The NSF/5C5E Handbook:
Doing Science Research in the Classroom

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Project Description

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Introduction

NSF/5C5E was a collaborative professional development program for teachers grades 3-12 based on the assumptions that:

- The most interesting and effective way to teach and learn science is to do science
- All students are capable of learning mathematics and science at relatively sophisticated levels
- Most teachers have not themselves had the opportunity to engage in research either during their undergraduate or graduate training and need that experience before they change their classrooms
- Using real-world topics that engage students' interest, the environmental sciences offer especially rich opportunities for engaging in research that is feasible, inexpensive, safe, and nontrivial
- Organizing teachers into research communities has two advantages: it models how scientists actually work and it is an extremely effective strategy for developing and managing a classroom full of young researchers

This Handbook has been written for faculty and staff of colleges, schools, science museums, or other collaborative groups interested in adapting our program to their own community. It was initially funded by the 1991-96 NSF Teacher Enhancement Project, NSF/5C5E (TPE 9150262). We hope you will be interested in our program, that you will think of ways of adapting it to your own setting, and that you will have questions. We look forward to hearing from you.

Designing and implementing a project based on the 5C5E model requires careful planning. Several major components are involved, and they all must be considered together. However, for clarity, we separate them in our discussion.

Many of these sections are also linked to specific descriptions of the NSF/5C5E Project.

This Handbook is also available in print or on disk from the Partnership (97 Spring Street, Amherst, MA 01002. Please call 413-256-8316. Checks or Purchase Orders ($5) should be made payable to Five Colleges, Incorporated.

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NSF/5C5E Rationale

The fundamental premise underlying our program is that teachers must participate in a properly structured research experience so that they may learn its value and be willing and able to design appropriate research opportunities for their students.

We designed our program so that teachers could learn about real-world topics that engage students' interest by using experimental systems and methods that are feasible, inexpensive, realistic and nontrivial. This program presented the concepts and related issues in several environmental science areas and used these to generate a variety of simple, safe, and interesting experiments that could be done during our training sessions and in the classroom. It presented teachers with a broad range of options as a tool box that they could adapt to their classes according to their needs, including field and laboratory studies of many physical and biological systems. The major emphasis was on the process of doing research "from scratch", so that the teachers are empowered to generate research projects on any topics that arise in their curricula or their day to day work with students.

Response to National Recommendations

Our project was designed in response to the national need for a citizenry and work-force that has the knowledge and skills demanded by the information and technology-based economy of the twenty-first century (SCANS, 1991). An underlying premise is that all students are capable of learning mathematics and science at relatively sophisticated levels. The fact that this has not always been true in practice is a reflection of our lack of understanding of how people learn. Cognitive science research has shown that individuals construct a personal view of the natural world based on their experiences. They need involvement in challenging experiences and the encouragement to think deeply about their meaning (Mestre, 1994). The classroom must be designed to offer such opportunities.

Many of the national reports focus on the interweaving of curriculum, pedagogy and professional development. All stress the importance of creating an environment in which students are engaged in long-term investigations and cognitive problem solving. All believe that we have underestimated students' conceptual abilities and stress the importance of their having the opportunity to think like scientists. (NSTA, 1995; NCTM, 1995; NRC, 1994; AAAS, 1993). There have been many efforts to develop the necessary school environment. One of the most comprehensive programs, the NSF State Systemic Initiative, focuses on transforming the whole system. SSI considers the school curriculum, classroom instruction, assessment, professional development, management, and governance. It also stresses the partnerships among the schools, the parents, and the larger community (Earle and Wan, 1995). The Partnership, which serves as one of the Regional Resource Providers for the Massachusetts SSI (Project PALMS), has found that this project enhances the other work in systemic reform.

Relationship Between National Reports and Doing Research

One of the best ways to work towards these national goals is to have students engage in original scientific research in their classrooms, something that has not even been considered in most schools in the past. Why is this a new idea -- why haven't we always expected students to conduct research as part of their science classes? Some of the reasons are logistical: too many students, too few supplies and equipment, too much information to cover, too little time. These are formidable problems, but many teachers have overcome them. There is a more fundamental reason why K-12 students have not been expected to do research: the teachers have never experienced it themselves.

Teachers teach the way they were taught. Unfortunately, their own college experience usually did not include any expectation that they would engage in research. That opportunity has been limited to some colleges and some honors programs. Teachers trained as secondary school science teachers have completed more science courses than elementary teachers, but with rare exceptions neither group has had the opportunity to do research of any kind either as undergraduates or as graduate students. Since they have not done research as students, they have not experienced the difference between learning through research and learning in a cookbook-laboratory environment.

Early in our planning, we found ourselves continually making the distinction between "research" and what might be called "science activities." Activities include "cookbook" exercises where students follow carefully outlined plans, where the methods are already chosen for them, and where no new knowledge is sought or where the answer is clearly known in advance. There is little encouragement or opportunity for students to follow up on surprising results or for them to ask their own questions. Activities can be very useful and have a real place in the curricula, but by themselves they are an incomplete picture of how science is really done. In 5C5E we insisted on developing methods by which students can experience true research.

We emphasized that the "scientific method" is not the cut and dried model that is often fantasized in textbooks. In reality, there is a lot of trial and error and evaluation and rethinking of the methods used and the results obtained. But certain methodological tools are used to allow sound conclusions, such as the use of controls in experiments, avoiding confounding effects in observations and including sound principles of experimental design such as replication, randomized sampling, estimation and comparison rather than just collection. We have made use of various approaches to help students choose questions, especially the four-question strategy (Cothron, Julia H., Ronald N. Giese and Richard J. Rezba, Students and Research: Practical Strategies for Science Classrooms and Competitions, Second Edition, Kendall/Hunt. 1993).

Defining Target Population of Teachers (Scholars)

The target population of participating teachers (and by extension, their students) must be decided at the very beginning of the program planning. Among the questions to be considered are whether to have multiple or single school districts, what grade levels to include, whether to have teachers apply as individuals or as teams, what additional criteria should be used, and what incentives/rewards can be offered.

Advantages and Disadvantages of Multiple Districts

There are two advantages of including teachers from a number of districts:

- It widens the range of teaching responsibilities, student populations, the ethnic and experiential background of the teachers, and the geographic diversity of school sites.
- Teachers move within districts and between districts - you lose fewer teachers in a multi-year project if they can continue from their new schools.

The major disadvantage is that it is more difficult to provide the formal and informal support for Scholars and their administrators - and therefore more difficult to support systemic change.

Advantages and Disadvantages of a Single District

The advantages of working with a single district, beyond those suggested above are:

- All or part of the program can be held at the school site, thereby providing teachers with a much richer understanding of their own school grounds and nearby areas than would be possible at a central location.
- It is easier and more important to arrange for the active involvement of principals, department chairs, and curriculum coordinators (where they exist) in the training.

The disadvantages of a single-district program are:

- Teachers do not benefit from the diversity of practices in other systems.
- Programs can sometimes be caught in the internal politics of a school district or in major changes in policy or administration that is beyond the control of the project staff or Scholars. Multi-district projects help participants to keep a perspective on these crises.

Deciding Which Grade Levels to Include

The original NSF/5C5E Project focused on teachers in grades 4-9 from the schools in the Connecticut River Valley of western Massachusetts. However, because of school needs and the changing job assignments of our participants, teachers from grades K-12 from schools with almost every configuration of grade levels (including K-8, 4-5, and 9 only) participated in the program.

- K-6 teachers are limited in the range of research projects that are developmentally appropriate for their students, but that should not necessarily exclude them from the program. Their skills and willingness to combine subject areas contributes significantly to the conversation.
- Middle grade teachers were the original target audience because of the developmental abilities of the students and the presumed flexibility in their daily schedules. They are still an ideal population for this kind of program, although the program staff should realize that teaching schedules are not always as flexible in practice as they are in theory.

