Student Science Projects and Science Fairs: How to Maximize Benefits to Students and Minimize Burden to Teachers

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STUDENT SCIENCE PROJECTS AND SCIENCE FAIRS: 
HOW TO MAXIMIZE BENEFITS TO STUDENTS AND MINIMIZE 
BURDEN TO TEACHERS 

Submitted to the Graduate Committee of the 
Department of Education and Human Development 
State University of New York 
College at Brockport 
in Partial Fulfillment of the 
Requirements for the Degree of Masters of Science Education 

by 

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CHAPTER 1

INTRODUCTION

Independent student science research projects are an invaluable component of secondary school level science. Often students do science projects which will be exhibited in a science fair. There is much discussion in the literature of pros and cons of science fairs. There is also much consensus on the value of long term independent student science research projects.

The purpose of this investigation is to focus on how long term student science research projects are conducted at several local schools, to review the purposes and problems involved in science fairs, and to collect techniques and methods for easing the burden on teachers and maximizing the value for students.

I propose to do a literature search which will describe the history of science fairs and student research projects. I will gather various approaches to providing students with science research opportunities. I will assess the needs and characteristics of Webster High School and make a recommendation for the most satisfactory method to incorporate student science research without burdening teachers or students, and how such projects can, in fact, enhance the science curriculum.
CHAPTER II

REVIEW OF THE RELATED LITERATURE

There are many journal articles discussing science fairs and science projects. Over the past 50 years, a few manuals on conducting science fairs and many books of ideas for research project topics have been published. Several universities have developed multifaceted science outreach programs which include science fairs. There are many national programs which include science project competitions. In addition, new educational program revisions are striving for more inquiry learning and authentic assessment activities.

History of Science Fairs in the US

The first modern science exhibition was held at a medical meeting in 1895 (Hull, 1961).

Even before WW II, students interested in science were encouraged to build or prepare projects for view in their own classes, hobby shows or school exhibits. Gradually several schools combined showings of the best projects. The first national science fair to gather the best projects on a large scale was held at Philadelphia, Pa. in 1950. In the 1950's, grades 7-12 participated in science fairs; grades 4,5 and 6 were beginning to get involved also (Welte, 1959).

The surprise orbit of Russia's Sputnik on October 4, 1957 and its Sputnik II with dog passenger just one month later was a shock to the U.S.. Immediately following Sputnik, the U.S. began investing billions of dollars in a variety of research, science education and teacher training programs all as a major attempt to regain U.S. superiority in science over
the Russians (Gilman, 1965). At that time, the rationale behind the science fair was that "Our future depends on scientists." (Welte, 1959, p.1).

In 1958, the first Chicago Student Science and Mathematics Conference was held. It currently hosts over 1000 students per year. Local businesses, industry, newspapers and colleges work together and sponsor monetary prizes and scholarships (Danilov, 1975).

Locally, the Rochester Council of Scientific Societies of NY was formed in 1960. A Science Congress program was developed for student science project exhibits and other student competition activities (NSTA, 1960).

During the mid to late 1960's, funding for science fairs declined (Lamb, 1984). Between 1965-1975 the popularity of science fairs fluctuated. By 1975, science fairs seemed to be on the increase again (Stedman, 1975). During the 1970's and 1980's, a variety of non-competitive and alternative type science events were developed. In 1989 there was New Jersey Chemical Olympics and a Chemathon in Maryland (Levine, 1989, Pax et al, 1989). By 1993, science fairs were gaining popularity (Galen, 1993).

The Department of Energy, Washington DC, and Sandia National Labs researched science fairs and prepared a 318 page program titled, "How to Implement the Science Fair Self-Help Development Program in Schools" (Menicucci, 1994).

**Purpose of Science Fairs and Student Science Projects**

The literature presented many purposes for science projects and science fairs.

- To promote interest in science (Burtch, 1983; Cothron, 1993; DeBruin, 1993; Fay, 1991; McNay, 1985; Vazquez, 1994)
• To give opportunity for "wondering and questioning" to develop deep interest in science (McNay, 1985)

• To gain a better understanding of the processes of science (Cothron, 1993; DeBruin, 1993; Gowen, 1993; Lacey, 1966; Stedman, 1975; Trowbridge, 1990; Kimbrough, 1995)

• To develop critical thinking skills (Blume, 1985; Cothron, 1993; Gowen, 1993; Smith, 1980)

• To advance student's scientific knowledge (Gowen, 1993; Trowbridge, 1990)

• To do science - experimenting - stating a meaningful problem, designing procedure, collecting data, and drawing conclusions (Gifford, 1992; Gowen, 1993; Knapp II, 1975; Lacey, 1966; Smith, 1980; Welte, 1959; Kimbrough, 1995).

• To encourage independent thinking and self-expression (Knapp II, 1975; Stedman, 1975; Welte, 1959)

• To provide opportunity to use knowledge and lab skills obtained in the classroom (Pax et al, 1989)

• To promote group learning and teamwork (Glassner, 1986; Levine, 1989)

• To increase minority and female students who are motivated and prepared academically to choose careers in science, engineering and technical fields (Champagne, 1987; Hill, 1990)

• To increase scientific literacy (Cothron, 1993; Gifford, 1992; Kelter, 1992; Rutheford, 1989; Welte, 1959; Vazquez, 1994)

• To develop library and writing skills (Eyster, 1969; Gowen, 1993)

• To promote creativity (Gowen, 1993)
• To practice statistical analysis (Gowen, 1993)

• To give Learning Disabled students opportunity to learn and grow more responsible for their learning, to experience a sense of accomplishment (Anderson, 1969; Rice, 1983)

• To enable participation in a scientific community (Bleicher, 1996; Richmond, 1998; Ritchie and Rigano, 1996). Apprenticeship models in science provide opportunities for students to develop technical and conceptual skills in addition to participating in the scientific enterprise (Richmond, 1998)

**Purposes more specifically for the Science fair:**

• To provide opportunities for the gifted and talented and scientifically-advanced to pursue research and receive rewards for their accomplishments (Darlington, 1986; Goodman, 1975; Gray, 1990; Levine, 1989; NSTA, 1960; Pax et al, 1989; Sisk, 1992; Stedman, 1975; Strassner & Simon, 1973)

• To ensure that students' academic achievements receive as much public recognition as athletic accomplishments (Grobman, 1993)

• To enhance community, school and home relations (DeBruin, 1993; Hoots, 1987; Welte, 1959)

• To find and stimulate young talent (Lacey, 1966; Strassner, 1973; Welte, 1959)

• To develop U.S. strength in sciences (Barry, 1959; NSTA, 1960; Strassner, 1973; Welte, 1959)
Suggestions for Teacher's Role

The science teacher's role in science fairs and student science projects has traditionally been to: (1) guide the students, (2) coordinate supervision of student projects with regular course curriculum, and (3) to plan a school science fair. The extra responsibility of supervising many student projects in addition to teaching already overloaded course curriculum can be a heavy burden on teachers (Menicucci, 1994).

Teachers are not always adequately prepared for such a role (Starr, 1972; Thorne, 1980). To prepare one's self for managing science fair projects, several suggestions were made. Refer to INTEL International Science and Engineering Fair (ISEF) rules and regulations regarding safety with hazardous substances, the use of animals in experiments, and criteria for judging (Lamb, 1984). Teachers should consult sources of assistance such as manuals for conducting science fairs, program guides, reference lists and web sites pertaining to science fairs.

Teachers should constantly keep track of and incorporate researchable topics into curriculum and then discuss with the students how to get involved in a topic (Starr, 1972). Investigating the local, regional, and state level science fairs will help in guiding the science talented. Gathering a list of potential sponsors and experts on various topics will be helpful when finding resources for students' projects (Anderson, 1974; Gifford, 1992; Starr, 1972). And finally, serving as a judge is an excellent method of learning about science fairs (Starr, 1972). In fact, Thorne (1980) recommended that pre-service teachers plan and conduct a science fair as a culmination of their student teaching at an elementary
school, and Dr. Walter Brautigan, SUNY Brockport Professor of Education, regularly invites his pre-service teachers to participate as judges at area science fairs.

