of, or loss of, resources (time, equipment,training,...). In our view, key to the most basic problem is a combination of dedicated teachers, using a reasonable curriculum, and with a reasonable minimum of resources available. Additional features taken for granted in many schools include: availability of two years of each of the sciences; use of relevant elements of modern curricula; and effective computer use, as an resource through internet searching and as an adjunct to, but not a replacement for, critical thinking. In physics, curricula examples are: C3P [4] which emphasizes broad exposure to many concepts; the modeling curriculum emphasizing rational and rigorous examination of a smaller number of concepts [5, 6]); and the "Just-in-Time" curriculum [7] which incorporates use of the web. Hands-on activities should be a part of any effective curriculum [8], and extracurricular enrichment opportunities are important for the group of future scientists [9].

The schools in our area mirror generally the problems in the state and the nation, and our approaches to these problems build on the developing national body of best practice for inquiry-based activities with students and work with "newcomer" groups such as first generation college students, women, and minorities. [10, 11, 12, 13, 14]. To summarize, our work is based upon the ideas that:

1. there is a gap in the present science instruction delivery systems: good curricula are available, but not all teachers know about them, or have the means to teach them.

2. hands-on activities are an essential component of learning. Such activities motivate students to learn, both by exposing them to the excitement of exploration and investigation and by showing them connections from abstract scientific ideas to the real world. In addition, as in any activity, "practice makes perfect", and one cannot hope to acquire the skills needed for effective scientific work without exposure to its tools.

   The recent reworking of state and national standards to emphasize hands-on and inquiry activities reflects a consensus that students must be engaged in order to learn effectively [12] and that hands-on activities both engage students more effectively than the lecture-homework model and solidify understanding. Laws, Mazur, McDermott, Arons, Carter, the C3P high school physics curriculum, and the high school modeling physics curriculum all emphasize the importance of dialog and re-checking ones understanding through both conversation and experiment. [8, 12, 11, 15, 16, 4, 5].

3. even highly skilled and motivated teachers benefit from collaboration with a specialist in implementing substantial hands on activities. Scarce equipment, organized into kits, could be simply mailed or delivered to a school, but the specialist is more familiar with the equipment, associated concepts, and current status of understanding or applications. The partnership between the visiting scientist and the teacher facilitates successful student lab work by providing prompt personalized advice, important for any non-trivial lab to be successful in a short class period. Also, both students and teachers find the occasional contact with a specialist in the classroom to be exciting.

4. beyond pedagogical motivations, making the acquaintance of an actual working scientist may motivate some "newcomer" group members to consider a scientific career as a real possibility [17].

5. for highly motivated students and teachers, exposure to research, or other individualized extra-curricular activities, and taking more time than a 50 minute class, are an important component of scientific learning. Particularly for students with scientific promise but limited resources in their home schools, such activities help to nurture their interests and skills.

6. close association of undergraduate and graduate students with mentors while participating in research or mentoring others reduces attrition.

2 Proposed Activities

2.1 Connections of Women in Science to General Outreach

While in some ways more opportunities than ever are available to women and minorities, the fact that only $\approx$ 13.4% of physics PhD recipients in 1999 were women [18] indicates that some losses of scientific potential still occur. We have chosen to address these losses not at the graduate school or later, but earlier in the "leaky pipeline", primarily in middle school and high school, with some students continuing in our research component as undergraduates. Our proposal parallels the ideas of Malcolm [9], which, broadly stated, are: start early, stay rigorous, get experience **doing** science (hands-on, research, jobs), and meet role models, find out how they live their lives.

In addition to the general problem of how best to encourage and solidify critical thinking in all our young scientists, there are affective factors which disproportionately impact women and minorities [19, 20, 21]. Three factors have emerged as particularly important for the success of members of these groups: high expectations, classroom climate, and role models. The contact between a practicing scientist and a younger student implicitly sets high standards for the students, and presence of women or minorities in staff positions demonstrates that physics expertise is accessible to members of such underrepresented groups.