High School teachers often believe initially they cannot cope with the logistics of research. They can - and should not be excluded from the program - especially with the increasing emphasis on long-block scheduling. Indeed, the constraints make them an important target audience. Their strong background in science benefits everyone.

Community College and four-year college teachers would be wonderful participants in the program. They face serious logistical problems in their introductory courses, but if we are to break the cycle of preparing teachers who do not have undergraduate research experience, they must be included. Our funding has not yet allowed us to invite them to participate in this project, but the Partnership sponsors other projects that include both school and college faculty as participants.

Teams vs. Individual Participants

Many reports on systemic change recommend that teachers attend as members of teams. We decided to include both individual science teachers and teams led by a science teacher. We make the following recommendations.

Include teachers coming alone - especially if they represent smaller schools that cannot produce a team or districts where the faculty is traditionally reluctant to participate. Such an individual often opens the door for others. "Tom had such a good time in his classroom this year that I wanted to see what it was all about."

Be sure all teams are led by a science teacher. Especially appropriate team members include those teaching on interdisciplinary teams, librarians, and principals. Elementary schools like to send cross-grade teams so that students have a continuous research experience (and teachers have support from their colleagues).

Beware of the danger that teams may become cliques or may reinforce each other's past practice. When teams carpool they have even more time to reinforce mis-information, "Hey, this research stuff is just hands-on activities with a few days in the library." Staff can avoid these dangers by organizing cross-school groupings of Scholars in various activities and by splitting large teams among the research communities.

We have included a detailed description of our recruiting procedures, which you can use to develop procedures for your site.

Selecting the Research Community Topics

In thinking about how to foster and manage classroom research, we found it useful to look at how professional scientific research is organized. It is, in fact, conducted in the context of loosely defined research communities. Scientists may work on a project individually or in a small group, but they are in contact with many others at their own and other sites who are interested in similar issues and who share a common knowledge base. These colleagues provide ideas, stimulation, and critical feedback and relate a scientist's work to a broader context. 5C5E adopted the research community model because it reflects how scientists actually work and because it is an extremely effective strategy for developing and managing a classroom full of researchers.

The basic organization and philosophy of the research communities, as well as the specific science content, is based on what we have learned from two cycles of 5C5E Scholars, plus our later, shorter programs. Each 5C5E Community included 20 participating teachers and two leaders, one college faculty member, whose area of research became the focus of the Community, and one school faculty member, who was an expert in science teaching. In the shorter programs we found that 15 was the upper limit to the number of participants in each community.

The selection of the college faculty, which is described in detail in the section Recruiting the Teaching Staff, will determine the general topics of the Research Communities. However, it is useful to have some criteria for the research topics before you begin recruiting the faculty. Each Research Community topic selected should:

- help the Scholars to understand the concept of research
- provide a natural vehicle for classroom research
- engage students and teachers
- involve cheap and safe materials, preferably using existing resources
- have the capacity for nontrivial research questions
- provide opportunity for easily discernible differences in the data
- relate to typical school curricula
- contribute to a deeper understanding of basic scientific concepts
- be appropriate for urban and rural schools
- provide opportunities for cross disciplinary and multi-site work

- encourage students with different interests and strengths to pursue their own investigations
- develop a greater appreciation of the local community and environment; highlight connections to major global concerns

It is also important to select topics which encourage students to go outside but do not require students to leave the school grounds for extended periods of time - data collection must be easy and safe. Here in New England, many of our stream and pond projects simply close down (actually freeze over) for the winter.

We have included a detailed decription of our three Research Community topics. Your topics will vary with the expertise of teaching faculty and local interests.

Selecting Essential Classroom Strategies

In the beginning, we thought we could focus all our attention on doing environmental research - letting the teachers work out their own classroom management strategies. Our school staff members disagreed. They argued that there were some absolutely essential classroom strategies that must be actively taught. Otherwise classrooms would be chaotic and teachers would either give up or reserve the research experience for small groups of well-behaved students. As one participating teacher (Scholar) said, "teachers need to learn how to be two places at once." Of course, our initial list of essential classroom strategies was far too long. We believe that our final list includes only those that are absolutely essential if all students are going to have the opportunity to engage in research.

There are special problems (opportunities?) which arise whenever a professional development program attempts to teach classroom methodology; the program is the teacher. If the teaching staff does not value a teaching strategy enough to use it themselves - the participating teachers will never it use it in their own classrooms. We, therefore, recommend that each strategy be presented in, at least, these four ways:

- assign readings that are discussed during workshops;
- lead Teaching Strategy Workshops in which Scholars have an opportunity to reflect on the strategy and its implications for doing research (in these activities we sometimes clustered the participants by grade level rather than Research Community);
- have staff (school and college) use the strategies themselves in the plenary meetings and research community activities;
- ask participants to reflect on the strategy and their use of it in their journals, their reports and evaluation forms.

Our list of teaching strategies included the following topics:

- Cooperative Learning
- Principals of Inclusion and Equity
- Principals of Cognitive Development
- Appropriate Assessment
- Parent and Community Involvement
- Using Writing to Learn Science
- Using Mathematical Analysis and Graphing to Learn Science
- Using Telecommunications to Learn Science

We have provided you with a detailed description of the rationale and methodologies we used for each of our NSF/5C5C Strategies You may want to add some additional ones - or eliminate ones that are not appropriate for your situation.

Recruiting the Teaching Staff

We recommend that each Research Community of 15-20 participants (Scholars) be led by two teaching staff: one college and one school faculty. (In our later programs we also had project alumni/ae serve as co-leaders as part of their leadership training.) It is, of course, essential to have teaching staff who are experts in their field, superb teachers, and work well with others. Such a high standard is not just a courtesy to participating teachers, it is essential because the act of teaching itself is the most powerful instructional tool available to any professional development program.

College Faculty

The college faculty must be excellent teachers and actively engaged in research - they must bring the enthusiasm and knowledge of a working scientist and the knowledge of how to formulate appropriate research questions. They do not have to be experts in the classroom strategies listed in this handbook, but they must be willing to learn, to adjust their teaching to include them, and to read the articles assigned to the participants. They cannot just "give lectures and run labs." They will find it more difficult adjusting to cooperative learning, inclusion, assessment, cognitive development and parental/community involvement than to incorporate the learning of science through writing, math, and computer technology. (We also recommend that you invite only tenured faculty to participate; this is a very time-consuming program and is not appropriate for young science faculty who should be engaged in research.)

School Faculty

The school faculty members of the teaching teams must also be excellent teachers of science, and must be knowledgeable and articulate about recent developments in cognitive learning theory and essential classroom strategies. They are more likely than college faculty to have had experience with team teaching - something that needs to be discussed and refined regularly at staff meetings. The teachers will be very helpful emphasizing classroom practically; they will have a more difficult time adjusting to a research-driven (and therefore flexible) syllabus.

It is important that everyone (staff and Scholars) understand that the college and school faculty are a teaching team - not a lecturer and lab assistant. Ideally, school faculty will represent different backgrounds: elementary/secondary, rural/urban, men/women, new/experienced, etc. If the Scholars include bilingual classroom teachers who are not comfortable with the technical English of science and classroom pedagogy, it is important to have a staff member with those linguistic skills. In the Partnership, we pay the school faculty who are members of teaching teams at the same rate as their college colleagues; traditional payment systems that calculate fees as a percent of academic year salary will almost always favor the college faculty.