Before beginning work on science fair projects and plans for a science fair, it is crucial for the science teacher to define the school's science learning goals and then proceed to design project criteria, exhibition and evaluation accordingly (Anderson, 1972; Stedman, 1975; VanDemian & Parfitt, 1985). Anderson (1972) stressed that the science teacher should

"Make a defensible decision as to whether or not to make available to volunteer researchers a "fair" in the traditional sense, with adult judges, and prizes. Weigh each aspect of such activities against your goals for student scientific attitudinal and rational skills development.” (p.204)

A survey of science teachers found that 42% of respondents felt that judging of projects is counterproductive because it moves the focus from science and learning to winning and losing. Poor quality judging and cash prizes can affect attitudes of participants (Grote, 1995).

Planning a science fair is best done with a committee of science teachers and a few parents. Menicucci (1994) explains that the main advantage of a science fair volunteer support committee is that it frees the teacher from organizational aspects of fairs and lets them concentrate on their job of teaching science.
Suggestions for Teachers to Guide Students

There were many suggestions for ways for teachers to guide the students.

- Explain what types of projects are acceptable. Explain what an experiment entails and if it is more desirable than demos, models or library reports (Smith, 1980; Stedman, 1975).
- Discover the child's interests. Students will do their best on projects that they are most interested in (Barry, 1959; Rivard, 1989; Kimbrough, 1995).
- Help a child identify a research problem that he can do (Barry, 1959; Rivard, 1989; Starr, 1972). Prepare a list of possible projects.
- Have students read and analyze actual research reports (Anderson, 1972).
- Prepare a list of criteria, requirements, expectations or rubric for each type of project in order for students to understand what is expected of them and later on to judge and evaluate the projects (McBride & Silverman, 1988; Stedman, 1975; Trowbridge, 1990).
- Act as a resource person (Gifford, 1992; Simmons, 1959; Trowbridge, 1990).
- Send letters home to parents explaining science project and fair, goals, types of projects, suggestions for parental assistance with library searching and daily log reports, weekly progress reports, resource experts, exhibition plans (Cothron, 1993; Menicucci, 1994; Teachworth, 1987; Vazquez, 1994).
- Invite parents to a meeting to present science fair plans and to answer any questions about the projects (VanDeman & Parfitt, 1985).
• Before beginning actual experiments, students should write a research proposal and obtain teacher approval (Fay, 1991; Rivard, 1989; Schenker, 1994; Ward, 1983).
• When students fail to stay on schedule, the teacher can send a letter to the parents informing them and encouraging them to help their child to complete to late work (Cothron, 1993; Fay, 1991; DeBruin, 1980; Teachworth, 1987).
• Teachers should consider allowing for pairs or teams of students to work on long-term projects. Cooperation is an integral part of scientific research. Most science journal articles have more than one author (Fay, 1991; Glasser, 1986; Grobman, 1993).

There were two unusual suggestions which were presented by only one reference each. To prevent parents from helping too much, one junior high school required that all work be done at school; the cafeteria was open two afternoons per week and there was an extra storage room for projects (Hansen, 1983). In an old teacher education text book, Welte (1959) advised science fair projects be optional because not all students will become scientists and that competition against classmates for monetary prizes should not be forced. Welte also cautions that science fair projects not be class projects because abuse of class time could generate resentment toward science.

Suggestions Regarding Library Research

The success of science fair projects is largely influenced by the background research done (Eyster, 1969). It assures student knowledge of the subject matter and thoroughness. Many students use only text books for background information. Teachers,
librarians, and parents should encourage thoroughness and help students locate resources (Cothron, 1993; DeBruin, 1993; Eyster, 1969; Ward, 1983).

A high school science research class can make a field trip to a nearby university library (Ward, 1983).

In the manual Students and Research, Cothron (1993) presents a comprehensive chapter with a five-stage model for relating library and science research. It also explains note-taking, use of concept mapping to define and narrow a topic, how to take notes on science research and technical procedures.

**Suggestions to Coordinate Teacher Supervision of Student Projects in Addition to Teaching the Curriculum**

Supervising individual student long-term projects in addition to teaching a full science curriculum can be a huge burden to teachers. Many references suggested introducing the scientific procedures to students during regular class and lab time (Anderson, 1972; Cothron, 1993; Fay, 1991; Starr, 1972; Teachworth, 1987). The manual of Cothron (1993) included specifics for modifying the curriculum and labs to parallel teaching components of experimental research through the fall and winter.

Because research project reports involve writing skills and math and statistics, some middle schools use an interdisciplinary approach thereby reducing the workload on the science teacher (Gowen, 1993).

Having the whole class do a long-term design project together aids student's understanding of scientific research methods. Koser (1985) has his physics class build bridges and "whizzers" and then tests the students' creations in class.
Doing a multifaceted "fair" at the end of an important science unit can be a non-competitive exhibition of students' projects, skits and activities for parents (Murphy, 1983).

An organizational tool called Gowin's Vee is useful for high school students to outline components of scientific experiments (Gurley-Dilger, 1992).

Research shows that girls have less contact and exposure to technical activities than boys and that more hands-on lab experiences and extra-curricular science activities help girls increase their confidence and interest in science (Champagne & Hornig, 1987; Hill, 1990; Jones, 1991).

Teachers should locate and bring together students and potential sponsors or experts (Anderson, 1972; Cothron, 1993; Menicucci, 1994; Starr, 1972).

Anderson (1972) had some good suggestions which included allowing students to read and analyze actual research reports, allowing students to analyze each others' thought and work while emphasizing the constructive effects of any objective criticism students offer, and to show respect for student decisions and allow students to experience the consequences.

A very effective way of teaching full high school science course curriculum and also ensuring advanced students pursue research successfully is to have a separate course (Sherman, 1984; Darlington, 1986) or a series of workshops or seminars (Galen, 1993; Glass, 1984). Students learn to define a topic, locate resources, write research proposals and research grant applications, have discussions with peers and scientists, prepare and give presentations and finally enter formal science fairs. These programs are especially
suited for meeting the needs of students considering science related careers (Sherman, 1984).

A last suggestion for meeting the needs of the advanced science students is to arrange for a mentorship whereby the student learns techniques and high-caliber research with a college or industry expert mentor (DeBruin, 1993; Gadd, 1979; Starr, 1972; Ward, 1983). One research study showed that success in science fairs is most dependent on the amount of time spent at colleges or universities (Gifford & Wiygul, 1992). Grote's survey of teachers found that over one third of the respondents felt that a scientist mentor was necessary to make student research projects successful (Grote, 1995).

**Suggestions for Teachers Regarding Parental Involvement**

Most authors appreciated parent volunteers and see parental involvement as beneficial to the students' science project experience. Only one author (Hansen, 1983) felt that too much parental assistance on projects was serious enough to require that all work be done at school. Some authors suggested informing parents of acceptable ways of helping and have students and/or parents complete a form stating the amount of outside assistance which a student received (Cothron, 1993; Fort, 1985; Gifford & Wiygul, 1992; Menicucci, 1994).

Parents can help students obtain pertinent information from libraries, colleges, and people with expertise (Burtch, 1983; Carnahan, 1988; Cothron, 1993; Fort, 1985; Gifford & Wiygul, 1992; Menicucci, 1994; VanDeman, 1985).

Parents can encourage student progress by use of a daily log book (Cothron, 1993; DeBruin, 1980; Fay, 1991; Teachworth, 1987). Letters home to parents when students
are falling behind schedule are useful (Cothron, 1993; Menicucci, 1994; Teachworth, 1987).