While much of our work is aimed at all students, with particular emphasis on those with limited home school resources, Thompson and Shaw find that women students are particularly receptive to the informal parts of their presentations and particularly likely to ask lifestyle questions such as "do you have any children?". Thus, even expanding our present work without a specific gender subtext is a small step in encouraging women to continue in scientific careers.

This proposal addresses directly two reasons for the losses of women to scientific careers: diffidence resulting from lack of hands-on experiences [10] and lack of role models [17]. A third reason: perceived conflict between values in the home environment and in the new environment of scientific colleagues, is addressed informally when role models are able to acknowledge that they too have felt such conflict and share some of their own solutions. But discussions about such conflict must always be handled circumspectly, with respect to the traditions from which the newcomer students are coming, and full realization that the solutions arrived at by one person will not necessarily be the right ones for others.

2.2 Expansion of Present Outreach Work

Below is a brief record of planned and executed visits with physics classes spring, 2001.

1. Four visits with physics class at Southwestern High School in Jersey County, $\approx$ 200 HS students. Teacher Julie Breden; introducing idea of cosmic ray detectors, (CosRayHS), helping to build and test simple scintillator cosmic ray detectors, and general waves and scattering lab. (25 physics students) Note: jat presented optics and other hands on activities to Ms. Breden's class in 1998, 1999, and 2000. Over the years she has worked with Ms. Breden's class, the enrollment

has grown from 5 initially to 25 this year. In 2000 Ms. Breden's class is a pilot project for the possible installation of cosmic ray detectors in southern Illinois high schools [22]. Ms. Breden will continue this work with Thompson in summer 2001 as part of her MS degree, through our pilot RET program.

2. Bunker Hill, ≈ 225 HS students. Mike Giles: waves and scattering lab. 8 students from physics class, geometry class also joined. about 25 students total.

3. Brussels, ≈ 90 students grades 9-12. Hugh Kinder: 16 physics students (class taught alternate years), three visits: evaluated equipment; waves and scattering lab; circuits lab.

4. Hardin HS (≈200 HS students) (Olivia Thouvenout): equipment inventory.

5. Edwardsville HS ≈ 2000 HS students. Cliff Parker: waves/scattering lab. 3 physics classes. 24,11,25 students. Prior to Parker's arrival Thompson worked with his predecessor, Lee Bolinger. Parker will begin work this summer, through the pilot RET program, on development of a cosmic ray detector to be placed in his high school.

6. E. St. Louis. TRIO (three ESTL Upward Bound programs; each program draws from the same geographical area serving Cahokia, Venice, Brooklyn, and E. St. Louis school districts, heavily minority. the participants are about 2/3 women). presentation to Upward Bound II (about 35 students; about 100 more may be addressed in later work), topic to be determined: likely simple hands on activity such as balanced ruler and weights, or perhaps basic introduction to elementary particles/adventures (in Utah Silver mine, Switzerland, Russia, South Africa) as particle physicist, ; more detailed collaboration with math and science Trio, which follows 50 students from 9th through 12th grade, including 6 weeks on-site at SIUE in the summer. Our REU students will help in tutoring and planning some Friday morning activities.

7. Northwestern HS, Palmyra, ≈ 150 students grades 7-12. Bill Metcalf: waves and scattering lab. 15 students, class taught alternate years.

8. Jacksonville HS, ≈ 1500 students grades 9-12. Susan Steckel: waves/scattering. three classes, ranging from 9th to 12th grade, math and physics. about 60 students total.

9. Carlinville HS, ≈ 540 students grades 9-12. Patricia Oser: inventory, explore physics equipment; waves/scattering lab on separate visit. (2 sections, about 50 students total)

10. Jerseyville HS, ≈ 1000 HS students. Jim Featherstone: waves/scattering lab. 2 classes, about 27 students total.

11. Alton HS, ≈ 2000 HS students. Nancy Meggos: oscilloscope, sound, electromagnetic wave lab. (developed in conjunction with teacher, at her request). two classes, about 30 students.