Additional Team Members

Teams will sometimes need skills not provided by the instructional pairs. In our project, we needed special strengths in computer applications - especially in using spreadsheets and telecommunications. In another project, it might be a college faculty member from the Department of Education, staff member from a science museum or environmental center, or an environmental researcher from a private company or public agency. It is, of course, vital that these team members participate in all planning meetings and activities, do all the reading, and develop the same team teaching skills expected of the school and college faculty. We have also benefited by having college and high school students serve as teaching assistants in our program.

Additional Consultants

It is, of course, possible to bring in consultants on virtually any scientific or pedagogical topic. We benefited from having individual researchers work with research communities (for example, a plant pathologist who raised a strain of tobacco plants used as an indicator of ozone pollution) and from having the author of our reading selection on cognitive development lead workshops on that subject. These guests have also served as on-going resources for some participants. Over the years, however, the Partnership has found that most one-day consultants misjudge the expertise of their audience (in either direction) and would be better used as consultants to the staff rather than to the participants. There is also the danger of filling all the time with new ideas/people and not giving Scholars enough time to engage in and reflect on their research.

Staff Meetings

It is essential that instructional and administrative staff maintain regular contact at meetings, via minutes/mailings and, if possible, email. Our staff met monthly in the six months before the project began, and then after each single-day event and once a week during the summer programs. It is vital that these meetings focus on issues which are best addressed by the entire group (how to integrate classroom strategies into all the teaching, how the schedule is working, ways to team teach, how each participant is progressing) and not on information that can be communicated more efficiently in writing (reimbursement and ordering procedures, etc.) Each instructional team also needs to meet

regularly. We sometimes scheduled these before or after our all-staff meetings in order to reduce travel time. In our shorter programs, the staff met at the end of every day, reading journals and talking with the Research Community and then meeting as a full group to make any adjustments in the next day's activities.
A list of our NSF/5C5E teaching staff is included with the list of participants.

Program Schedule

This Handbook assumes that those involved in professional development programs realize that they teach more by how they teach than by what they teach. The decision about how time is spent is part of that teaching. Since we are recommending a relatively short program, decisions about how time is spent are especially important.
Our program included spring Saturdays, a 3-week summer institute, academic year meetings, and a 1-week follow-up summer institute. We have also offered the program as a one-week summer program with some academic year follow-up and a two-week summer program and are planning a academic-year only afternoon/evening workshop series. All shortened programs reduced the number of plenary activities - concentrating instead on the Research Community experience. One week programs were too short; they served as an excellent introduction but would have been strengthened by more time the first summer or an additional week the second summer.
Scholars have continued to emphasize the importance of "continuing the conversation." They stress the importance of call-back meetings in providing them with an opportunity to be inspired by the work of their colleagues, to refine some of their own classroom activities, and to become more confident in working with colleagues in their own school. In fact, every major evaluation questionnaire asks Scholars to list the most valuable resources; the most commonly listed resource is always "the other Scholars." In planning these activities, you can assume that a few summer participants will drop out (moving to jobs outside the area, transferring to different positions within their system, personal and family illness). The Partnership usually has 1 out of every 20 participants drop out during the follow-up year.
We have included details of the NSF/5C5E Program Schedule.

Leadership Training

In various places in this Handbook, mention has been made of additional follow-up activities beyond the 18 months. Although we recognize that these also add to the cost of a project, we are describing them here so that project leaders can think about ways to support these additional learning experiences. We were able to provide some financial support for these activities (travel expenses for presentations, stipends for participation in writing groups or serving as co-leaders of modified projects). There might be other ways to provide incentives (credit, meeting school inservice requirements) for these activities. Participation in these activities was voluntary. Of our 117 Scholars, 85 have participated in one or more post-program activities: 71 Scholars gave presentations, 36 participated in writing groups, and 26 have served as co-leaders of modified projects.
These activities serve a number of purposes:

- strengthen the project dissemination because the Scholars are more credible experts on managing a classroom full of researchers than the staff
- provide Scholars with an opportunity to reflect on their practice
- introduce Scholars to new or under-utilized professional resources (print, meetings, people)
- offer the Scholars some small recognition for all their work

We have included specific Leadership Training activities and procedures from the NSF/5C5C Project.

Resources

Facilities

We recommend that you locate your summer project on the campus of one of the college Research Community faculty. The project can then use the faculty member's name when requesting space and special facilities. Programs for single school districts, however, should consider using a school site. One of our most successful projects had teachers doing research on their own school grounds for two weeks - a dramatic way to change teachers' definitions of the resources available to them. No matter where the project is located, there are a few basic requirements:

- inexpensive, safe, convenient parking
- reasonably comfortable temperatures
- convenient access to lunches, coffee/juice, snacks, and potable drinking water - bring in if necessary
- access to appropriate lab facilities (these can be very basic since teachers will not later have access to sophisticated equipment -- some access to sophisticated equipment is valuable, but most time should be spent working with equipment readily available in the schools); it is essential to be able to make a mess - and running water is very useful; access to duplicating equipment
- secure meeting spaces where resource materials, posters, and other materials can be left each evening; each Research Community should have its own meeting/storage space
- access to computer labs where participants can work and where small-group instruction can be given on the use of software
- access (including a good catalogue and check out procedure) to print, tape, and electronic classroom curriculum materials - it is obviously easier to take advantage of a college, school, or science/environmental center library than to create your own
- plenary space - and a sound system if the space is difficult
- access to standard audio-visual equipment - overhead, slide projector, VCR and monitor
- refrigerated storage for food, bag lunches

Space for academic year follow-up meetings is not so complex. If possible, it is nice to have those meetings located so that participants continue to have access to curriculum resources; to safe, inexpensive parking; and, of course, to any special facilities needed for workshops (labs, computer space).

The 5C5E Project established and maintained its own Resource Center. We had already learned in the NSF/ SpaceMet Project that maintaining such facilities can be very time-consuming and hence expensive (Sternheim, Wilson, 1992). We strongly recommend that projects take advantage of established curriculum resource centers rather than trying to develop and maintain their own. Such centers can be found in some colleges, school systems, environmental centers and science museums, regional state department of education offices, and private educational organizations.

Recruiting Administrative Support for the Project

We were fortunate to be sponsored by the a school-college collaborative, the Five College/Public School Partnership. The Partnership was organized in 1984 to strengthen communication and share resources among the members of the consortium Five Colleges, Inc. (Amherst, Hampshire, Mount Holyoke, and Smith Colleges and the University of Massachusetts Amherst), the school systems in the four western Massachusetts counties (Hampshire, Hampden, Franklin, and Berkshire), and the museums, environmental centers and other cultural organizations, professional organizations, and businesses in our area. However, as helpful as the Partnership has been in providing support for the project, having an established collaborative in your community is not necessary for a successful project. Indeed, sponsoring a program could help develop such an on-going organization in your area.

It is not appropriate to expect school and/or college faculty to assume major administrative responsibility for the project. They have neither the support system nor the time. The project can be administered by staff at a college, school, or third-party such as a collaborative, environmental center, government agency, or business. If the home institution of the college faculty does not take major administrative responsibility, every effort should be made to have it co-sponsor the project so that there will be an on-going commitment to the participants.

The purpose of the administrative staff is to support the teaching staff and the participants. Obvious administrative responsibilities include:

- scheduling and facilitating staff meetings, distributing minutes, monitoring staff timelines and needs
- recruiting participants and sending all related communication
- working with the staff to decide on the schedule, preparing all related communications throughout the entire span of the project
- monitoring and working with the evaluators, helping staff act on recommendations
- arranging for and monitoring the use of all facilities
- monitoring the budget, ordering and distributing supplies, paying bills and maintaining records for auditors and for academic/certification credit, and compiling reports

Budget

The functional budget components are:

- Administration
- Evaluation
- Instructional Team
- Administrative and Instructional Team Travel
- Participant Stipends and Travel
- Participant Subsistence
- Participant Supplies
- Facilities

We have provided a detailed description of a possible project budget.

