THE NEED FOR AN INDUSTRIAL ARTS-RELATED SCIENCE PROGRAM FOR OREGON SECONDARY SCHOOLS AND A PROPOSED METHOD TO FILL THIS NEED

by

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CHAPTER I

INTRODUCTION

Thorough preparation of a modern scientist is dependent upon many phases of education. All too often today's high school student is guided toward a strict academic program to prepare him for further education on the college level. Is enough thought being given to the preparation for a career in science or science teaching so that a youngster may be guided along lines that will prepare him well for his chosen field and also prepare him well to live, work, and play in his industrial environment?

There appears to be a need today for those young people contemplating a scientific career to be oriented and adjusted to the industrial world in which we live. There is also a need today for these budding American scientists to be able to construct apparatus, set up experiments, manipulate equipment, and in general handle the technological-mechanical devices associated with industry. The United States is the most industrialized nation in the world and yet we have some scientists in the field who lack sufficient mechanical skills to work with ease on the equipment they use.

STATEMENT OF THE PROBLEM

The problem was to ascertain the need for an industrial arts-related science program for Oregon secondary schools and the current practices used in preparing secondary science teachers in the state. More specifically, the study sought to gather data which would aid in answering the following questions:

1. What skills are needed by today's secondary science teachers to enable them to properly handle the equipment in their field?
2. What training in mechanical-technological skills did secondary science teachers receive in their teacher preparation?
3. What preparation in mechanical-technological skills is currently being offered to those students preparing to teach in the science areas?
4. Can a technical training program in industrial arts be set up on the high school level to help prepare a student for a career in science or science teaching?
5. Are secondary industrial arts teachers interested in a program of mechanical skills improvement for science students?

PURPOSE OF THE STUDY

The purpose of this research is to determine the need for a cooperative effort to produce more capable science students and industrial arts students on the high school level. The author wishes to define the areas in science and industrial arts needing improvement and to establish that those students preparing for a science career need or desire additional instruction along mechanical-technological lines.

SIGNIFICANCE OF THE PROBLEM

It is desirable to produce high quality high school students with sufficient background in the science and technical areas so that they may be motivated and prepared to attain high levels of understanding on the college or technical school level.

Our national survival may well rest with these young people and our technological advance in many fields does depend upon them. The burden is not light; are the preparations sufficient?

The possibility exists that there is a need for a more technical industrial arts-related science course for high schools. It seems apparent that full use of the available teacher skills, equipment, and natural tendencies of a student, to relate one subject to another, are not being used to the fullest extent possible.

The question can be raised as to whether science teachers who teach on the secondary level today are adequately prepared by a straight academic program to cope with the technological-mechanical problems associated with experimental apparatus in their field.

There also may be a possibility, if the mechanical skills of secondary science teachers can be improved, that this improvement will result in better understanding and learning on the part of the science students.

Finally, there is the possibility, when considering those mechanical skills associated with experimental apparatus, that an improvement can be demonstrated in the science student through an experimental study utilizing industrial arts facilities or equipment.

There is some evidence to indicate that "grass roots" cooperation does not exist to a satisfactory degree between the high school science department and the industrial arts department; that is to say, equipment is not interchangeable, materials cannot be transferred or suitably accounted for, plant facilities cannot be utilized by both instructors, and both groups of students. A case in point would be the lending of a science microscope to an industrial arts class studying wood identification. It seems reasonable that both classes have a need for a microscope if a serious study of trees, cellular structure, growth rings, etc., is to take place. An additional situation exists in that too many people harbor the thought that science and industrial arts or technical education are, or can be, always studied, manipulated, and utilized as two separate distinct unique fields; when in reality, these two fields are interwoven to a marked degree. A review of significant literature in the field has served to bear this out.

SCOPE AND LIMIATIONS

1. It is assumed that science teachers on the secondary level are in need of mechanical-technological improvement to better enable them to accomplish their scientific labors.
2. It is assumed that industrial arts teachers on the secondary level are in need of mechanical-technological review and reinforcement, and that an industrial arts-related science program would be of considerable benefit in the preparation of students predicated to our technical environment.
3. It is further assumed that the necessary cooperation of science teachers in proposed laboratory experiences will be forthcoming.