**Types of Science Fair and Competition Opportunities Available**

Organizations providing assistance and opportunities for exhibiting results of student science research projects include:

- Duracell/NSTA Exploravision Awards Program
- Future Scientists of America
- International Bridge Building Competition
- International Science and Engineering Fair (ISEF)
- Jets-Teams Competition and National Engineering Design Challenge
- Junior Academy of Science (AAAS)
- Junior Science and Humanities Symposium
- Science Congress
- Science Olympiads
- Science Clubs of America
How Do Science Projects Fit In With the Goals of New Programs?

Benchmarks for Science Literacy states that

"Before graduating from high school, students working individually or in teams should design and carry out at least one major investigation. They should frame the question, design the approach, estimate the time and costs involved, calibrate the instruments, conduct trial runs, write a report, and finally, respond to criticism." (Benchmarks, 1993, p.9)

The mission of Webster Central School District (WCSD) is to provide an environment in which all students can achieve success and become productive citizens. (WCSD K-12 Curriculum, 1996, p.7) Of the nine essential outcomes for students, all but the last outcome are met by doing a long term independent science research project. (See Appendix C - Essential Outcomes of Webster Central Schools)

Science research experience also meets all of the Webster Language Arts Standards - Writing, Reading, Speaking, and Listening - in relation to expository writing and reporting. (WCSD K-12 Curriculum, 1996, Chapter on Language Arts)

Science research experiences help students meet all four of the standards for Science in Webster High School, but most thoroughly cover Standard 1. Understands scientific inquiry and models, and utilizes them to pose questions, address problems, develop solutions, and make informed decisions. (Appendix C - WCSD K-12 Curriculum, 1996, Chapter on Science).

Clearly, long term independent science research projects far exceed the standards and goals of science and language arts education!
CHAPTER III
DESIGN OF SURVEY OF LOCAL SCHOOLS

My initial research proposal, spring of '95, included conducting a survey of STANYS - CWS science teachers (Science Teachers of NYS - Central Western Section). The purpose was to determine which schools included student science research projects and whether school size, funding, teacher commitment, or number of AP courses offered, had strong influence on the schools' provision for student science research opportunities.

In Statistics course, EDI 685, summer of '95, I designed a survey and tested the plan for statistical analysis. The data was from graduate students completing the questionnaires based on what details they knew about local schools. The only factor considered for this test survey was school size v.s. number of science extracurricular activities. The results suggested that as school size increases, a significant increase in the number of science activities that the school participates in does, in fact, occur.

A revision of the research approach was necessary. Sending surveys in June 95, and 96 resulted in zero returns. In addition, after teaching full time for a few more years, it has become clear that the key factor in whether a school provides opportunity for independent student science research projects is the presence of a teacher who believes in the value of such opportunities AND who is willing to commit the extra time and energy required for successful facilitation of student research.

In spring 1999, I revised the research project to include, as a goal, evaluating various programs in order to determine what program would best meet the needs of
Webster High School. Information about local high school courses and approaches was obtained by phone calls and visits with the teachers involved.
CHAPTER IV
SURVEY OF SCIENCE RESEARCH COURSES

Introduction

During the summer of 1999, I interviewed the Science Department Chairpersons of 12 high schools in the Monroe county area. The questions asked varied depending on whether the school had a science research course. For anonymity, the schools will be identified as school A, B, C, etc.

In addition, a school program which is running successfully in many schools in eastern New York is included because of its strong specialized NSF sponsored research approach.

Variations in Science Research Programs at Local Schools

Three schools (A, B, C) reported offering an elective science research course primarily for juniors and seniors to pursue an independent research project of their choosing. Skills such as developing a hypothesis, library searches, reading journal articles, designing experiment, statistical analysis, writing and presentation are taught as needed. Students enter Science Congress, Intel ISEF (formerly Westinghouse), Junior Science and Humanities Symposium. A spring presentation night provides an opportunity to communicate the results of completed projects along with work in progress. Mentors are optional, but generally, only projects involving a mentor are completed successfully. The optimum class size is 6-12 students. Of the three schools offering this course, schools B and C, which began within the past 3 years, are experiencing difficulty enrolling the minimum number of students as designated by their principal which does not realize that the optimum research class must be small (i.e. 10).
School L has regularly offered Environmental Studies Independent Study for juniors and seniors. A few (4-10) students meet with the teacher during free periods and are guided in a long term independent research project involving environmental science. Students also take the AP Environmental Science exam in May. Skills building is individualized as needed. Having a regular whole class meeting time would improve skills building, provide opportunity for group discussions and support and, ultimately, make students more successful. The Environmental Science Independent Studies students participated in the high school’s spring presentation night with the mandatory Regents Biology projects. Some projects also went to Science Congress and further competitions. The weakness of independent study will be remedied by offering an AP Environmental Science course which includes an independent long term research project.

Schools G and L have a spring presentation night with mandatory Regents Biology projects poster and paper exhibited and graded but not judged. A few of these students continued to Science Congress. School G is planning to end the mandatory aspect of the projects because of an increase in inquiry and experimentation and writing in the school’s revisions of Regents Biology labs.

Several schools (D, E, F, K) which did not have a regular science research course explained that many AP science courses were already offered and that some of the AP courses included a student research project during few weeks after the AP exam. The end of the year is full of activities for juniors and seniors and it doesn’t allow enough time for skills building, experimenting, and writing of thorough papers.

School D offers an elective science research course which involves seniors in ongoing U of Rochester science research on parasitic wasps and chromosome analysis.
Skills are taught and practiced with a few group experiments. Then each individual designs a project involving some aspect of the ongoing research topic. The benefits of this program is that students don't have to struggle to choose a topic and will have the skills required for experimenting. In addition, the teacher is facilitating a topic for which he is very knowledgeable rather than trying to manage students on a wide variety of projects outside his area of expertise. The single drawback to this program is that the biological topic may not interest students interested in earth science or physics.

Schools A, B, and K had a strong tradition of middle school student research projects, a few of which went on to Science Congress. Schools A, I, and L had an honors earth science course which included individual projects which were entered in Science Congress. Having a middle school science project and fair can help students experience science research to a limited extent. Judging of such events is of questionable value. In addition, it can serve as a feeder program for high school student research courses and identify science-interested and talented students.

One small School K enabled science-interested seniors to participate in ongoing scientific research mentorship and required a report and presentation of the experience as the student's Senior Project, a project required by each student.
**Authentic Science Research in the High School**

Dr. Robert Pavlica of Byram Hills High School in Armonk, New York has designed a comprehensive science research course which begins during the summer of freshman year and runs through senior year (see Appendix B for program outline). During the summer of freshman-sophomore year, students read ten articles in their interest area and compose three questions. Sophomore year involves library and computer skills, narrowing their topic, locating a mentor, improving communications and presentation skills, and presenting their progress at a spring presentation night. Junior year is spent on intense lab research and includes presentations of research findings. By October of the senior year, the student’s research is completed. Formal writing of the research paper and designing of a poster is done entirely by the student. Students can then enter the Intel ISEF competition, Science Congress, and Junior Science and Humanities Symposium.

The recommended class size is 10 students per class. Not only do the participants earn high school credit, they can earn college credit. Very thorough skills building - especially reading of science journals, several presentation opportunities, careful monitoring of student’s progress and mentorships combine to make this the strongest program design found in New York State. In fact, this program increased from running in two schools in 1994 to 102 New York State schools in 1998/99.

A unique factor in the success of this program is the NSF-funded three week teacher training course and five follow-up sessions.
CHAPTER V

CONCLUSION

Summary

There is full agreement that long term student science research projects provide an excellent opportunity for students to do problem-solving and higher level thinking skills. Such projects can develop a student's communication skills. In fact, long term independent research projects far exceed the National Standards and New York state standards. Also, research projects provide students with the opportunity to learn about the world of science research.

Science fairs provide a forum to communicate results and discuss with others. The judging of fairs should be considered carefully in order to avoid discouraging developing scientists. Spring Presentation Nights at schools provide an opportunity for underclassmen to learn from upperclassmen and for students to communicate their findings with the community.