Evaluation

In a perfect world, the evaluation of professional development programs will provide the:

staff with timely, accurate information so they can adjust project activities; an opportunity to be reflective about the goals of the project so they can revise and re-prioritize them; a knowledge of the overall, long-term effectiveness of the project;

participants with an understanding of project goals and to allow them to contribute to the design of the project;

participants and staff with an opportunity to be reflective about their learning, thereby contributing to that learning and providing a model for effective classroom assessment procedures (Madaus, et al., 1992; Stevens, et al., 1993).

While we recognize that other projects will need to develop instruments suited specifically to its own goals, we recommend considering the following types of evaluation instruments.

Pre-program written questionnaire. These were especially useful in giving staff some background on the Scholars. We returned copies to the Scholars near the end of the program, asking them to reflect on their experience in the project.

Written questionnaire. These were scheduled at the end of each single-day sessions and at the end of every week of summer programs. We found that stating the goal (for the day or week) and then asking for comments provided participants with a better opportunity to be reflective (and provided us with better information) than the usual "what was the most useful/least useful" questions.

End-of-project questionnaire. We provided participants copies of their initial responses, asking them to reflect on their experience.

Interviews. We tried video-taped group interviews and individual telephone interviews. The participants definitely enjoyed the group interviews more and we probably got as much, or more, information. While these sources do not provide easily-tabulated results, they do allow the staff to move beyond the initial answers thus gaining a deeper understanding of the program.

Tests. Our staff and Scholars would say that we never gave tests. We did. Participants were often asked to reflect on what they had learned and what they still had questions about -- both in writing and in discussion. Participants were constantly being observed as they engaged in their research. Staff and other participants helped those having problems with concepts or with new skills. While there was never a grade, there was constant feedback on accuracy of understanding and mastery of skills. The research community staff also met with participants regularly to discuss the progress of their research and their classroom activities.

Products. Participants gave a formal group presentation (talk and/or poster session) at the end of the program. These were reviewed by the evaluators for their scientific accuracy and the extent to which the students appeared to have been engaging in research (as opposed to just activities.) Written summaries were also read by staff who followed up with additional ideas and resources. In a previous project, evaluators visited classrooms to confirm that teachers were, in fact, teaching according to project criteria (in that project, the goal was inquiry-based space science). We found that the correlation between teachers' descriptions of their teaching and the observed teaching was so high that we eliminated this very costly component from future programs. We did not ask teachers to keep portfolios (Actually, we did in the first cycle but found the teachers were so reluctant to surrender them for even a day for fear we would lose them, that we gave up.) Other projects should consider some way to encourage teachers to create and evaluate their own portfolios.

Student work. Teachers brought student work to the follow-up sessions and final presentations where they shared ideas with each other. We could not use test data because state testing practice is constantly changing, making it impossible for us to use state tests to compare students over time. We did review student work, but did not have reliable pre-post, long-term, or control group data. We recommend that all projects devise some way to collect such data.

In general, we recommend that staff be fierce about collecting evaluation forms. We traded meal tickets, parking passes, stipend checks, whatever we had available, for completed forms. The Partnership always asks that participants sign evaluation forms so that we can follow up on comments. We also summarize evaluations and return them to participants and talk with participants about changes we have made based on their suggestions. We also learned, the hard way, to provide enough time to complete evaluation forms thoughtfully. If time is provided at a meeting, the room should be quiet. For weekly evaluations, we handed them out Thursday afternoon so participants could fill them in at their leisure. In our most recent versions of the project, we have scheduled the last 20 minutes of each day for quiet, reflective writing about the day's activities. After participants had gone, teaching staff met to read and discuss the journal entries and to complete planning for the following day.

The selection of the evaluation team is described in the Budget section of the Project Description.

References:

Madaus, George F., Walt Haney, Amelia Kreitzer, Testing and Evaluation: Learning from the Projects We Fund, Council for Aid to Education, NY, 1992.

Stevens, Floraline, Frances Lawrenz, Laure Sharp, User-Friendly Handbook for Project Evaluation: Science, Mathematics, Engineering and Technology Education, 1993, NSF 93-152.

Project Description: Introduction

The NSF/5C5E Handbook is based on our NSF/5C5E Project (TPE 9150262), the Five College Education in the Earth's Environment, Ecology, and Energy Project. Now completed, NSF/5C5E gave teachers an opportunity to understand the nature of scientific research by actually designing and carrying out original research projects in environmental science. It also gave them the knowledge and tools needed to offer a similar experience to their own students.

In 5C5E, two cycles of 60 teachers (5C5E Scholars) participated in a program of at least 16-months duration, including three spring workshops, a three-week summer institute, six academic year meetings, a one-week summer institute, and optional follow-up activities. Scholars were members of a specific research community made up of 15 or 20 colleagues and members of the larger 5C5E community. In the last years of the project, we experimented with a number of shorter, more intensive (and less expensive) approaches. In all versions, teachers learned how to do research themselves and then helped their students to undertake their own research.

The Project Description is designed as a series of linked documents - these descriptions, in turn, are linked to the sections of the Handbook. For more information on those sections, go to the Handbook Introduction.

Recruiting Participants (Scholars)

Incentives - Stipends, Graduate and Recertification Credit

NSF Teacher Enhancement Projects traditionally offer $60/day stipends; Eisenhower projects offer $50; some others offer $100. In the Partnership, we have found that projects offering stipends draw a greater demographic diversity than those that don't: young women and men with child care responsibilities and/or summer jobs cannot afford to attend summer programs unless they receive a stipend to cover their costs (and the extra taxes since stipends are taxable income).

We offer many of our summer programs for graduate credit through Continuing Education at the University of Massachusetts. Although the credits have limited value for those enrolled in graduate degree programs (they have to be transferred into those programs), they meet contractual obligations and salary-ladder increases within the school systems. Our participants pay for their own credit (currently $170 for a 3-credit course) and some school systems reimburse their teachers. We recommend that the program staff explore the contractual needs of teachers with the local or state teachers association and the application requirements for credit approval as early as possible in the planning. Procedures can be incredibly complex; participants should be warned that they may need pre-approval of the course if it is to be used for a salary increase.

Staff should also check with the state teacher certification office to make sure the title of the course includes all the words necessary to meet recertification requirements for both classroom teachers and special teachers who may have additional certification needs (including Continuing Education Units for some state license renewals for some school staff).

Printed Materials

Most of our recruiting procedures have been developed over the past 12 years of the Five College/Public School Partnership. Along the way, we have probably made every mistake possible - from elegant fliers that took so long to print that the deadline had passed, to illegible copy with incomplete or inaccurate information, to descriptions that intimidated potential applicants.

We are careful that all materials have all the necessary information (dates, times, eligibility, expectations, compensation, and the required application information). Partnership materials are always printed in dark-colored ink on light-colored paper (so that schools can easily duplicate extra copies).

The information is always published in the Partnership's quarterly newsletter, the Partnership Calendar, which is distributed to over 5,000 teachers and administrators in the four western Massachusetts counties (Hampden, Hampshire, Franklin, and Berkshire). That is approximately half of the school staff in the area. We also use the same text to prepare simple (one-page, duplicated) fliers for each project which we distribute at other Partnership events and mail to individuals who we think might be interested or might be able to recruit appropriate participants. All Partnership announcements are also posted on the Partnership Homepage (http://k12s.phast.umass.edu/~partner).

If you do not have a similar newsletter, we recommend asking the publishers of other newsletters in your community to include your recruiting information. In most states, the state teachers association has a very useful announcement section of its monthly newsletter - as do many state and regional discipline-based professional organizations such as the local NSTA affiliate.

