RESEARCH MENTOR'S REFERENCE HANDBOOK

THE STUDENTS AND TEACHERS AS RESEARCH SCIENTISTS PROGRAM

2011 STARS

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Sponsored by

LMI Aerospace/D3 Technologies – Solae Company – Green Foundation
Saint Louis University – Washington University
St. Louis College of Pharmacy
University of Missouri-St. Louis
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in Partnership with
Donald Danforth Plant Science Center,
Saint Louis University, St. Louis College of Pharmacy, Solae Company,
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http://www.umsl.edu/~sep/programs/stars.html

INTRODUCTION

I. The Issue

The scientific literacy rate in the United States continues to hover around 10%. This is unacceptable in the face of the technological knowledge-base needed to compete, survive and meet the challenges of the 21st Century. How will an informed citizenry be developed? Under what paradigm can the appropriate workforce be trained and readied? How can we meet the societal, economic and resource demands with the current state of science education?

A paradigm shift is needed in our thinking in the preparation of teachers and students. Teachers tend to teach as they have been taught. Historically educators have been taught through an autocratic process and not an experiential one. There is a need to change this strategy in order to better serve the science education of the citizens and the workforce demands of the institutions of this region.

II. Establishing a Solution

A. Introduction

The mechanism that best prepares teachers to teach science is to experience the process itself. A real encounter with the total scientific enterprise addresses both subject matter content and process skills. Through this realistic type of encounter, educators gain insight into how to properly go about teaching the sciences.

B. Mechanism

In response to this critical need to enhance student science education, our sponsors have granted partial funding to provide a program that will allow students to experience science as a learning process. This initiative entitled STARS is a unique program that seeks to achieve this goal.

GOALS AND OBJECTIVES

I. Mission

The mission of this project is to enhance the understanding and augment the application of the philosophy and processes of science and mathematics in teachers and their students and to promote the integration of research and science career activities into high school curricula.

II. Goals

The Students and Teachers As Research Scientists (STARS) program is designed to introduce both high school science teachers and associated rising junior and senior students to the multiple aspects of the scientific enterprise in real, on-going research programs under the mentorship of successful scientists and mathematicians in academic, private and governmental institutions.

III. Objectives

The specific objectives of the STARS project are to:

1. Foster an understanding of the philosophy, nature, and ethics of science and the dynamics of the scientific enterprise, including the methodology, aims, and the nature of the scientist in teachers and students;

2. Mentor teachers in the preparation and evaluation of laboratory-based curriculum projects initiated by a real research experience;

3. Upgrade the skills of teachers in developing and implementing curriculum materials using the learning cycle (spiral), inquiry and cooperative instructional strategies;

4. Introduce teachers to the concepts, paradigms and processes of action research;

5. Enhance content knowledge of current topics in mathematics, science, and related fields;

6. Provide experiences in scientific research design, experimentation and evaluation through the explorations of one or more scientific problems;

7. Instruct participants in technical writing and oral presentation of scientific papers;

8. Increase knowledge of the variety of career opportunities in science and technology and the breadth and depth of their applications in the workplace;

9. Allow participants to practice basic laboratory technologies in an open-ended, problem- solving environment and to learn the operation of a variety of technical equipment;

10. Provide participants with assistance and support for continued work on independent research projects and curriculum development and implementation;

11. Facilitate the development of social skills appropriate for professional and intellectual interactions, cooperation and leadership;

12. Provide participants with the opportunity to interact with peers of similar academic and career interests, reinforcing their goals and achievements; and

13. Establish an electronic network between teachers, students, and researchers for continued support and professional development.

A statement of the educational philosophy, mission statement, goals and objectives can be found in Appendix A.

THE STARS PROGRAM

I. Overview

The STARS program introduces high school juniors and seniors to the various aspects of the scientific enterprise as practiced by successful scientists in academic or private and research institutions. Seventy-eight students from 37 high schools have the opportunity to work with scientists, mathematicians and engineers in a professional work setting at either the Donald Danforth Plant Science Center, Saint Louis University, St. Louis College of Pharmacy, Solae Company, Washington University, or UMSL. The students join the research mentors and work together on a research project for six weeks during the summer. Students are encouraged to continue their work after the program ends.

Participants choose a research project from a variety of top quality research programs. More than 60 faculty members from the participating institutions have volunteered for this project. In addition, Solae, and St. Louis Children's Hospital have identified research scientists to make career presentations.