Locally, science research courses may possibly compete with AP science course offerings. Yet the science research provides the unique challenge of independently doing science rather than focusing on information content.

Some schools have top caliber science students involved in Science Olympiads. Yet a carefully planned science research course could be arranged to dovetail with the Science Olympiads competitions in order to allow students to participate in both the research course and Science Olympiads team. By establishing a regular class time for the science research course, students could successfully fit research into their busy schedules.
Characteristics of Webster High School

Webster has a very large student body of over 1,953 students in grades 10, 11 and 12. In fact, in one year it will begin a process to split into two separate campuses of grades 9-12 offering the same courses and sports. Webster also plans to adopt block scheduling next year. Two new science courses are being offered this fall - a combined Regents Biology/Chemistry course and AP Environmental Science. The Webster Science Olympiads team is large and wins awards at the national level. In the past two years, I have met with a few students interested in doing a research project for Science Congress, yet only one student successfully completed an experiment and entered Science Congress. The other interested students had difficulty choosing a topic and finding time in their busy schedules. All of the after-school students agreed that having a science research course with a designated meeting time would help immensely.

Conclusions

Given that only one local school is successfully conducting a regular course for doing long term independent student research in unlimited science fields, and two schools are struggling to establish new courses of a similar nature, I conclude that the best plan for Webster High School calls for identifying the student interest by explaining the possible course and research opportunities and conducting a student survey (Appendix E). I recommend embracing the strong and highly successful program designed by Robert Pavlica (Appendix B). In addition, I recommend that Webster prepare two teachers at Robert Pavlica's training workshop and, thereby, have one teacher at each of the two high schools who could also assist each other.
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APPENDIX A
SURVEY QUESTIONS

1. How does your high school provide students with the opportunity to do long term independent science research projects?
2. If you have a dedicated credit course for student research,
   - number of students,
   - sophomores, juniors, seniors
   - prerequisites
   - teacher work load
   - maximum/minimum number of students for a class
   - individual projects on student’s chosen topic
   - group experimenting on teacher-selected topics
   - checks on student progress
   - competitions entered
   - spring presentation event
   - skills building
   - mentorships
   - connections with business, industry, colleges
   - student satisfaction, drop out rate
   - overlap with Science Olympiads
   - teacher training
   - how to assign a grade
   - strongest aspect of the course
   - weakest aspect of the course

3. If there is not a course dedicated to student science research, how do students pursue science research?

4. In the district’s middle schools, do students participate in a school science fair?

5. Have you heard of the research course designed by Robert Pavlica and Daniel Wulff, "Authentic Research in the High School", currently running in 102 schools in eastern New York? What is your opinion of the course?
AUTHENTIC SCIENCE RESEARCH IN THE HIGH SCHOOL

There is a growing demand, nationwide, for science based education which is:

Student Centered

Project Oriented and Long Term

Driven by Problem Solving

Cost Effective

The course described meets all of these needs. We are presently training teachers in the science research course methodology devised by Dr. Robert Pavlica of Byram Hills High School in Armonk, New York.

For further information and training workshops contact:

<table>
<thead>
<tr>
<th>Daniel Wulff</th>
<th>OR</th>
<th>Robert Pavlica</th>
<th>OR</th>
<th>Leonard Behr</th>
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<tbody>
<tr>
<td>Dept. of Biological Sciences</td>
<td>Byram Hills High School</td>
<td>Byram Hills High School</td>
<td>Taconic Hills High School</td>
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<tr>
<td>University at Albany</td>
<td>12 Trip Lane</td>
<td>12 Trip Lane</td>
<td>Box O</td>
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<td>Albany, NY 12222</td>
<td>Armonk, NY 10504</td>
<td>Armonk, NY 10504</td>
<td>Philmont, NY 12565</td>
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<tr>
<td>(518) 442-4290</td>
<td>(914) 273-9200 ext 391</td>
<td><a href="mailto:rpavlica@purvid.purchase.edu">rpavlica@purvid.purchase.edu</a></td>
<td>(518) 672-7942</td>
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<td><a href="mailto:dlw96@cnsvax.albany.edu">dlw96@cnsvax.albany.edu</a></td>
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<td><a href="mailto:lenbehr@epix.net">lenbehr@epix.net</a></td>
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OVERVIEW OF THE SCIENCE RESEARCH PROGRAM

This program affords students the opportunity to participate in the community of scientific research and scholarship as part of their high school experience. It furthers excellence in performance and achievement, while drawing from and developing scientific capabilities in a broad spectrum of the student body. Students taking the course accomplish the following skills:

Students choose and explore a topic of interest. The topic may come from the natural sciences or the social sciences. They develop skills in using electronic mail and the internet. They learn to conduct on-line bibliographic searches of a wide range of databases.

Students find and study several journal articles, eventually choosing one which they will present to the class. Their presentation to the class emphasizes how research described in the article was conducted. Thus, it makes the scientific method, which is the essence of the course, explicit for the student and the class. The elements of this method always include:

- A review of literature
- A statement of the hypothesis or the problem
- Methodology
- A presentation and analysis of results
- Conclusions
- Bibliographic work and footnotes

Students prepare a statement of what they intend to study based on their bibliographic research.

Students contact the authors of journal articles they have studied. They ask for suggestions for future research that they might undertake. As their relationship with the scientist develops, they ask the scientist to serve as a mentor or to help them find an appropriate scientist mentor to assist them in carrying out a research project.

Students then engage in an original piece of research under the guidance of their scientist mentor and their classroom research teacher. The classroom teacher meets with individuals and the research class on a regular basis. The students communicate with scientist mentors, wherever they are, using electronic mail capabilities.

Students conduct statistical analyses using appropriate statistical computer software.

Students make presentations of their findings to their class, their school district, and at regional and statewide symposia. Their presentations are based on the
scientific protocol listed above and incorporate visual presentation techniques (e.g. Power Point).

Each step in the student’s progress is carefully and systematically monitored to assure that the student engages in each phase of scientific research and attains desired capabilities.

THE THREE YEAR TIME LINE

Freshman Summer: Students should choose their area of scientific interest. They are required to read ten articles from magazines, newspapers, or books. From these articles the student must develop three questions.

Sophomore Year: During this year the students are required to continue to narrow their topic. They master computer searching skills using Dialog, and they locate and retrieve approximately twenty journal articles in their field of study. After reading appropriate articles the sophomores are required to write a statement of what they intend to study, based on their bibliographic research. Subsequently, they contact the authors of these articles by telephone, engage them in conversation about their own related topic, and begin developing a rapport which hopefully develops into a student/mentor relationship. Each sophomore presents at least one article from the journal articles retrieved. The article is presented using overhead projections. The presentation must include: a review of literature, a statement of hypothesis, a discussion of the author’s methodology, presentation and discussion of data using graphs, or charts, and a conclusion. The student’s presentation is assessed by his peers. Assessment is done on two levels:

Technical accuracy and thoroughness in presenting the author’s research as outlined above.
General presentation qualities such as speed, clarity, eye contact, and posture.

During this year the student should locate a research facility where he/she will work. This may be a university or company laboratory. Many research projects can be done at home, in school, or in the local community. During this year the student will make a time line for each quarter and one for the summer. He/she will also create a poster outlining the intended research to be accomplished along with any results already gathered. Finally, during this year the student research project may begin. No college credit is offered for this first academic year.

Junior Year: This is the year of intense laboratory research. The student confers with the mentor at least twice a month and is actively engaged in the project. The hypothesis is redefined as needed, based on continuing literature searches and reading. During this year the student makes public presentations of the research findings to the class, school community, and public. In all presentations he/she must follow the same format used in presenting earlier articles. The student should learn
to use the statistical software of choice in the laboratory where the work is being done. The student must make five time lines this year, as last year. The student may elect to gain university credit for the sophomore-junior summer and the junior year.