In fact, we sometimes wonder why we bother with fliers at all. Our most effective recruiting has always been done by participants in past projects (science teachers recruiting other science teachers but also foreign language teachers recruiting science teachers). In the past few years, more than 75% of our summer program participants have reported that they were encouraged to attend by a colleague. The fliers and newsletters do have a role, of course, but they are most effective in the hands of our teacher-recruiters.

Application

We do not use separate application forms because most teachers prefer to word-process their application. We never require a vita - many teachers do not have an updated, elegantly printed version and will put off applying if they believe that is essential. The flier requests candidates to provide the following information (limited to a single page):

- name
- school address and school phone
- home address and phone
- teaching responsibility (grade(s), subject area(s), position)
- a statement of why they are interested in the institute
- relevant background and experience
- how they envision integrating the program into their curricula and classrooms

Letter of Support

All Partnership programs ask for a letter of support from the principal or supervisor. We believe it is important for administrators to be informed of the professional activities of the staff - and to support them. The recruiting flier describes what must be included: a description of the applicant's present responsibilities and support for the activities of the project including whatever release-days are required during the academic year. The Partnership never asks for more than two release-days for any project. Since administrators' letters are often slow in arriving, we have a pre-printed form ready to mail to the applicant stating that we have received the application but not the letter of support. Principals can write one letter of support for an entire team.

Application Deadline

The advantage of publishing an application deadline in all materials is that you have a completed roster well before the event. The disadvantage is that, if you are not full, the printed deadline will discourage last-minute applications and the "new deadline" fliers carry a subtext of "failure." Instead of a deadline, we announce that we will "review applications the first of each month and acceptances will be mailed within a week."

We also recommend accepting at least 2 applicants to a waiting list - there are always participants who have to drop out for personal or professional reasons.

Notification

The Partnership sends a personal letter of acceptance to each participant with a copy to the principal, superintendent, and if someone else wrote the letter of support, to that person as well. The letter restates the dates, times, responsibilities, compensation, expectations, and costs (e.g. college credits, parking, lunches, whatever is not covered in the budget). The last paragraph states, "Two copies of this letter are enclosed, please sign one, add your social security number and home address, and return within two weeks of receipt of this letter."

A copy of this letter is later included with the request to the business manager for stipend payments in order to provide appropriate documentation. (An initialed attendance sheet is also submitted with the request for the final stipend payment.)

A press release of the acceptance is included in the letter (and in the copies to the principal and superintendent). We have found that newspapers are interested in school success stories - but are more likely to accept them from the schools than from us. These press releases also serve as a recruiting device.

Second Letter

Either the initial letter or a second letter, if time permits, includes a map to the parking and meeting space, information about food (what is provided and/or what the costs will be), appropriate clothing (our participants collected pond water in late March, they needed sturdy boots), and procedures in case of bad weather. In short, the letter has all the information that a participant who is not an experienced institute-attendee will need to feel welcome and comfortable.

Research Communities

The Earth Community

The Earth Community had two components, water and solid earth, woven together as they are in nature. The water component examined the relationships among rainfall, stream flow and groundwater from both water quality and water quantity aspects. Measurements were made of rainfall volumes and stream flow using simple, inexpensive materials so that teachers (and their students) could visualize and calculate, for example, how much water a one-inch rainstorm actually produced, and what fraction of that input ultimately appeared in a stream. Water-quality studies focused on some easy-to-measure indices such as pH, hardness, nitrate and dissolved oxygen to examine some regional variations in these constituents. Site visits included pristine, impacted and contaminated streams so that both anthropogenic and natural influences on surface-water composition could be documented.

The solid earth component examined the relationships between topography and underlying geology. The teachers participating in the program (Scholars) used topographic and geological maps of their localities to learn the relationships between the two and how they differ from the characteristics of other localities represented within the research community. The goal was to have them collect rock samples with their students during the school year and compare those (via the Internet) with those of the other schools in order to explore the relationships between the kinds of rocks in a locality and its geological characteristics and history. In addition, we looked at the range of topographic features in each locality, such as the underlying geological differences between flat and hilly regions of each site. Map analysis was supplemented by field trips to key areas. This component can also be woven nicely into the water component in order to focus the Scholars' attention on possible geological influences on water flow and composition.

The Ecology Community

The Ecology Community considered a range of ecological topics but focused especially on the concepts and related issues of (1) biodiversity and the study of plant and animal populations and communities and (2) sustainable agriculture and pest management. Plants, animals, and their interactions are fascinating and easily understandable to even the youngest students and thus provide a rich source of entry points to science as a process and even adventure. The community discussed what and how ecologists study in the natural world and concepts that have motivated research, such as the impact of ecotones (where different types of habitats, such as forests and fields, meet) or the search for nonchemical forms of pest control in agriculture.

One beginning experiment tested the effect of Tabasco sauce, which contains pepper (a natural insect repellent) on the choice of foods by crickets, using a water-only control. A discussion followed on how to do further experiments to see what in Tabasco actually repels crickets. Thus students quickly go from a basic concept in ecology and/or pest control to original experiments on causal mechanisms. Scholars were also given suggestions of a wide variety of animal choice experiments.

Plants are easy to grow in small pots in the classroom and can be used in experiments that mimic the production of agricultural crops and associated research questions. There are many interesting window-sill and seedling experiments such as the search for the optimum level of fertilizers and the use of vinegar to simulate the effects of acid rain. Other experiments developed by the teachers included: testing why you need to scarify seeds, growing sprouts, and finding the best way for growing flowers for sale by a class at holidays (an exercise in research to optimize real production). It is also easy to measure and graph plant growth. Small school gardens allow outdoor crop and insect experiments to test effects of mulches, fertilizers, organic pest control methods, etc.

The Scholars were introduced to a variety of methods to do experiments or sample populations of insects and other animals in the wild (including the school lawns, shrubs, and edges of parking lots). Teachers enjoyed great success comparing insects and insect diversity in a wide variety of habitats (e.g., trees vs. weedy fields) using sweep nets, pitfall traps, and other standard entomological sampling methods, suitably adapted to their grade levels. In addition, they discussed how students could offer choices of foods to other animals that are easily observed: they can watch birds or measure seed loss rates at feeders or offer choices of nuts or feeding locations to squirrels or place food baits for ants. It would also be easy to study plants in nature e.g. dandelions in the yard, trees in nearby woods. The Scholars reviewed the concept of diversity, along with other ideas about the distribution of different types of organisms in different habitats. They were then introduced to the basic techniques of using quadrats and/or transects to sample plant communities in varying habitats. These simple but powerful techniques produce a great deal of data that generates discussion and good opportunities for teaching math skills and graphing results.

The Atmosphere and Energy Community

The Atmosphere and Energy Community explored the delicate interplay between the atmosphere's chemical constituents and energy input from the sun. These are tied to issues of global warming, stratospheric and tropospheric ozone, and energy sufficiency. Such topics seem almost unapproachable given the dimensions of the problems, but we found a variety of inexpensive and readily available materials that allowed participants to carry out classroom research on them. The Scholars studied the basics of the chemistry and energetics of the atmosphere, the effect of modern human (industrial, energy-use, transportation) activities on the atmospheric balance, and explored alternative sources of energy and energy conservation. And of course, no examination of the atmosphere would be complete without understanding the connections to the earth (acid rain, el niño) and biosphere (greenhouse gas generation, gaia hypothesis), so we also bridged topics with the other communities.

One of the initial projects in the atmosphere/energy community studied the greenhouse effect through simple modeling using plastic soda bottles, but we opened up the experience to be more than an exercise. The greenhouse chambers designed by the Scholars were wonderfully sophisticated, and allowed them to develop scientific skills to refine their ideas and to isolate variables. To further study the greenhouse topic, we used an inexpensive test for carbon dioxide content, which allowed us to study production levels of this greenhouse gas. The Scholars calibrated this test on their own, incorporating additional procedural and math skills that could be applied in the classroom at the higher grade levels. Many studies developed out of this project: students studied the relative production of CO_2 from different automobiles, from human beings, and even from different animals.