4. It is assumed that industrial arts facilities, equipment, materials and instruction will be available.
5. The limitations imposed on this study are several and generally administrative in nature. The severest limitation exists in confining the work to secondary schools with administrators, teachers, and students who cooperated in the study. As a beginning study, an attempt was made to set up an experimental program in Newport High School. Newport High is one of six secondary schools in the Lincoln County Unit System in Oregon.
6. Other limitations have to do with confining the study to the relation of science and industrial arts. Many other fields are directly related to industrial arts such as mathematics and reading; however, insofar as possible, the study will only be concerned with science as dealt with in the fields of biology, chemistry, physics, and physical science with emphasis on the last two.
7. The laboratory experiment section of this research was limited to those students of industrial arts who demonstrated good mechanical ability

and comprehension and who were in their third or fourth year of industrial arts.

8. The science student participating in this industrial arts-related science program was a junior or senior and demonstrated average comprehension in science as indicated by the academic record.

CHAPTER II

BACKGROUND FOR PLANNING AN INDUSTRIAL ARTS-RELATED SCIENCE PROGRAM

PURPOSES OF GENERAL EDUCATION

Wilbur (19, p. 3) stated the summarized version of the purpose of general education when he wrote:

> ...various statements may be summed up as implying three basic purposes: (1) to transmit a way of life, (2) to improve and reconstruct that way of life, and (3) to meet the needs of individuals.

A more elaborate thought on the purposes of general education is offered by Bonser (1, pp. 3,5):

> The aim of schooling is always educative, but the practice often is not. By the educative (aim) we mean having experiences through which we learn to act, think, or feel in ways that are better than the ways we would act, think, or feel without the experiences. No experience is educative unless we behave in some way desirably different as a result of it. The most highly educative experiences also develop tendencies to engage in further similar experiences and reveal new possibilities for larger activity.
>
> Education, of course, relates to the improvement of the desirable activities that are important in life--those that are significant in the practical life of the home and the occupations, health, community, and other forms of social and civic life, and the use of leisure.
>
> Have we not very largely neglected in schools to give children experiences in the real activities of life and therefore failed to develop in them any connection between the things we require them to learn and the activities in which they are useful? We

> violate all the laws of learning and of human nature, and then wonder why children come out of the school uneducated.

PURPOSES OF INDUSTRIAL ARTS EDUCATION

The purposes of industrial arts as given by the California State Department of Education (6, p. 2) are:

1. Understanding industry and industrial processes through which man changes materials to increase his health, comfort, and enjoyment.
2. Appreciating the influence of industrial products and industrialization upon modern social and economic life.
3. Using tools, machines, and materials.
4. Constructing objects to enrich personal and group living.
5. Discovering personal aptitudes, interests, and abilities.
6. Understanding the opportunities and requirements of industrial employment.
7. Selecting, using, and caring for the products of industry.
8. Developing attitudes and appreciations leading to sound safety practices in the school, in the home, and in everyday living.
9. Planning and working alone and in cooperation with others toward the orderly, efficient, and

complete performance of assigned and selected tasks.

10. Appreciating good design and good workmanship in construction and industrial products.
11. Applying ~~the~~ skills of measuring and calculating, using scientific information, graphic illustration, reading and using reference materials; appreciating the values and importance of these skills.
12. Understanding the sources and conservation of the basic materials of the world that provide resources for man's comfort, health, and enjoyment.

DEFINITION OF INDUSTRIAL ARTS EDUCATION

According to a recent industrial arts curriculum study made on the Oregon State Campus (16, p. 2): The people of today are living and will continue to live in a highly technological and mechanized world. The study further stated that the development of skills, technical knowledge, habits and attitudes enables the student to better understand his environment and the contributions he can make to society.

Industrial arts is a vital and integral part of the total school program. The objectives as set forth indicate the contributions made to the growth and development of each child.

I. SOCIAL CIVIC

TO DEVELOP SOCIAL-CIVIC TRAITS AND RELATIONSHIPS. The student:

1. Participates in group undertaking.
2. Exhibits group loyalty.
3. Demonstrates unselfish attitudes.
4. Responds as a leader and/or follower.
5. Assumes friendly relationships with others.
6. Respects the rights of others.
7. Recognizes the inseparability of privilege and responsibility.
8. Recognizes a need for conservation of materials.