Participants work from 8:00 a.m. to 5:00 p.m. Tuesdays, Thursdays, Fridays and Monday and Wednesday afternoons. Monday and Wednesday mornings are reserved for the formal activities of computer research skills, statistical analysis, career consulting, and laboratory rounds. Formal instruction on writing scientific papers, paper presentations, and science lectures will be presented over the six-week period. Participants work together to prepare a report of their work in a format paralleling an article in a typical professional journal for that discipline. Oral presentations of their paper are made on the last day to peers and faculty. A generalized schedule of activities is presented in Appendix B. Appendix C

defines the various activities.

The overall STARS Program design is taken from the typical graduate student education format. Major emphasis is placed on development of skills associated with successful independent research. However, the mechanics for introducing and practicing these skills incorporates a guidance relationship with the scientist mentor and a more social and less independent relationship with participant peers. The common theme that underlies the generalized experience for each participant is the philosophy, process, mechanics, and social interaction of the total scientific experience.

This program will ensure that the youth of this region are well-educated in the sciences and will benefit the entire greater St. Louis community. It could ultimately serve as a nationwide model for pre-collegiate training of young scientists programs.

II. Specifics of the STARS Program

A. Research Component

Participants are expected to devote an average of 30 hours each week in a research environment, whether it be in a laboratory, in the field, at an observatory, or in a computer facility. Under the guidance of a chosen mentor scientist the participants experience various approaches to problem solving and have the opportunity to practice these approaches in an independent manner.

Each team of participants may have individualized experiences keyed to their choice of a research topic, therefore a universal activity program cannot be outlined. However a set of standard mutual experiences includes: 1) completing a comprehensive, systematic library literature search; 2) demonstrating theoretical reasoning in establishing research questions and formulating hypotheses; 3) using separation and control of variables reasoning to prepare an appropriate research design to test a hypothesis involving recognition and control of variables; 4) gathering data in an organized, systematic manner; 5) applying one or more forms of statistical analysis, 6) using probabilistic and correlational reasoning to interpret observations; 7) drawing appropriate conclusions using inductive and deductive reasoning patterns; and 8) preparing and presenting a research-based scientific paper.

It is anticipated that the nature of the research projects will vary as widely as the research scientists who have volunteered to mentor the students. Because of the limitations of the experiences provided and the short time period, the student research projects are not expected to be at the level or quality of publication in a professional journal. Rather, a more realistic goal would be to aim for the typical science fair level of achievement. The most important aspect of the experience is the students' exposure to the scientific enterprise and an opportunity to practice the mental skills and academic processes involved in systematic problem solving.

Each participant is expected to participate fully in the typical activities of the laboratory. They should learn requisition procedures, basic maintenance techniques, general administrative procedures, publication and audiovisual preparation techniques, and appropriate social and behavior patterns for effective group or cooperative problem solving efforts.

Each Monday and Wednesday morning the participants will meet to relate their experiences and research accomplishments in the Collaborative. This activity will be in an informal, group discussion format on the UM-St. Louis campus. Participants will share their insights into the scientific enterprise and their enthusiasm for their research project with each other and the STARS coordinators from each campus. They will also share their progress, career interests, and perceptions of the effectiveness of the activities of the program. Library, word processing, and statistical analysis skills will be reviewed on an as needed basis. The main purpose of this component is to guide participants into designing their own independent research project that can be continued at their high school. This project may be a continuation of their summer work or a new area that utilizes resources they will have during their regular academic year. For students these projects may be aimed at possible entry into science fairs, junior academy of sciences, JSEHS, math competitions, etc. *Students and Research - Practical Strategies for Science Classroom and Competitions* by Julia H. Cothan, Ronald N. Giese and Richard J. Rezba, Kendall Hunt, 1993, 279 pp. and *Guidelines for High School Students on Conducting Research in the Sciences*, 2nd edition, by Laurie A. Lyon, JSHS, Moore publishing Co., Durham, N.C. 1991, 47 pp. can be used as study guides and references.

<u>It should be emphasized that introduction to research methodology and the practice of the processes of science is the major component and objective of this program</u>.

B. Science Inquiry Series Subject Area Enrichment Component

Breadth of experience will be provided through the Science Inquiry Series. University faculty members and other researchers in the community will present interactive experiences in areas of their research interest. The setting will be similar to the typical university demonstration/laboratory and the participants will have an interactive role. See Appendix D.

C. Communications Component

In addition to the math and science disciplines, a communications component is woven throughout the program. Participants will have six hours of formal class instruction in technical writing.