In addition, we used a fairly inexpensive chemically-treated ozone test-strip to study tropospheric ozone. The amount of ground-level ozone is connected to the penetration of UV light from the sun, to the presence of certain pollutants, and to atmospheric circulation patterns. This connection allows for a variety of experiments to examine local ozone variations, and to study damaging effects on certain plants, crops, and trees. We also examined more directly technological approaches to passive and active solar energy collection (and related "alternative" energies), and experimented with designs to understand issues of conversion and efficiency. We concluded by applying ideas developed in studying the greenhouse effect to explore models of a "green" (energy-efficient) house by experimenting with different design strategies.

Teaching Strategies

Cooperative Learning Strategies

Without some kind of cooperative/collaborative organization of daily responsibilities, teachers cannot manage a classroom full of researchers. We found our Scholars' previous experience with this strategy varied from skilled to novice. We assigned readings (Johnson et al., 1988; Griffith, 1990), discussed the various approaches in a session - which itself was a cooperative learning activity - and used those models in the Research Communities. We also included questions about cooperative learning on the evaluation forms. At the end of the project, 74% Scholars agreed that cooperative learning was essential in the research classroom. (Writing ranked second at 34%.) In fact, somewhat to our surprise, we found that some teachers valued the research experience as an opportunity to provide an authentic task for developing cooperative learning skills - rather than the other way around!

Principles of Inclusion and Equity

Since our goal was to have all students engage in research, we had to be certain that the teachers knew how to observe their own teaching and their student's learning - and knew how to intervene to insure opportunities for all students. Again, we found that our participants' previous background varied widely. We assigned readings (Emmett; 1992; Delpit, 1990; Wheelock, 1992), discussed the issues, and tried to model appropriate behaviors in all our activities. We were assisted in our efforts by the fact that our participants were themselves diverse: demographically, in background and teaching responsibilities, and especially in their comfort with mathematics and computers. At the end of the project, teachers reported that many students became engaged in classroom activities for the first time - especially those with short attention spans. They also reported being more confident about intervening appropriately when they noticed less assertive students move to the back of the collecting area or away from the computer screen.

Principles of Cognitive Development

Our program was based on research in cognitive development and specifically in constructivism, i.e. that students come with a set of experiences and cognitive structures through which they interpret their environment, that if new information is to be a part of a learner's framework, and not just added on and easily forgotten, the learner must fit this knowledge into the existing framework. Therefore, the staff wanted teachers to understand this work. Again, they varied in their background, and again we assigned reading (Mestre, 1994), sponsored a workshop to explore the ideas (we were fortunate to have Jose Mestre lead these workshops), and used it as the basis of our discussions of what teachers had learned during the program. Teachers often spoke of the importance of this information in understanding the direction of educational reform. In fact, when they read the first draft of the National Science Education Standards their response was one of relief, "Well, at least these folks have read the research and are recommending what we are doing!" At one Friday meeting, we found that some of the Scholars had created a song about cognitive development to the tune of He's the Man Who'll Never Return. The chorus was: "Will they ever learn, no they'll never learn, when minds remained unchanged./ Constructivism will unlock the prison, and awake their slumbering brains."

Appropriate Assessment

New approaches to teaching require new approaches to assessment. Teachers need accurate feedback on the impact of new teaching methods if they are to strengthen their skills and continue to use innovative methods (Kelley, 1993). They can only get that information from assessment data. Again, our Scholars' backgrounds varied and, again, we assigned readings (Angelo and Cross, 1993; Marzano et al., 1993), held discussions, and tried to model good assessment ourselves (journals, written and oral project reports, staff observations, evaluations). Other programs might want to include portfolios and concept mapping.

The information from our assessment procedures helped the research community leaders when they met with the Scholars each week during the summer and at every follow-up meeting. These group meetings and individual interviews were used to provide feedback to Scholars on their classroom projects. Those participants who continued with follow-up activities (planning and giving presentations at professional meetings, writing for professional publications, and co-leading new versions of the project) received even more intensive feedback on their work from the staff and fellow participants. Our goal in all our assessment activities and discussion was to stress the importance of the learners (in this case, the participating teachers) developing the ability to evaluate and reflect on their own learning. It is this idea which Scholars reported as being the most useful to them as they reconsidered how to assess student work.

Parent and Community Involvement

This strategy was not included in our formal program goals and yet regularly appears on Scholars' lists of the strategies they learned and valued. It demonstrates that the informal curriculum -- what participants taught each other -- was as important as our formal curriculum. The Scholars described how parent and community volunteers helped by taking small groups to the stream for water monitoring projects, binding the research project notebooks, organizing fund-raising for research projects, and providing mentoring expertise to students. One classroom decided to organized a multi-year monitoring of the ecosystem changes along a new rail-to-trail bike path. Another used their research skills to organize community service projects for the middle school students. A number of classrooms are beginning to combine School-to-Work activities as part of their research projects.

Our shorter versions of the program include a workshop on enriching the program by involving the community. We would recommend that other projects include this topic in their discussion of classroom strategies. An excellent source of recent information is the National Association of Partners in Education (NAPE, 209 Madison Street, Suite 401, Alexandria, VA 22314), its state affiliates, and the state School-to-Work Office.

Using Writing to Learn Science

This strategy (and math and telecommunications described below) were much easier to include. We did assign readings and discuss each one, but mostly, we just did it.

Readings included Olson, 1985; College Board, 1990; there are many new materials available on this topic. All Scholars in our program received the traditional marbled-front lab notebooks and used them for both daily journal entries and their notes. Participants in research communities and plenary sessions were regularly asked to take a few minutes to reflect on what had been discussed and to write down their thoughts and questions.

In our later versions of the project, we set aside quiet writing time (20 minutes) at the end of each day. Staff then stayed to read the journals, write notes to the authors (either in the book or on separate sheets of paper depending on their teaching style) and then used the journal entries to help adjust plans for the next day. Scholars were asked to submit two reports of their work: one at the end of the first summer, a second at the end of the second summer. It was understood that these reports would be word processed, that computers labs were available, and that those (relatively few) needing help in learning an MS-DOS or Mac word processing program could ask for assistance from each other or the staff.

In addition, all participants attended one workshop on writing for publication at the end of the second summer and were encouraged to engage in individual and collaborative writing for publication. Three writing groups met for an extended time (2 during the summer, one during the academic year). Five Scholars have already had articles accepted for publication in major journals, another 6 papers, mostly with multiple authors, are being submitted for publication. At the end of the program, teachers reported doing more writing themselves and using student writing to both assess student understanding and their own teaching.

Mathematical Analysis and Graphing

The readings for this section (Fogarty, 1991; Jacobs, 1991) were really more about procedures for integrating curriculum than specifically about mathematics. There was no need to preach the importance of graphing and analysis; Scholars were surrounded by data. How could it be organized? What did it mean? What if the numbers had been different?

The staff was somewhat surprised to find how few teachers were familiar with spreadsheets and their graphing capabilities. However, the data drove the learning and virtually every Scholar used an MS-DOS or Mac spreadsheet program. (Older Apple II programs which did not allow graphic interpretation were soon abandoned.) Graphs also served as a good "bottom line" for research projects. When teachers (and later their students) could see how data would be graphed, it became a feasible project to undertake.

At the end of the program, many teachers reported that they were delighted that their students' mathematical skills were improving as they worked with their own messy data. One high school math class that was not allowed out of the building to collect their own data helped a fifth grade class analyze theirs. Teachers generally reported having students do more graphing and reflecting on results. Students, of course, learned to use spreadsheets quickly.