From the list above, some indication of the present range of activities is seen. A summary of the discussion on waves and scattering, a popular presentation, can be found at: http://www.phyast.pitt.edu/~jth/scatidea.pdf. In addition to collaborating with teachers on hands-on activities they suggest, we are exploring the scientific and pedagogical interest of an extended grid of cosmic ray detectors in high schools[22, 23]. Such a grid is being implemented by the NALTA groups (Alberta, Los Angeles, Nebraska, and Seattle) and serves as a way of connecting students' love of astronomy with modern technological tools. More details can be found through:(http://www.phyast.pitt.edu/~jth/CosRayHS.html), which has links to all the groups' web sites.

2.3 "Chilly Classroom Climate" Issues

Over the last decade or so a body of work generally referred to as "chilly climate" [21] has documented a number of differences in the approach of instructors to women and men, to minorities and "mainstream" students. We now know more about how to avoid these problems and how to motivate women to follow and achieve in science [19, 20, 10, 24, 25, 26]. Women do equally well with men up until about grade 6, when their interests and achievement begin to diverge. Some subtle factors appear in the classroom. Some examples are:

1. instructors may not challenge or call upon women, sending a signal that they don't expect them to contribute to the class discussion.

2. women students gain confidence in situations in which hands on work is closely tied to the conceptual discussions [10].

3. women may resonate more to an approach which allows interpretation rather than a purely empirical and analytical approach [27, 17]

4. women on average are more conditioned to find helping others important, and are especially interested in applications to enhanced quality of life (for example, for physics, medical instrumentation, superconductivity, semiconductors, lasers, devices to help handicapped people) [10].

5. while not necessarily explicitly a classroom attribute, an important subtext in many women's lives is family and peer pressure toward culture-specific activities (e.g., preparation for homemaking) rather than academic or scientific achievements.

Thompson was part of the visiting committees of the APS Committee on the Status of Women in Physics and the Committee on Minorities. These committees used pre-visit questionnaires to assess current situations, then gathered information through discussions with students and staff while present on the campus, and finally sent back their findings after the visit. While such a formal arrangement is probably counterproductive in this situation, Thompson's experience from these visits will be helpful.

Many of the chilly climate issues are common to settings from high school to graduate work.

In this work we plan to do surveys at the beginning of the year and at the end of the year, of attitudes toward science and scientific careers, for both high school and university students.

Identification of chilly climate issues will not immediately solve them, but discussions will sensitize teachers and demonstrate alternate strategies which might be more successful in encouraging women to continue in scientific careers. Correlations of attitudes toward scientific careers with classroom practice would be studied. Over time, cooperating teachers will gradually become more self-aware, and adoption of identified best practices will improve the classroom climate for women. Often, as in the women and minority visiting committees' experiences, practices which improve the climate for women will improve it for all students.

Of course, teachers would not be forced to participate in this aspect of the activities, but most who work with us are interested in improving their classrooms, and will welcome such assistance. Teachers with whom the idea has been discussed are enthusiastic about the project as a whole and none has wished to avoid the part focussing on encouragement of women.

2.4 Middle School Presentations

In the years 1993-1997, as many as 40% of high school physics students were women (a large increase over earlier years), but few of them considered a career in physics. In 1998, only 19% of all undergraduate physics degrees were to women [28]. We believe that the seeds of disparaties between men and women in scientific achievement are sown as early as middle school [29].. The leadership award would allow us not only to reach young women in high school who are studying physics and who may decide to consider science as a career but also to reach younger students and influence them to consider physics, at least at the high school level. We would expand Thompson's HS activities downward into middle schools, expand Shaw's school visits, and coordinate the two together.