Participants are expected to write and present a formal research paper in the area of their research project. Proficiency on both the written paper and oral presentation will be used to assess the growth in technical communication skills of each participant and the overall effectiveness of the research component of the program. The research presentation will be made on the last day to peers, parents, faculty, and private sector guests.

D. Career Exploration

The Career Confabs consist of presentations by leaders selected from participating institutions and the corporate world. Five major presentations are scheduled.

In addition to the formal Career Confab component of career education, there will be an informal aspect as well. This will come into play as the participants interact over six weeks with their respective mentors and other mentors of the research unit in which they will be working. During the Lab Rounds activities, students will visit other research laboratories and observe the variety of career opportunities available.

PREPARING THE SCIENTIFIC PAPER

I. Introduction

Objective: The primary objective of the STARS Program is to provide an opportunity for the participating teachers and students to become involved in a university-level research program. As a major component of that experience, the student will write a formal technical paper for submission to the Program in partial fulfillment of the requirements for becoming a STARS Scholar. The paper will describe the scientific body of work attempted by the participants. This paper will be written in a style typical of the particular scientific discipline and area of research. It will form the basis for the final oral presentation of the research completed by the student. The paper should include pertinent background information, experimental procedure, results, data, discussion, conclusions, and formal citations from the scientific literature. Internet sources that have not been peer reviewed should be discouraged.

Resources: The primary resource for the preparation of the paper is the research scientist (mentor). Additional resources to help the participants include: 1) a formal writing course with a knowledgeable scientific writing instructor; 2) the university library and staff; and 3) the staff of the STARS Program.

Responsibilities: It is the responsibility of the participants to seek the research mentor's advice and guidance, and it is the mentor's responsibility to oversee the preparation of the paper at all stages. It is the responsibility of the participants to work diligently on the paper from the first week of the program. The participants are expected to read the goals established for each week of the program, and to complete each assignment by the end of the week specified.

II. Schedule Guidelines for Writing the Scientific Paper

Week 1

Goal: Find and read background information that will help understand the scientific area in which the research will be conducted.

Responsibilities

1. Participants: Discuss research area with mentor; ask for suggested reading material; go to library to research topic; make a list of relevant books and articles; borrow or copy reading material; read the material; write down questions to ask mentor about the research area.

2. Mentors: Meet and discuss proposed area of research; provide reading material, or suggestions for books or articles that can be found in the laboratory or library; meet to determine whether the material is clear and understood.

Week 2

Goals: Write a rough draft of the introduction to the paper; statement of the problem; include the beginning of the review of literature and a complete the list of references to be used in writing the paper.

Responsibilities

1. Participants: Continue reading reference material, find additional reference material that may be needed. Take notes on all reference material. Compile notes into a rough draft of the introduction to the problem section of the paper. Discuss with the mentor the materials, methods and techniques that will be used in the research and take notes on these. Begin writing the paper as in the "Goals" above and turn a copy of draft to STARS supervisors.

2. Mentors: Meet with the participants and make sure they are "on target"; check to see that the appropriate reference material has been obtained; be sure the participants understand what has been read; discuss materials, methods, and techniques to be used in the research; help participants to organize an outline of the experimental procedure; read, revise, and return the rough draft of the paper.

Week 3

Goals: Revise the rough draft of the introduction to the problem; statement of the problem; review of literature; write a rough draft of the experimental procedure section of the paper, and begin to compile data and write results that may have been obtained to date.

Responsibilities

1. Participants: Revise the paper as in the "Goals" based on comments of the mentor. Discuss any problems with the mentor before writing the second draft. Be sure all references have been found and read. Write the first draft of the procedure of experimentation section. Record and analyze data, and begin to incorporate data into the appropriate section of the paper. Turn in the updated draft to STARS supervisors.

2. Mentors: Meet with the participants; discuss any problems with the paper and suggest changes for the second draft. Help the participants to understand the best way to record and analyze data. Read, revise, and return the rough draft of the paper.

Week 4

Goals: Finalize the introductory and experimental procedure sections of the paper, continue to compile and analyze data, and write a rough draft of the discussion of results section with results to date included.

Responsibilities

1. Participants: Write the final draft of the introductory sections of the paper based on comments of the mentor. All references should by now have been read, cited and included in the final reference section. Revise draft of the sections as needed.