Telecommunications

In our original project, we supported a network of four user-friendly, microcomputer-based electronic bulletin boards. These provided participants and staff with a convenient way to share information and ideas. The system also provided a connection with the global educational and scientific communities using "echomail" conferences. These are distributed worldwide via the FidoNet network of about 30,000 bulletin boards.

We invested a significant portion of our funds in establishing this network, and a larger amount in support staff and other operating costs. However, despite its success, we no longer recommend the maintenance of such systems for project support. The explosive growth of the Internet and the equally rapid growth in user-friendly interfaces and in resources make the Internet the obvious medium for electronic communications.

Every college and commercial Internet provider offers access to gopher and world wide web clients, and to good electronic mail programs and newsgroup readers. Some, such as the UMassK12 service at the University of Massachusetts Amherst developed in part by our project, also provide a menu-driven environment that is especially easy to navigate. Graphical interfaces were added in the final year of the project, making it possible for Scholars to develop homepages so that their students could publish their research on the web.

However, the need for adequate training and ongoing support must be recognized no matter how friendly the system may be. People will always have questions about technical details, how to locate the resources they need, and how to use the most recent bells and whistles. We have not included references to the readings we used because so many new publications are becoming available. Those searching for good background materials should check with the American Association for Supervision and Curriculum Development for special issues of Education Leadership and newly published booklets. Information on the training programs offered by UMassK12 is available on their website.

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Program Schedule

Pre-Summer Meetings

Our original project included three spring Saturday workshops. Scholars were introduced to all research communities the first two Saturdays, selected the one of their choice and began their work on the third Saturday. For budgeting reasons, later projects eliminated this component, replacing it with written communication, phone calls to each participant from a staff member, and pre-summer readings.

It is better to have at least one pre-summer meeting where Scholars can become familiar with the site, the staff, each other and the program goals. When a project-plan does not include a spring meeting, a sense of community should be created through personal contact and letters. In a recent adaptation of 5C5E, our co-leaders (former participants) divided the list of those accepted and called to introduce themselves and answer questions. Everyone arrived knowing someone on the project staff.

In the Partnership we do not use introductory, warm-up games; we have found that the best introduction is the content itself. We begin teaching the way we will continue to teach. The content and the pedagogy themselves create a safe, comfortable environment for learning.

Summer Plenary Meetings

The schedule of our original project called for morning plenary sessions, with four days a week devoted to science (lectures, demonstrations, labs, field trips) and one day a week to pedagogy. The afternoons were spent in the research communities. In later versions of the project, we dropped the plenary science programs completely, spending one hour each morning in discussions of pedagogy and a half hour at the end of the day writing and reflecting. The rest of the day was spent in the research community.

In a two-week program, we recommend that morning plenary sessions (1-2 hours) include both discussions of pedagogy and science topics of common interest to all communities: acid rain, concentration/pH, greenhouse effect and energy balance, chemical cycles (oxygen, carbon, water), and ecology and biodiversity. Each of these workshops should include time for small groups of participants to design and even carry out brief independent investigations. In a one-week program, plenary sessions focus on pedagogy only.

Plenary meetings also help develop a sense of community. However, it is important not to confuse being together with doing something worthwhile. In a short program, it is important to consider alternatives to each activity. For example, we were able to eliminate plenary announcements by publishing (and relying on Scholars to read) a daily bulletin. Samples are included in the Appendix. The bulletin also solves the problems of those not in the room during announcements and is an easy vehicle for information on other resources or opportunities that staff and Scholars learn about during the institute. We also used chalk boards and newsprint in the coffee room to generate lunch meetings of groups of teachers interested in special topics - rather than have these logistical discussions consume plenary time.

It is essential to plan some kind of closing activity; it is equally important not to have this activity consume too much preparation energy and time. We have found that a brief overview of the research community's work, followed by a display of data collecting procedures and results, works very well and can serve as an appropriate event for administrators. Such presentations also help participants review what they have learned and practice teaching the new materials to others. There should be some kind of celebratory event so that staff and Scholars have the opportunity to reflect on all they have accomplished.

Summer Research Community Time

Each Research Community instructional team will, of course, need to work out the best way to use their time. Often, the first few days will be taken up with learning experimental techniques and understanding what questions can be asked; the middle will be spent collecting and analyzing data; and the last few days focusing on thinking about comparable activities in the classroom. (Questions and ideas about classroom applications are part of every day.) We predict that the initial schedule will include too much new information and not enough time to work, to reflect on data, to make mistakes. It is also possible that the schedule will devote too much time to planning for the classroom and too little time having the teachers engage in environmental research themselves. We recommend that participants spend at least 75% of the Research Community time doing research (including data analysis and reflection) and no more than 25% planning for their students.

Classroom Projects

We recommend that each Scholar leaves the summer program with a simple, written plan for the classroom and that they bring stories and student work to each call-back session.

Academic Year Meetings

The program should schedule at least one early fall meeting (to renew enthusiasm and get people started), one winter meeting (so that the first projects can report results), and one in early spring (so that everyone will have some classroom stories to share.) Having five sessions would be even better. Dates are usually selected during the summer institute so that everyone's schedule can be considered. Follow-up should continue once a semester for another year. Our meetings were planned with input from the Scholars and usually included Research Community meetings, some plenary discussion and new content information, workshop, or resource.

Some kind of informal project newsletter should be used to provide Scholars and staff with logistical information about meetings, and toupdate them on new resources, activities of other participants, and special events of interest to them. The newsletter should be monthly the first year and bi-monthly the second (and hopefully third). If Scholars have Internet or other telecommunication access, its use increases the level and ease of communication, but does not replace the meetings of participants. It can replace the newsletter if everyone is actively on-line.

Second Summer

During the second summer, the one-week institute was devoted to helping Scholars complete and reflect on their projects, learn new content, and strengthen some of the skills which were introduced during the first summer. While this adds to the expense of a project, it provides closure for both Scholars and staff and gives everyone a chance to make plans for the second year. We recommend that projects consider at least a 3-day second summer program.

We have included information about our post-program Leadership Training activities to help you design a multi-year program.

Project Leadership Training

Professional Presentations

The Partnership has always encouraged project staff and participants to share their experiences with their colleagues. Toward the end of most projects, we offer a workshop on giving presentations for other adults (something which makes many teachers uncomfortable) and more recently have provided them with an excellent reference book (Gramston and Wellman, 1992). While we encouraged Scholars to give workshops within their own school and school district and many do, we also publicized deadlines for state and locally-sighted national meetings and help those interested prepare presentation proposals. We did not send participants to national meetings (even when these meetings are scheduled in our area) unless the presentation had already been given (practiced) at a local or state level.

Participants gave presentations at the annual meetings in Boston (NSTA, the National Association of Biology Teachers, and Geological Society of American/Association of Geology Teachers) and at many regional science (MAST, MASS), mathematics (M3), computer (MassCUE) and education conferences (New England Regional Council of the Social Studies, New England League of Middle Schools).

In the Partnership we encourage, but do not require, that participants present as teams rather than individuals and that staff members serve on the team when appropriate. Staff are especially important if we anticipate that some of the questions will be technical in nature (either about the science, pedagogy, computer technology, or administration). We reimburse presenters for all associated travel costs, but we only subsidize the conference registration at the membership rate, expecting participants to become members themselves and to spend time attending other conference sessions and visiting exhibit areas.