**Senior Year:** The student research is completed by late October. The student must now write his formal research paper. This must be done entirely by the student and must follow the format of other articles written in the chosen field. This is the time to write the Westinghouse paper, the Junior Science and Humanities Symposium application, and the all important abstract. Now it is also time to prepare 35 millimeter slides and other presentation graphics. Finally, each senior is expected to attempt to publish his work. This year the student makes four time lines, one for each quarter. The student may elect to gain university credit for the junior-senior summer and for the senior year.

**SOME BENEFITS OF THE PROGRAM**

- **The student at center stage:** The Science Research Course is student centered. Students work on problems they identify and on hypotheses they develop. The resourcefulness and imagination shown by students in the identification of practical research problems is truly impressive. Science Research students learn that scientific research often requires a great deal of tedious work, but that the end result can be glorious, namely, the acquisition of new knowledge for which they have shared responsibility. Students come to take enormous pride of ownership in their work.

- **The teacher as facilitator:** The teacher is the facilitator, and not the supervisor of research. The teacher teaches students the scientific method; the teacher helps the student to identify appropriate scientific literature in the students' chosen field; and the teacher gives constructive feedback to the student's hypotheses and experimental designs. The teacher also helps the student obtain research scientists as mentors, and helps the student identify resources that will be needed for the conduct of research. The teacher monitors the student's progress through biweekly conferences and through examining the detailed records the student keeps concerning all aspects of the research experience. The teacher coaches the student in methods of both oral and written communication of scientific results. These responsibilities require considerable skills on the part of the teacher, but they do not require that the teacher be present in a laboratory supervising research at all hours including evenings and weekends.

- **The research scientist as mentor:** Students recruit research scientists from anywhere as mentors, but only after they have studied their areas of interest extensively and come to a preliminary formulation of the problems they wish to investigate and the hypotheses they wish to test. Senior scientists, who are often "too busy" if asked to work with a high school student, usually cannot resist helping a
student who has read their papers and has ideas for further research. Greater than 80% of scientists who are contacted agree to serve as mentors for students.

- **Scientific creativity and problem solving:** In an era in which the sheer technical complexity of science often makes research training little more than an exercise in developing technical skills, the Science Research course emphasizes the development and disciplined use of scientific creativity. Students who have taken the course emphasize that, besides learning how to do scientific research, they have acquired skills to deal with problems of all sorts that one must face in living a life, problems that might otherwise have overwhelmed them.

- **Authentic research:** Students do authentic research using the scientific method. They work on real problems, and the results they obtain constitute new scientific knowledge.

- **Student portfolios:** Research students create an extensive portfolio which gives them an excellent sense of how they are doing, and which allows the teacher to make detailed assessments of progress. For example, the portfolio contains records of every telephone conversation with a mentor, every e-mail message, every bibliographic search, every conversation with the research teacher, and periodically formulated goals.

- **Communication of results:** Emphasis is placed upon communication of results. Students prepare slides and posters and make public presentations. Students write abstracts of their research and seniors write a twenty page paper. Seniors are required to enter various contests such as the Westinghouse and the Junior Science and Humanities Symposium. However the emphasis is on communication of results, and not winning contests. The work remains very much the student's own: mentors do not help to write the papers even though many would be happy to do so and even though this would increase the chance of winning major competitions.

- **Realistic expectations:** Although students may drop the course at any time, the Science Research course is normally a three year course, allowing students time to develop ideas, do significant research and then enter various contests without heroic efforts by students and teachers. In the first year the typical student identifies problems and recruits mentors; in the second year the student does the research; and in the third year emphasis is placed upon communication of results. Upper level students are role models and provide encouragement to beginning students.

- **Expense:** The course is relatively inexpensive for the school (less than $1,000 per year plus the teacher's time). Students do their work in their backyards, in basements, in stream beds, and many students do science and social science experiments that are not laboratory based. A few students find their way into large industrial and university laboratories, and a few students work in their school laboratory. The annual supplies budget is less than $500, and communication costs are also less than $500.
WHAT SCHOOLS SAY ABOUT THE SCIENCE RESEARCH COURSE

The Science Research in the High School Program has grown from two schools running this course in 1994 to 102 New York State schools in 1998/99. According to assessment reports by the Evaluation Consortium at the University at Albany, school administrators consistently differentiate this course from other science courses, stating

• it involves more critical thinking and problem solving skills,
• students work independently and are responsible for individual progress, and
• it is a more hands-on approach and real life application of science.

In relating the Science Research program to the New York State Education Standards in science, administrators say that

• the Science Research program exceeds the standards because more problem solving and higher level thinking skills are involved, and
• the Science Research program provides an authentic, interactive, and collaborative science course.

Administrators also see benefits to the school that go beyond the Science Research classroom, including

• exposure of non-Science Research program teachers to strategies which could be implemented in their classrooms, and
• an increased level of teacher expectations of what students can do once the entire faculty has observed student performance in a school spring Science Symposium.

Administrators also note that the Science Research program

• enhances parental support, and
• improves the reputation of the school in the community.

Administrators and school counselors note that the Science Research program

• helps students make contacts for their post-secondary education and career,
• aids students in their college application essays in demonstrating a long term commitment to scientific research, and
• impresses college interviewers when they view the students' portfolios.

Parents report that

• their children transfer critical thinking skills to such things as news reports as a result of their participation in the Science Research program. They say that students are more likely to ask "how" questions and show a greater desire to "see the data" before accepting the results reported.
SCHOOLS WITH SCIENCE RESEARCH COURSES
1998-9

GREATER HUDSON VALLEY REGION

ALBANY COUNTY
Bethlehem Senior High School
Watervliet Junior/Senior High School

COLUMBIA COUNTY
Chatham High School
Hudson High School
New Lebanon Junior/Senior High School
Taconic Hills High School

DUTCHESS COUNTY
Stissing Mountain Junior/Senior High School (Pine Plains CSD)

FULTON COUNTY
Broadalbin-Perth High School

GREENE COUNTY
Cairo-Durham High School
Coxsackie-Athens High School
Greenville Junior-Senior High School

HERKIMER COUNTY
Mohawk High School
Poland Junior/Senior High School
West Canada Valley Junior/Senior High School

MONTGOMERY COUNTY
Amsterdam High School
Canajoharie Senior High School
St. Johnsville JSHS

ORANGE COUNTY
Goshen Central High School

PUTNAM COUNTY
Brewster High School
Haldane Junior/Senior High School
Mahopac High School

RENSSELAER COUNTY
Columbia High School (East Greenbush)
Hoosic Valley Junior/Senior High School
Hoosick Falls Senior High School
Tamarac Senior High School
Troy High School
ROCKLAND COUNTY
   North Rockland High School
   Pearl River High School
   Ramapo Senior High School
   Suffern Senior High School
   Tappan Zee High School

SARATOGA COUNTY
   Corinth High School
   Saratoga Springs Senior High School
   Schuylerville Junior/Senior High School
   South Glens Falls Senior High School

SCHENECTADY COUNTY
   Mohonasen Senior High School
   Niskayuna High School

SCHOLARIE COUNTY
   William H. Golding High School (Cobleskill)

SULLIVAN COUNTY
   Liberty High School
   Narrowsburg Central School

ULSTER COUNTY
   New Paltz Senior High School
   Saugerties Junior/Senior High School

WARREN COUNTY
   Lake George Junior/Senior High School

WASHINGTON COUNTY
   Granville Junior/Senior High School
   Greenwich Junior/Senior High School
   Hartford Central School
   Salem High School

WESTCHESTER COUNTY
   Blind Brook High School & Middle School
   Byram Hills Senior High School
   Croton-Harmon Senior High School
   Edgemont Junior/Senior High School
   Fox Lane High School (Bedford CSD)
   Gorton High School (Yonkers City SD)
   Harrison High School
   John Jay Senior High School (Katonah-Lewisburgh UFSD)
   Lakeland Senior High School
   Mamaroneck High School
   Mount Vernon High School
   New Rochelle High School
   Ossining Senior High School
   Pleasantville High School
   Port Chester Senior High School