Continue to record and analyze data, and write the discussion of results section of the paper. Discuss results, data, analysis and conclusions to date with mentor. Make semi-final graphs, tables, etc. for inclusion in the paper. Discuss these with mentor. Take notes on these discussions and begin to formulate the discussion section of the paper. Turn in a draft for STARS supervisors to review.

2. Mentors: Meet with the participants and review their progress; discuss the data and results to date. Help the participants to understand the data, and to formulate the results and discussion section of the paper. Help the participants to organize the data and establish reporting procedures. Read final drafts of the introductory section and methods section and suggest changes.

Week 5

Goals: Begin to finalize the paper.

Responsibilities

1. Participants: Finish recording and analyzing data. Discuss results, data, analysis and tentative conclusions with mentor. Make semi-final graphs, tables, etc. for inclusion in the paper. Write the rest of the paper. Turn in a draft for review by STARS supervisors.

2. Mentor: Read all the sections that have been written; revise and return to participants promptly. Discuss results and help participants to formulate the discussion and conclusions section. Suggest the most effective way to present the data in both the paper and in the oral presentation.

Week 6

Goals: Write the final paper. Prepare oral presentation.

Responsibilities

1. Participants: Discuss final results, data, analysis and conclusions with mentor. Prepare the final paper. Give to mentor to read, critique, and return with comments. Using the written paper as a guide, prepare an oral presentation. Prepare a power point presentation for the oral presentation. Practice oral presentation with STARS supervisors and research mentor prior to final public presentation. Turn in final paper to Mr. Kardis by Thursday. Present paper orally to peers and faculty on last day of the Program.

2. Mentors: Read, critique and return paper to participant promptly. Guide participants in preparation of oral presentation including a power point presentation**.** Listen to participant practice the oral presentation at least once, preferably twice. Come to the oral presentation and ask the participant appropriate, supporting and guiding questions. Attend the award ceremony.

Week 7-? (Optional)

Goal: With mutual agreement, provides an opportunity for participants to continue work and extend the research experience in the laboratory setting.

Responsibilities

1. Participants: Seek mutual agreement with mentor for extended laboratory work.

2. Mentors: Evaluate proposed extension of program for optional weeks. Establish feasibility, goals, and possible outcomes with participants.

STUDENT SCIENTIFIC COMPETITIONS

It is anticipated that some student research scholars will choose to participate in scientific competitions (such as science fairs; Junior Science, Engineering and Humanities Symposium; Intel Competition; 2012 St. Louis Science Fair; etc.). It would be desirable for mentors to discuss the question of science competitions with their students in the first week of the program. If the student is clearly interested, and the mentor is willing to have the summer project used in a science competition, **certain protocol forms must be done prior to the start of the work.**

If the student or mentor is unsure at that time, but thinks the project may eventually be used for a competition, it would be best to fill out protocol forms.

While the program and its faculty mentors have no obligation to support such endeavors, many faculty are willing to provide guidance to students who choose to compete. The level of support provided by mentors and teachers can vary greatly from simple encouragement and general advice, to personal involvement in the research and supervising the writing of the project report. Students interested in pursuing competitions should discuss this with their scientist research mentors and the STARS mentoring staff, since specific and unique protocols may be required (e.g., the St. Louis Science Fair or Missouri Junior Science, Engineering and Humanities Symposium protocol). Some projects that are done as part of the STARS program may be suitable (with further work and some modification of the paper) for science competitions; others will clearly not be suitable. **The decision as to whether a project performed in the mentor's laboratory is appropriate for a science competition is left entirely to the mentor.**

If mentors do not feel that the research performed as part of the program is appropriate for science competition or that there are proprietary considerations, but would be willing to help with another type of project to be performed in parallel or after the program, that possibility should also be discussed with the student. Students should anticipate the possibility of continuing their projects beyond the six weeks of this program in order to have a competitive project.

If desired, the science research mentor will have the responsibility for final approval of the text written for the presentation.

If mentors have any questions or concerns about science or mathematics competitions or how a project might fit with the goals of the program or have questions about the rules and regulations that govern the various contests call the STARS program office at 314-516-6226.

MENTOR RESPONSIBILITIES

The major responsibility of guiding STARS participant achievement falls to the faculty research mentor. The one-to-one relationship between the participants and the scientists is the link the participants have with the scientific enterprise as a reality. If we look back at our formative years most of us can point to an individual, not necessarily a particular body of knowledge, who was instrumental in our decision to explore science or mathematics as a career possibility. When we accept a STARS participant we are really committing to taking the responsibility of providing a working model, if not the sculpturing of that individual's lifetime perception of science and the scientist.