We will consider which middle school presentations should be used. Possible **examples** follow:

1. One presentation, which has been popular with the schools Thompson has visited is a variation of the scattering ideas referenced above in the section on high school visits. It starts with the question "what is the smallest piece of anything you can make", and has the students in groups tearing pieces of paper into small bits and measuring them. Then we figure out some approximate number of atoms in the smallest bit (suitably hyped as made by the winner of our contest), and go from there to the ideas of how one found out about these small things, the idea of scattering illustrated by a cannonball in a blob of cotton candy, and finally introducing the funny "up" and "down" (happy and sad faces) and other strange, charmed, beautiful, and truthful quarks.

2. Another kind of presentation might be a joint social studies/science presentation

in which Thompson describes some of her adventures. One anecdote, a good motivator for learning languages, is her story of transiting Russia during the standoff between Yeltsin and the parliament, with the city of Moscow under curfew.

With some attention to scheduling, middle schools could be visited in conjunction with high schools, to minimize travel time.

2.5 Teacher Research Participation

It is important for teachers to become more aware of current developments. The Glenn report [30] has emphasized the need for improving incentives for high school science teachers in the field, and upgrading the high school science teacher's working environment, as well as the teacher's skills. All the opportunities in our project aim to include the science teacher as an important collaborator in science education. The research component of the program allows the teacher to participate in a research team, earning a stipend while exploring new directions in the field, keeping the teacher's knowledge fresh not only for the purpose of teaching but also simply for the teacher's satisfaction (with additional incentives modest stipends and the chance to earn academic credit, useful for Illinois recertification and points on most local school district pay scales).

Teachers and students will be encouraged to describe their findings to a physics meeting, following the example of Southwestern HS this spring [22].

Planned activities are summarized in Table 1 and discussed below.

Table 1: Summary of Present and Planned Objectives and Activities

About 10 schools and 300 students were visited in 2001, straining our present support. With the help of this grant we would expand the number of contact schools to be visited in a given year, stably, to about 15 and the number of students to about 450. We would expect to rotate schools in the visits, since a) not all schools have physics each year; b) when new teachers come into a school, a working relationship must be built up with the new teacher; and c) as teachers begin to absorb and use the equipment and hands-on activities, several of the labs may be done by the teachers locally, without requiring assistance from our group. A graduate assistant and undergraduate assistant will help in improving the kits and in some of the school visits.

Evaluation (by Prof. William C. Kyle, jr.) will be done through pre- and post- class surveys and sampling interviews of students and teachers. The time for the evaluation is anticipated to be ≈ 25 days.

School Year Activities

Objectives	Activities	Personnel
improve hands-on infrastructure in high schools and middle schools	refine presentations, using HS feedback	sr. phys. grad. and und. assts.
	participate in/lead hands on activities	sr. phys. grad. and und. assts.
improve classroom climate	identify strategies, (surveys, literature)	sr. phys. grad. and und. assts.
	implement strategies	staff, HS teachers
make female physicist visible	visit schools, make informal presentations	sr. phys. grad. and und. assts.

Summer Activities

Objectives	Activities	Personnel
Build teaching skills	devel. and eval. curriculum	staff, HS teachers (5), grad, and und. assts.
Build interest and research skills	research (material properties, elem. particle phys., CosRayHS, and physics ed.	dk,jt,tf,ks, HS teachers(5) HS students (5) grad. and und. assts. guest undergrads (5)
Build confidence	final presentations	HS teachers, students, and undergrads

facilities of the SIUE science departmens.

3 Results from Past NSF Funding

3.1 REUP-FOM: PHY9987904

Thompson has been the director, at Pittsburgh, of an NSF Research Experiences for Undergraduates site which emphasizes women and minority participation. The program is typically 90% women and about 2/3 or more minority. In the summer of 1999 a new component, Research Experiences for Teachers (high school teachers) was added, as a special supplement.

Full reports of the previous cycles of funding have been filed. Highlights are described below; further details are available in the full reports.