It is, of course, an advantage to the Partnership to have teaching staff and participants describe their work at professional meetings - they are thoughtful and credible presenters. Teachers in the audience are much more likely to try a new approach or to help organize a comparable professional development opportunity in their own community when the presenters are also teachers. The presentations also provide our teaching staff and participants with well-deserved recognition for the work they have done. However, our main objective is extending the learning opportunity for our participants. We have found that giving presentations:

- helps participants continue to strengthen their teaching - they are naturally more conscientious about perfecting and being reflective about new teaching approaches when they have to present them to others
- encourages participants to widen their professional activities - many had not been active members of state and national professional organizations and attending conferences introduced them to the advantages of membership and to other resources described during the conference

We also found in 5C5E that presentations can serve as a team-building activity. One of our teams gave such an excellent workshop on their interdisciplinary project, The Pond, that they were asked to give variations of it at many different professional development conferences over the next three years of the project. During that time there was considerable turn-over in their team membership as new math, language arts, social studies, and special education teachers joined the team (the others leaving for a variety of family and professional reasons). It would have been very easy to give up the interdisciplinary unit. However, already-scheduled presentations of a very carefully organized project gave the team an extra incentive to keep the interdisciplinary unit in place - even with all the additional work necessary to train the new members.

Writing for Publication

In the first years of the Partnership, we were not very successful in convincing staff and participants to write about their projects for publication. A few excellent articles appeared (Bieda, Gibbs, Goldie, 1990; Watson and Konicek, 1990), but many wonderful stories were never written down. We even offered introductory workshops for project participants on writing for publication, just as we had done on giving presentations, but it is much easier to talk teachers into giving a presentation than it is to force them to sit down and write.

In 5C5E we did just that. Over a two-year period, we formed 5 voluntary writing groups, 3 during the academic years and 2 in the summers. Over those 2 years we learned that:

- the membership in the group should remain constant
- members of the group must be helped to follow good peer editing and process writing practices (ideally the leadership in the writing process will come from within the group)
- the expectation of a finished paper is essential - it is too easy to find excuses

The only extrinsic reward we could offer, a small stipend, was delivered when work was completed. We also found that concentrated time in the summer was more productive than meetings scattered throughout the year, but we were hesitant to exclude participants who could not spend time with us in the summer.

It is obviously useful to the project and the Partnership to have project staff and Scholars share in the dissemination responsibilities. However, the writing groups are organized primarily to provide participants with an opportunity to be reflective about their learning and for us to model our belief in the power of writing as a teaching/learning tool. Indeed those 36 participants who have volunteered to participate in these writing groups have described their increased understanding of the philosophy of the project and their own teaching practice. And the articles are good (Kinneavy, 1996; Jamros et al., 1996; Lawler, 1996; Smith, 1995).

Multi-media Dissemination

Early in the program, we also considered developing a videotape about the program. We rapidly learned the difference in quality and cost between professional and home-grown video work - and gave up. We would encourage others to budget for at least a 20-minute professional-quality video, which can be used by staff and participants as they explain the program to their colleagues, the community and larger professional organizations (estimated cost $40,000).

In the last summer of the project we were able to produce our first Internet homepages so that Scholars could help their students publish their research on the web. Scholars were trained to write HTML code (rather than just use a packaged conversion program) so that they could help their students extend the homepages in the future. While our

Scholars varied in their previous experience with the use of the Internet and Netscape, we found that they all needed two weeks to produce a set of linked homepages for their school.

Scholars as Project Leaders

It has been Partnership practice to ask some of the outstanding participants in one project to serve as staff in the next related project. Of course, the Partnership always gains new resources and skills this way - but so do these teacher-leaders who have the opportunity to reflect on their own classrooms while working with colleagues with different backgrounds, teaching responsibilities, and student populations. In 5C5E we were able to offer this opportunity to participants in five shorter variations of the project. The participants who have served in this role indicate that they valued the opportunity to help others while reflecting on their own learning experience. As they said, "You never really know it until you teach it."

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Project Budget

The estimated costs below are based on a program which has two research communities with 20 participants each. It assumes they will participate in a 2-week summer program, attend 5 follow-up meetings the first year, a 3-day second summer program, and 2 meetings the second year.

Administration

We recommend that, if possible, someone already responsible for coordinating comparable projects be asked to administer this project. The funding should be distributed among office staff, office supplies, and undergraduates assisting in office work and serving as go-fers during the summer. If the project can recruit undergraduates interested in science research or education, both the students and participants will benefit from the experience. Office supplies include phone, duplicating, and postage. The administrative team must work closely with the fiscal agent - ideally as a member of that staff or in some other arrangement that insures clear communication. We suggest a minimum of $5,000.

Evaluation

We recommend finding an evaluator who is familiar with good evaluation procedures and with school systems. We were very fortunate to have the Instructional Director of a local school as our evaluator. She was assisted the first year by a teacher and the second year by an undergraduate. Primary responsibilities included: working with the staff to establish goals and a decision making timeline; developing data collection procedures; monitoring, analyzing, and reporting, in a timely manner, the data collected throughout the project; logging major changes in goals, priorities, and activities; and providing the staff and participants with additional information on unanticipated effects. A discussion of the purposes of evaluation and types of data appears in the Evaluation section of this handbook. We suggest a minimum of $2,000 per year.

Instructional team

As mentioned earlier, school and college instructional staff should be paid at the same rate ($3,000/team member the first summer and $1,000 the second). This stipend includes the academic year meetings.

Administrative and Instructional Team Travel

The staff travel needs will vary with the project. Some projects will expect staff to visit school sites; some will expect them to give presentations at local and regional professional meetings.

Participant Stipends

It is a Partnership tradition to give participants the first half of their stipend the first day of the summer program. This provides them with the funds to pay for college credit, if they are requesting it, and sets a tone of trust. The second check, however, is given only when all project requirements and evaluation forms are complete and when all the clean-up necessary at the end of a teacher institute is complete (so much for trust!).

As mentioned under the recruiting section, participants receive a letter of acceptance which they sign and return. This serves as their contract with the Partnership. They are also asked to initial an attendance sheet at the beginning of each day. NSF rate is $60/day. We pay stipends for the summer meetings but usually not for the academic year meetings - especially not if they are held on release days. We also offer programs without stipends if funding is not available but recognize that there will be a decrease in the percentage of young teachers who cannot afford the child-care costs or the loss of second-job income.

We do not pay participant travel to the workshops themselves, but we do pay travel to professional meetings.

Participant Subsistence

The Partnership sometimes provides lunch tickets for institute participants - and sometimes does not. If you are able to find the funding for any lunches, we recommend that you at least plan Friday lunches in a quiet place where the group can talk and review the week's activities. If participants are expected to purchase lunches or bring their own, we recommend finding one local place where participants can gather to carry on their conversations. If you have not had previous experience with college dining commons in the summer, be prepared to have your schedule disrupted by the unexpected (freshmen parents who have lost their children, starving and assertive tennis campers, slower moving but equally hungry elderhostelers). We also provide morning coffee and tea, bring in dorm refrigerators for soda and juice and encourage participant-sponsored healthy snacks. We suggest that you budget at least $2/day per participant for coffee and snacks during the summer and $10/day for lunches or dinners during academic year call-back meetings.

Participant Supplies

In general we recommend that participants select their own materials rather than receiving piles of books they already have or don't want (make sure they keep their receipts). However, every participant should receive a copy of Cothron, Giese and Rezba (1995) at the very beginning of the program and be expected to read chapters 1-4 before the program begins. Some other science background and classroom strategy materials will need to be purchased (or duplicated with written copyright permission). As we stated earlier, we have listed the most updated editions of the materials we used. A list of the reading materials provided during our project appears in the Appendix: 5C5E Annotated Bibliography. However, we urge program staff to review newly published materials before making up their own list. We suggest $100/participant.

Facilities

There are two kinds of facilities needed: administrative offices and teaching spaces. Office space must include access to standard office equipment and supplies. The requirements for teaching facilities were described in detail earlier. Sponsoring organizations will sometimes donate these facilities as an in-kind contribution.

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