II. CHARACTER DEVELOPMENT

TO DEVELOP DESIRABLE TRAITS OF CHARACTER. The student:

1. Accepts responsibility for assigned tasks.
2. Develops habits of reliability, honesty and loyalty.
3. Shows satisfaction in successful completion of activities.
4. Develops orderly work habits.
5. Develops an awareness of the value of time.
6. Exhibits initiative for maintaining orderly surroundings.
7. Exercises care and consideration in the use of personal and public equipment and materials.
8. Demonstrates increasing self-reliance and confidence.
9. Shows an understanding of the need for regulations.
10. Accepts constructive criticism.
11. Exhibits respect for authority.

III. CREATIVE THINKING

TO DEVELOP CREATIVE THINKING AND PROBLEM SOLVING ABILITIES. The student:

1. Develops an awareness of the principles of good design.

2. Develops ability to select appropriate materials.
3. Develops ability to select appropriate methods.
4. Exhibits curiosity and imagination in expanding his interests.
5. Demonstrates the use of the problem solving approach in attacking problems.
6. Demonstrates ingenuity in solving design and construction problems.

IV. ABILITIES AND APTITUDES

TO DISCOVER ABILITIES AND APTITUDES THROUGH EXPLORATION.
The student:

1. Recognizes his ability to do mechanical and/or technical work.
2. Identifies mechanical and/or technical interests.
3. Recognizes the need for development of abilities and aptitudes.
4. Becomes aware that individual differences exist in varying degrees of ability and aptitude.

V. HEALTH AND SAFETY

TO DEVELOP DESIRABLE HABITS AND ATTITUDES WITH RESPECT TO HEALTH AND SAFETY.
The student:

1. Practices personal and public health rules.
2. Abides by safety rules.
3. Demonstrates awareness of his responsibilities for the health and safety of others.
4. Uses tools, equipment and materials in accordance with their accepted use.
5. Exercises caution when exposed to hazardous situations that cannot be completely eliminated by protective devices.
6. Shows an awareness of the existence of occupational hazards.
7. Evidences a favorable attitude toward safety training and education.
8. Exhibits an awareness of the relationship of wholesome leisure.
9. Recognizes physical, mental and emotional limitations as potential hazards in an industrial situation.

VI. BASIC SKILLS

TO DEVELOP A DEGREE OF SKILL AND UNDERSTANDING IN THE USE OF TOOLS, MACHINES, TECHNICAL EQUIPMENT AND PROCESSES.
The student:

1. Develops manipulative skills.
2. Develops skill in use of common hand tools.
3. Develops skill in use of machines.
4. Develops technical communication skills. (Drafting and Shop Drawings)
5. Demonstrates understanding of purposes of uses of drawings, tools, and machines.
6. Exhibits an understanding of a variety of materials used in the shop.
7. Demonstrates increased skill in the use of English, mathematics and science as related to shop work.
8. Develops skill in the use of scientific principles as applied to technical work.

VII. CONSUMER EDUCATION

TO DEVELOP THE ABILITY TO MAKE INTELLIGENT EVALUATION OF CONSUMER PRODUCTS AND SERVICES.
The student:

1. Recognizes good design and good construction.
2. Recognizes how good craftsmanship increases value.
3. Recognizes appropriate use of materials.
4. Demonstrates understanding of how consumer goods are marketed.
5. Demonstrates understanding of production problems.
6. Evaluates consumer products as to suitability, use and costs.
7. Realizes that prompt and proper maintenance and adjustment of equipment is essential.

VIII. OCCUPATIONAL GUIDANCE

TO DISCOVER AND DEVELOP THE INDIVIDUALS' ABILITIES AND TO RELATE THESE ABILITIES TO OCCUPATIONAL PURSUITS.
The student:

1. Recognizes occupations and related skills as represented in the school shop.

2. Realizes the importance of the mechanical and technical fields of work.
3. Develops an awareness of working conditions in various occupations.
4. Develops an awareness of the occupational trends; opportunities and qualifications for various occupations.
5. Becomes increasingly aware of the need for better qualified craftsmen and technicians.
6. Recognizes the desirability for establishing an occupational goal.
7. Explores a variety of technical fields.
8. Explores and develops selected areas of interest.