(CONTINUED ON NEXT PAGE)
WESTCHESTER COUNTY (CONTINUED FROM PREVIOUS PAGE)
  Roosevelt High School (Yonkers City SD)
  Rye High School
  Rye Neck Senior High School
  Saunders Trades & Tech High School (Yonkers City SD)
  Sleepy Hollow Middle and High School
  Somers Senior High School
  Walter Panas High School (Lakeland CSD)
  Westlake High School
  White Plains Senior High School
  Woodlands Senior High School (Greenburgh CSD)
  Yorktown High School

NORTHERN COUNTRY

CLINTON COUNTY
  Plattsburgh Senior High School

FRANKLIN COUNTY
  Franklin Academy High School (Malone CSD)

SYRACUSE REGION

MADISON COUNTY
  Oneida Senior High School

ONONDAGA COUNTY
  Liverpool High School

LONG ISLAND REGION

NASSAU COUNTY
  East Meadow High School
  George W. Hewlett High School (Hewlett-Woodmere UFSD)
  Hicksville High School
  Malverne Senior High School
  Northshore Senior High School
  Oceanside Senior High School

SUFFOLK COUNTY
  Cold Spring Harbor High School
  Harborfields High School
  Hauppauge High School
  Wantagh Senior High School
NEW YORK CITY REGION

BRONX
  Christopher Columbus High School
  Herbert H. Lehman High School
  Theodore Roosevelt High School

BROOKLYN
  Franklin K. Lane High School

PRIVATE AND PAROCHIAL SCHOOLS

ALBANY COUNTY
  Academy of the Holy Names (Parochial)
  Albany Academy for Boys (Private)

NASSAU COUNTY
  Lawrence Woodmere Academy (Private)

NEW YORK CITY
  Christ the King High School (Parochial - Queens)
  Horace Mann High School (Private - Manhattan)
  Our Lady of Perpetual Help (Parochial - Brooklyn)
  Regis High School (Parochial - Manhattan)
  St. Francis Preparatory School (Parochial - Queens)

WESTCHESTER COUNTY
  Our Lady of Victory (Parochial)
  Rye Country Day School (Private)
  Ursuline Academy (Parochial)
June 25, 1999

Ms. Pat Wartinger
Webster High School
875 Ridge Road
Webster, NY 14580

Dear Pat,

I have now scheduled interest meetings in western New York for administrators and teachers interested in establishing Science Research courses in their schools in fall, 2001. All meetings are from 4:00-5:00 PM this coming fall. The schedule is as follows:

Tuesday, October 5  Cattaraugus-Allegany-Erie-Wyoming BOCES
Center at Olean
1825 Windfall Road
Olean, NY 14760

Thursday, October 7  Monroe 1 BOCES
41 O'Connor Road
Fairport, NY 14450

Tuesday, October 12  Erie 1 BOCES
355 Harlem Road
West Seneca, NY 14224

Thursday, October 14  Niagara-Orleans BOCES
4232 Shelby Basin Road
Medina, NY 14103

Tuesday, October 19  Erie 2-Chautauqua-Cattaraugus BOCES
8685 Erie Road
Angola, NY 14006

Tuesday, October 26  Genesee Valley BOCES
80 Munson Street
Le Roy, NY 14482

Thursday, October 28  Monroe 2-Orleans BOCES
Wemoco Conference Room A
3599 Big Ridge Road
Spencerport, NY 14559

Tuesday, November 9  Steuben-Allegany BOCES
Conference Room B
6666 Babcock Hollow Road
Bath, NY 14810
If you are unable to attend the meeting in your BOCES, then you may attend one of the other meetings. I encourage more than one individual from a school district to attend an interest meeting. It is not necessary for everyone attending from a particular district to attend the same meeting. Individuals from school districts not in a BOCES may attend any meeting that is convenient.

Please address any inquiries regarding these meetings to me. The various BOCES are only making their spaces available for these meetings. I will mail a second invitation in the early fall.

As a reminder from my first letter to you, we are offering two intensive training workshops for Science Research teachers in Western New York in Summer, 2001 for schools implementing Science Research courses in Fall, 2001. This is made possible by a major grant from the National Science Foundation. The complete tentative schedule is:

1999: Manhattan (NYC teachers only), Verona, Owego, Poughkeepsie
2000: Manhattan (NYC teachers only), Syracuse, St. Louis (MO), Lawrence (KS)
2001: Manhattan (NYC teachers only), Western New York (CA), Los Angeles (CA)
2002: Long Island, Florida, two in New York State to be determined
2003: Long Island, three in New York State to be determined

To be accepted to a Summer workshop, a teacher must be scheduled to teach a Science Research course in the following Fall. Teachers receive a $900 stipend, round-trip transportation at 32.5 cents a mile, room and board if they live too far to commute, an $8 lunch allowance and three graduate credits. Teachers also attend five follow-up sessions the following academic year, for which they receive an additional $300 and transportation.

The National Science Foundation requires schools to pay a portion of the teacher training through cost sharing. The school's share depends upon the summer in which the teacher is trained. This goes by

1999 zero
2000—$277—(5% of project costs)
2001 $562 (10% of project costs)
2002 $1,397 (25% of project costs)
2003 $1,664 (30% of project costs)

Have a productive summer, and I will be in contact with you again next fall!

Sincerely yours

Daniel L. Wulff
Professor of Biological Sciences
Director of Outreach Programs in Science and Mathematics
Mission:

The mission of the Webster Central School District is to provide an educational environment in which all students can achieve success and become productive citizens.

Beliefs:

The Webster Central School District believes...

- All rights have corresponding responsibilities.
- Self-respect is a prerequisite to respect for others.
- All people have a right to the basic necessities of life.
- Human potential is immeasurable.
- Every person has potential to change and to effect change.
- Every person has equal intrinsic value.
- Excellence cannot be compromised.
- The pursuit of knowledge is a lifelong process.
- Knowledge has intrinsic value.
- Individuals are responsible for the choices they make.
- Risk taking results in growth.
- Achievement as well as performance deserves recognition.
- Caring is essential to positive human relationships.
- Parent-family should be actively involved in the education of their child to promote positive development of the individual.
- Mutual trust and respect are essential to the well-being of the organization.
- The well-being of the family impacts the overall quality of society.

Essential Outcomes:

Academics: Webster graduates will apply, in a variety of contexts, the skills, knowledge, concepts and attitudes learned from their courses of study.

Aesthetics: Webster graduates will appreciate beauty in nature and the arts by building their knowledge through active experiences with various forms of creative expression.

Communication: Webster graduates will effectively apply listening, speaking and writing skills to express and exchange ideas, information and feelings.

Global Responsibility: Webster graduates will have the knowledge, skills, understandings and attitudes to participate as citizens in a diverse interdependent world. They will demonstrate a commitment to the civic well-being of the community.

Higher Order Thinking Skills: Webster graduates will apply higher order thinking skills in order to set goals, make appropriate decisions and solve problems in a variety of contexts.

Interpersonal: Webster graduates will work collaboratively and demonstrate concern and respect in their relations with others.

Self-Directed as Person & Learner: Webster graduates will demonstrate initiative, persevere in their commitments and take responsibility for their ongoing learning.

Self-Esteem: Webster graduates will have confidence in their abilities, pride in their achievements, a healthy acceptance of self and a positive vision for their future.

Wellness: Webster graduates will have the skills necessary to maintain a healthy life-style and will value physical and emotional wellness.
Standard 1: Understands scientific inquiry and models, and utilizes them to pose questions, address problems, develop solutions, and make informed decisions.

Benchmarks are assumed to be cumulative.

Grade 9
1. Designs and conducts scientific investigations.
   - Uses scientific literature as a source of information.
   - Understands that scientific inquiry is guided by conceptual principles, knowledge, and practices, that are specific to a particular scientific discipline and which influence the design and interpretation of investigations.
   - Formulates and revises scientific explanations and models using logic and evidence.
   - Uses scientific discourse as a means of evaluating and developing explanations.
   - Formally presents and defends a scientific argument.