This program was funded one year for 6 students internally as a University of Pittsburgh pilot program, and has now been funded 7 years as an NSF REU site. In order to describe the program, we use the term

"student-summers", since students may participate in more than one summer.

In the first year of support (through the University of Pittsburgh), 6 students participated, all African American, and one woman.

Over the 7 years of NSF support, (93 student-summers), 51 students have been African American, 30 white, 7 international (African or Caribbean), 2 Hispanic (one American, one Spanish), and 3 Americans of Asian, (Asian) Indian or Pacific Islander; 34 have been men (20 African American men);

In the 7 years of NSF support through fall, 1999, there were 64 individual students (34 African American, 41 women). Of the 70 students total in the program since inception, 27 are still (fall, 1999) in school, 11 chose work in some technical area directly after completion of their undergraduate work, 12 combined some form of further study with work (graduate courses paid for by work, or first MS degree or beginning graduate school, then work), 18 continued into PhD graduate programs, and 2 have not yet been successfully contacted. Of the 18 continuing into graduate PhD programs, there is one each in the fields of materials science, engineering, radiation physics, math, biomedical engineerng, and computer science (NSF graduate fellow). There are two each in nuclear engineering and chemistry, and 8 in physics or applied physics. Of the 8 in physics, one is an international student, and 4 are African American. The students attend schools such as Pitt, Georgia Tech, Atlanta Clark University, Columbia, Michigan (2), and MIT. One Ford Foundation fellow who had been working in mathematical physics at the University of Pittsburgh with J.D. Crawford, one of the faculty in our program, decided to take a break from graduate school after Crawford's death in 1998., and is now pusuing a degree in Engineering Management at Old Dominion University while working with the Dept. of Defense. The one who dropped out after finishing his Associate Degree, (in part to support his family, including 5 children) did finish a technical training program as a chemical technician, paid for by ALCOA and PPG corporations and now works as a laboratory assistant.

3.2 Work with specific high school physics, general science teachers.

Below is a partial list of pre-college teachers with whom Thompson has worked, apart from those included in the visits described above. Work supported by NSF funding through a supplement to PHY9987904 are marked in bold face.

1. Richard Taylor, developed optics module using microwaves for high school demonstration. (summer funding, Univ. of Pittsburgh) (Quaker Valley High School)

2. **Ivan Ober**, as Research Corporation Scholar, assisted in design, construction, and testing of E865 optics and magnetic shielding, also data analysis. as RET (Research Experiences for Teachers) supplement, assisted in further data analysis (Mt. Lebanon High School).

3. Annie Watkins. jat worked with Ms. Watkins informally for about a year on jat sabbatical (unfunded), developing appropriate hands on activities with simple equipment to supplement usual hands on activities (East St. Louis High School).

4. Carol Davison. jat visited Ms. Davison's school, giving presentations based on trip to South Africa (where jat presented E865 results at physics conference, then visited physics classes in high schools around Capetown), and on jat normal collaborative physics travel to Novosibirsk, Russia. (special education classes, O'Fallon high school).

5. **LaDonna Singleton**, worked with the RET component of the REUP-UP-FOM program in 1999 and 2000, studying the physics behind lead detectors, and correlation of apparent depth of lead and lead detected compared to the measurements of our XRF device. The results of Singleton's work are being prepared for publication. (E. St. Louis, earth science).

6. **Andrea Habakuk**, participant in Teach for America, RET participant in 2000, working directly with Senior Lecturer Chandrelekha Singh on pretest to identify common misconceptions in magnetic fields and their effects. Habakuk has enrolled (summer, 2001) in a Master's Education program at the University of Pittsburgh, to receive full physics teaching accreditation.

7. **Loretta Williams**, RET participant in 2000, working directly with St. Louis University on development of better lead abatement techniques, specifically on testing efficacy of dust removal from carpets. Thompson also worked with Williams on inventory and organization of equipment in her school.

4 Section D: References Cited

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