We are providing a list of some of the things you should do as a research mentor. Responsibilities of the research mentor are to:

1) Provide an orientation to your lab and the subject(s) of your research. Share some of your previous written work and personal and professional history with your participants.

2) If you teach, share some laboratory or class activities and personal experiences that might be of interest to the teachers.

3) Discuss the specific research and teaching interest of the participants and develop a research plan that allows them to become integrated into your lab activities.

4) Guide and supervise the research. Inquire on a regular basis to see if the participants have any questions or are having problems. Assist them in becoming involved with your lab team (post-docs, graduate students, undergraduate students, technicians, etc).

5) Require a laboratory log that includes a diary of observations and experiences during the program and, if appropriate, protocols and experimental results. Separate notebooks or logs might be needed, particularly if there are proprietary concerns.

6) Guide the participants in writing the research paper or in the case of the teacher, discuss possible lessons and instructional activities that might come out of their work. The format that you feel appropriate for the subject area should be used. Ask to review early drafts and comment on them promptly. Help to revise and prepare the final draft.

7) Help the participants prepare an outline of their final research presentation. Critique a practice presentation two or three days before the final presentation.

8) Attend the student's research presentation and the Students and Teachers As Research Scientists confirmation ceremony at the end of the six-week program.

9) In a personal manner, explore career opportunities with the student in your area and share your personal history of interest and professional development. Introduce the teachers to appropriate professional organizations or other sources of career information in your area.

10) Convey an enthusiasm and interest for science and support the emerging understanding of the scientific enterprise in both the teacher and student as the opportunity allows.

Additional Desirable Activities to Consider:

1) Attend a campus social function with the participants.

2) Invite the participants to your home for lunch, BBQ, or other appropriate personal or social function.

3) Take the participants to a professional meeting or formal seminar.

4) Take the participant to visit a colleague on yours or another campus or private sector laboratory.

5) Make known to the teachers your willingness to visit their classroom in the fall and perhaps give a guest presentation or help teach an activity they generated from their laboratory experience with you.

Please mark your calendar now to attend the STARS Confirmation Ceremony on Friday, July 15, 2011. We will convene at 3:00pm in J.C. Penney Auditorium, UMSL campus. Your student(s) would appreciate the support of you personally attending their confirmation. Dr. James C. Carrington, President, Donald Danforth Plant Science Center, will be the challenge speaker. All are welcome!!

Remember, you are in charge of the participant's experiences. Your research and laboratory activities take priority. Consider these participants as you would a graduate student or research assistant. They are yours with all implications that has for you as a professional scientist associated with the Students and Teachers As Research Scientists (STARS) Program as well as for the professional development of the participants that will be your charges.

BUDGET

Each participant carries a $1,000 allowance. The money can be used for expendables, equipment, travel, reference materials, salary, etc. Items can be purchased through the University of Missouri-St. Louis directly on the STARS account set up for that aspect of the program or funds can be reimbursed to your University through an invoice. You will be asked at the first-day luncheon how you prefer that your allowances be expended. Specific help with purchasing or reimbursement of funds can be obtained by contacting Kathy Kirkpatrick, Office Support Staff III, telephone (314) 516-6522, email kirkpatrickkj@umsl.edu or Fax (314) 516-6233.

You might want to ask your participants to establish a budget and keep informal account records. Any experience you can provide in the search for needed materials, requisition procedures and mechanical aspects of outfitting for a research project would be useful and add another dimension to the scientific enterprise that they probably have never considered.

SUMMARY

It is a rare opportunity for high school students and teachers to be able to work in a research laboratory setting. From past experience we know they will learn more about the research process and independent learning than they have ever envisioned. It will be a rapid and existing growth period for them. We believe you will gain a sense of accomplishment and feel a contribution to the profession as you see your participants develop problem-solving skills and gain confidence over the six-week period. We want you to know that we would like the program to be as individualistic as the personality and need of the mentor and the participants dictate. We also want you to know that we are here to help you meet the goals of the program and support you in your efforts to juggle your research and this added responsibility. We are here to help as much as possible without intrusion. A Help Directory has been prepared and appears as Appendix E. Do not hesitate to telephone and let us know how we can assist you.

Best wishes for a productive and rewarding summer as you join with your research colleagues in a science education partnership, the Students and Teachers As Research Scientists Program.