Grade 10
1. Designs and conducts scientific investigations.
   - Uses scientific literature as a source of information.
   - Understands that scientific inquiry is guided by conceptual principles, knowledge, and practices, that are specific to a particular scientific discipline and which influence the design and interpretation of investigations.
   - Formulates and revises scientific explanations and models using logic and evidence.
   - Uses scientific discourse as a means of evaluating and developing explanations.
   - Formally presents and defends a scientific argument.

Grade 11
1. Designs and conducts scientific investigations.
   - Uses scientific literature as a source of information.
   - Understands that scientific inquiry is guided by conceptual principles, knowledge, and practices, that are specific to a particular scientific discipline and which influence the design and interpretation of investigations.
   - Formulates and revises scientific explanations and models using logic and evidence.
   - Uses scientific discourse as a means of evaluating and developing explanations.
   - Formally presents and defends a scientific argument.

Grade 12
1. Designs and conducts scientific investigations.
   - Uses scientific literature as a source of information.
   - Understands that scientific inquiry is guided by conceptual principles, knowledge, and practices, that are specific to a particular scientific discipline and which influence the design and interpretation of investigations.
   - Formulates and revises scientific explanations and models using logic and evidence.
   - Uses scientific discourse as a means of evaluating and developing explanations.
   - Formally presents and defends a scientific argument.
### Standard 2: Understands the historical development of scientific ideas and the interaction among scientific research, technological development, and societal need.

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<th>Grade 11</th>
<th>Grade 12</th>
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Grade 9

4. Understands that individuals and society must decide on proposals involving new research and technologies. Decisions involve assessment of alternatives, risks, costs, and benefits, and consideration of who benefits.

5. Understands that scientific knowledge is often not made readily available because of patents, military and political issues, and the financial potential of the idea or inventions.

Grade 10

4. Understands that individuals and society must decide on proposals involving new research and technologies. Decisions involve assessment of alternatives, risks, costs, and benefits, and consideration of who benefits.

Grade 11

4. Understands that individuals and society must decide on proposals involving new research and technologies. Decisions involve assessment of alternatives, risks, costs, and benefits, and consideration of who benefits.

Grade 12

4. Understands that individuals and society must decide on proposals involving new research and technologies. Decisions involve assessment of alternatives, risks, costs, and benefits, and consideration of who benefits.

Standard 2: Understands the historical development of scientific ideas and the interaction among scientific research, technological development, and societal need.
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Grade 9
6. Understands that all scientific knowledge is, in principle, subject to change as new evidence becomes available.
   - Core ideas of science have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested.
   - In areas where data and/or understanding are incomplete there is great opportunity for making advances.

Grade 10
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   - In areas where data and/or understanding are incomplete there is great opportunity for making advances.

7. Understands that there are advances in science that have important and long-lasting effects on science and society (e.g., Copernican revolution, Newtonian mechanics, relativity, geologic time scale, plate tectonics, atomic theory, nuclear physics, biological evolution, germ theory, molecular biology, quantum theory, galactic universe).

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The Ask the Experts site is Scientific American's conduit to experts on all fields of science.
www.sciam.com/askexpert/index.html

Primer, a hypertext tutorial, tells how to do everything from planning science fair projects to judging finalists. Ted Rowan from Falmouth, MA, has been working with science fairs for 20 years. He wrote this resource for students.
users.massed.net/~tedrowan/primer.html

The Idea Exchange allows you to trade ideas about science fair topics. Ideas are listed by discipline, and the site offers links to other online resources.
www.halcyon.com/sciclub/cgi-put/scifair/guestbook.html

The International Science and Engineering Fair site tells about the Intel-sponsored competition. ISEF winners receive scholarships, tuition grants, internships, scientific field trips, and a trip to attend the Nobel Prize ceremonies.
www.sciserv.org/isef/index.htm

The Internet Science and Technology Fair, the University of Central Florida's online science project, brings together students, experts from the field, and Internet resources to create project homepages on "National Critical Technologies." istf.ucf.edu

The Resources site has science fair project ideas and reference links to help students begin scientific discovery.
www.tyler.net.ruskhslb/scifair.html

The School Science Fairs Page, presented by the eastern Newfoundland Science Fairs Council, offers various project ideas, listed in primary, elementary, middle school, and senior high school sections.
www.stemnet.nf.ca/~jbarron/scifair.html

The Science Fair Home Page offers ideas for putting together a science fair project within the framework of the scientific method.
home.eagt.net/elhardt

Science Fair Tips, from Eduzone, offers ideas by grade level. It also contains informative pieces on preparing for a science fair and a demonstrator's kit.
www.eduzone.com/tips/science.asp

Science Fairs, a virtual library, presents science fairs around the country that have an online presence.
physics.usc.edu/~gould/ScienceFairs

Ultimate Science Fair Resource contains these sections: Doing a Science Fair Project; Project Hints; Writing a Report; Display Hints; Project Categories; "How To" Links; Project Ideas; Idea Board; Links; and more.
www.neiltec.com/scifair

Project Resource Guide, from the Internet Public Library, tells how to complete a successful project, gives examples of projects, and offers ideas and resources.
www.ipl.org/youth/project-guide

Kids Connect helps students look for information for reports and projects. This free service responds to questions by providing Internet resources and referrals to librarians and information specialists.
www.onlineclass.com/Ferrous/schools.html

The Mighty Mentors—E-mail Mentoring for Teachers site finds mentors or mentees. It allows you to search by grade, subject, and location.
www.mightymedia.com/mentors

The Virtual Creatures site includes a three-dimensional computer model of a frog. The program uses interactive software to teach vertebrate biology.
summit.stanford.edu/creatures
APPENDIX E

Draft of Survey for Webster High School Students

Name: _______________________
HR _____
Science course which you are currently taking: _______________________
Science Teacher: _______________________

1. Are you considering a career in science? ____________
   If so, what field(s) are you interested in? _______________________

2. Would you like to do a science research project if a Student Science Research course were offered next year? ____________

3. How would you benefit from such a course?

4. Did you ever do a science research project? ____________
   If so, what was your project? _______________________
   Did you enjoy the experience and/or find it worthwhile?

NOTE: BEFORE doing survey, students should be informed of the program and benefits, possibly in a morning video announcement including a Sci Congress winner and college admissions rep. Also, include a brief paragraph at the top of the survey form.
School Size

VS.

Participation in Science Extracurricular Activities

SUNSHINE GROUP

"We're so bright!"

Molly Heatherington
Jayme Donoghue
Sue Reynolds
Pat Wartinger

Dr. Beers
EDI 685
8-4-95
Science projects, science fairs, and other extracurricular science activities are opportunities for students to expand their knowledge and exercise higher level thinking skills. These skills help them not only in their immediate scholastic ventures, but also in building life skills. The purpose of this study is to determine whether or not there is a relationship between high school size and participation in such activities. Smaller schools tend to have lower budgets, less equipment, fewer teachers, fewer free periods, less classroom and lab space. The lack of such resources creates obstacles in terms of participation in extracurricular science activities. Therefore we believe that as school size increases, participation in extracurricular science activities will also increase.

The results of this study will determine whether or not more attention should be given to investigating why smaller schools have a lower level of science activity and then finding solutions to the problem. Possibly businesses, government, and local universities should be encouraged to support science programs via finances and/or materials.

The null hypothesis (Ho) is that there is no relationship between the size (number of students enrolled in high school) and the level of science activity (total number of different types of activities offered to students) for Monroe county high schools. The alternative hypothesis (HA) is that there is a relationship between the size of school and the level of science activity.
CHAPTER 2: REVIEW OF THE LITERATURE

Long term student science projects are an invaluable component of secondary school science education. Often students are put in a position to do long term science projects which will ultimately end up in a science fair. There is much discussion in the literature of the pros and cons of science fairs. There is also much consensus on the value of long term science projects for the students.

The literature presents many purposes for science projects and science fairs. Student science projects serve to promote interest in science, to develop a better understanding of the process of science, to develop critical thinking skills, to encourage creativity and independent thinking, to develop library and writing skills, to promote group learning, and finally, to increase scientific literacy (Cothron, 1993; Gowen, 1993; NSTA, 1960; Welte, 1959). Hands-on science activities are especially beneficial for minority and female students (Champagne, 1987; Hill, 1990). Science fair projects and participation give Learning Disabled students the opportunity to learn and grow more responsible for their learning and to experience a sense of accomplishment (Rice, 1983). A primary purpose for science fairs is to provide opportunities for the gifted and talented and scientifically-advanced to pursue research and receive rewards and encouragement (NSTA, 1960).

After the Russian satellite Sputnik orbited Earth in 1957, there was a tidal wave of federal money and programs for increasing our country's science education and regaining U.S. superiority in the world of science (Gilman, 1965). At that time, the rationale behind the science fair was that "Our future depends on scientists." (Welte, 1959, p. 1).
As the initial federal funding for science programs began to taper off in the mid to late 1960's, business, industry and universities began to sponsor a variety of science programs - some competitive and non-competitive, some individual and some team events.

Today, there are many national programs available for secondary students (Grand, 1994; NSTA, 1990).

Local opportunities include Science Olympiads, Science Congress, Odyssey of the Mind, E 3 at RIT, Science Exploration Day, Broaden Your Horizons, and Challenger Space Program. Some schools hold an annual science fair. The Rochester Council of Scientific Societies of New York, formed in 1960, developed a Science Congress program for student science project exhibits and other student competition activities (NSTA, 1960). Science Congress of 1995 included 165 student science project exhibits and was judged by specialists from local industries along with science teachers. Another local event, the E3 at Rochester Institute of Technology, is a hands-on technology fair and team competition event which includes hands-on exhibits form local industry, colleges and even BOCES.

As part of their Regents variance, some schools require a science research project for Regents Biology and/or Earth Science (unpublished data, Hilton H.S., 1995). A few schools arrange for exceptional students to do research under a mentor in a local industry or university research lab (unpublished information, West Irondequoit H.S., 1995).

There are several state and national curriculum revision projects currently underway. These include New Compact for Learning, Project 2061, M/S/T/, S,S&C, S/T/S, and National Education Standards. For all of the programs, student science projects are the very kind of inquiry learning desired and are ideal for authentic assessment and portfolios.
CHAPTER 3: RESEARCH DESIGN

The school districts used in this study included all districts located in Monroe County. A survey will be sent, with a self-addressed envelope, to the chairperson or head of the science department in each high school. Each school will be given at least five business days to return the completed survey. If the anticipated number of surveys are not returned by the deadline, schools that have not replied will be contacted randomly for a phone survey.

Designing an effective survey instrument for our study was a challenging process. Examples of the various stages involved in creating our survey are included in the appendix. The survey which will be used in our study includes only questions which directly apply to the purpose of the study, (see Appendix C). The wording of each question has been carefully considered so that they are easily understood and are not biased in any way.

We have defined the size of the school as being the number of students attending each high school. Although it is not important for our purposes that we know specifically which science activities each school has participated in, we have included a list on our survey to help each chairperson recall activities which their school has been a part of. We have also asked schools to identify the number of students who have advanced to state or national science fair competitions. We will use this information along with the other data collected on each survey to draw further
conclusions about the effect of school size on participation in science-related activities.
CHAPTER 4: ANALYSIS

1) \( \bar{x} = \frac{\sum x}{N} \) \hspace{1cm} \( \bar{y} = \frac{\sum y}{N} \)

Mean \( \bar{x} \) = 1103.824
Mean \( \bar{y} \) = 4.941

2) \( S_y = \sqrt{\frac{\sum x^2 - (\sum x)^2}{N}} \) \hspace{1cm} \( S_y' = S_y \sqrt{1 - r^2} \)

\( S_y = 2.900 \)
\( S_y' = 2.129 \)
\( S^2_y' = 4.533 \)

3) \( r = \frac{N(\sum xy) - (\sum x)(\sum y)}{\sqrt{N(\sum x^2) - (\sum x)^2} \sqrt{N(\sum y^2) - (\sum y)^2}} \)

\( r(15) = +0.679 \)
\( r^2 = 0.461 \)
\( 1 - r^2 = 0.539 \)

\( r_{\text{crit}}(15) \) for two tail test = +/- 0.482 \( p<.05 \)

4) \( Y' = b \cdot X + a \)

\( b = \frac{N(\sum xy) - (\sum x)(\sum y)}{N(\sum x^2) - (\sum x)^2} \)

\( a = \bar{y} - (b)(\bar{x}) \)

Linear regression line formula: \( Y' = .003x + 1.403 \)
SCHOOL SIZE VS. NUMBER OF SCIENCE ACTIVITIES

<table>
<thead>
<tr>
<th>Student Population</th>
<th>Science Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>3</td>
</tr>
<tr>
<td>400</td>
<td>3</td>
</tr>
<tr>
<td>450</td>
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<tr>
<td>465</td>
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<td>7</td>
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<tr>
<td>2500</td>
<td>14</td>
</tr>
</tbody>
</table>
CHAPTER 5: CONCLUSION

Our relatively low values for the standard error of the estimate and the variance of our $Y'$ scores around $Y$, (2.124 and 4.533, respectively) reveal that the $Y$ values, in general, fall somewhat close to $Y'$ or along the regression line. Low $S_{Y'}$ and $S_{Y'}^2$ values are associated with relatively high absolute values of the correlation coefficient, $r$. This accounts for the calculated $r$ value of +0.679 being greater than the critical $r$ of +0.482. Therefore, we can reject our null hypothesis which states that there is no relationship between our variables. Because $r$ is positive, and it is greater than the critical $r$ value, a significant positive relationship exists, which supports our research hypothesis. As school size increases, a significant increase in the number of science activities that the school participates in does, in fact, occur.

We performed a two-tailed test with an alfa value of 0.05. This means that we can be 95% sure that we did not commit a Type I error. In other words, we can be 95% sure that this positive relationship actually exists in the population, and is not merely due to sampling error.

After only eleven of the surveys had been returned, a preliminary $r$ value of +0.516 had been calculated. Although this was lower than our final $r$ value, it is still higher than the critical $r$ value. This leads us to believe that as the size of the sample increases, up to a certain point, the stronger the relationship between our variables will be.
Therefore, we are assuming that possibly an even stronger relationship exists in the population. Further study should include all 30+ high schools in Monroe county to determine if this is true.

These findings will be forwarded, along with a listing of smaller schools in need of support, to local businesses, government, universities, and to the Science Teachers Association of New York State (STANYS).
This survey is the pilot study for a thesis involving science fairs and student science research projects. For the actual thesis, it will be completed by the chairpersons of local high school science departments. But, for today, please imagine yourself as the chairperson of a science department in a local high school with which you are familiar. Understandably, you won't know many of these answers. Just give a quick guestimate on the data according to your best knowledge of one school's science activities.

Thank you, Chairperson for a Day!

Name of high school: ________________________________

# students in the high school: ________

What science activities did your students participate in over the past 1994-5 school year? Please check the following:

- Science Clubs
- Optional student projects
- Required student research projects
- Mentor research opportunity
- Research class/course
- In-school science fair

What local science competitions and events did your school participate in during the past 1994-5 school year? Please check the following:

- Science Olympiads
- Science Congress
- Odyssey of the Mind
- E 3 RIT
- Challenger Space Program
- Science Exploration Day
- Broaden Your Horizons
- Other

____ # Students to advance to state or national science fair competition
REFERENCES


NSTA (1960). *New developments in high school science teaching*. Washington, DC.