PURPOSES OF SCIENCE EDUCATION

Oburn (14, p. 1) has stated

"...that problem solving, or scientific thinking, is a widely accepted outcome of science teaching in schools over the country. In the past much attention has been given to this objective in science education literature and there appears to be an interesting increase in it at present.

Very little reliable evidence is available to indicate the extent to which the problem solving objective is provided for in day-to-day classroom activities. Still less evidence is available on the extent to which the objective is achieved with the young people who study science.

Among other difficulties in reaching the fullest attainment of the objective is the failure, on the part of many teachers, to recognize that problem solving behavior is a complex ability made up of elements which can be identified. Some of these elements are quite simple manipulative skills but many more are of a highly intellectual character.

Regardless of the category in which these skills fall, it is very important to recognize that they are developed by recurrent practice just as any skill is developed."

Thus, if a teacher wishes to develop some manipulative skill related to problem solving the skill must first be taught thoroughly and then practiced until achieved.

It follows then that certain objectives could be set up to achieve this result. Richardson (17, pp. 8, 9, 13) has set these up as objectives of the secondary science teacher so that they will teach in such a way that students will:

1. Develop the ability to think critically, to use the method of science effectively.

2. Acquire the principles, concepts, facts, and appreciations through which they can better understand and appreciate the nature of the earth, its inhabitants, and the universe.

3. Use wisely and effectively the natural resources of our earth as well as the products of science and technology.

4. Understand the social function of science and think and act in relation to the implications of science and technology for society.

5. Develop understandings that will contribute positively to their physical and mental health and their recreational interest.

6. Acquire information, understandings, and appreciations that will contribute to their educational and vocational guidance."

Burnett (5, p. 20-24) established objectives for science education that reinforce those of Richardson when he composed the following general statements:

1. To relate science to the progressive refinement of the democratic way of life

....The over-all responsibility of science teachers in a great democracy is therefore to challenge, stimulate, guide, and assist young people to develop the understandings, critical abilities, attitudes, and viewpoints that represent the best in the scientific and democratic traditions.

2. Sound college preparation is an essential and fundamental part of our (the high school science teacher's) responsibility.

3. We must wisely select and soundly organize the content and experiences of our instruction so that facts, principles, and broad understandings that are fundamental to sound human living in the modern world will be learned--really learned--and retained.

4. Critical thinking--We must develop abilities that will enable our students to engage, throughout their lives, in the process of self education and in the judicious and critical use of facts for the betterment of their personal lots and the lot of mankind."

Of the imperative needs of youth as listed by the Educational Policies Commission (10, p. 225-226) the following have been selected which tie in science education with the balance of general education.

1. All youth need to develop salable skills and those understandings and attitudes that make the worker an intelligent and productive participant in economic life. To this end, most youth need supervised work experience as well as education in the skills and knowledge of their occupations.

3. All youth need to understand the rights and duties of the citizen of a democratic society, and to be diligent and competent in the performance of their obligations as members of the community and citizens of the state and nation.

5. All youth need to know how to purchase and use goods and services intelligently, understanding both the values received by the consumer and the economic consequences of their acts.

6. All youth need to understand the methods of science, the influence of science on human life, and the main scientific facts concerning the nature of the world and of man.

9. All youth need to develop respect for other persons, to grow in their insight into ethical values and principles, and to be able to live and work cooperatively with others.

10. All youth need to grow in their ability to think rationally, to express their thoughts clearly, and to read and listen with understanding.

CLOSE RELATION OF CERTAIN OBJECTIVES OF SCIENCE EDUCATION WITH THOSE OF INDUSTRIAL ARTS EDUCATION.

Further study of the definitions and objectives of the two separate fields indicates a closer relationship than might be assumed at first. A comparison of the two yields the information that those objectives that are common to both fields could be taught or attained in either environment. This should help allay the fear that a student of science would be negating his position were he to undertake a course in industrial arts. On the contrary, the science student would be enriched by accomplishing part of his objectives in a complementary field.

Some of the objectives that indicate a good relationship are:

SOCIAL CIVIC

TO DEVELOP SOCIAL-CIVIC TRAITS AND RELATIONSHIPS
The student:

1. Participates in group undertaking.
2. Assumes friendly relationships with others.
3. Recognizes a need for conservation of materials.

TO DEVELOP DESIRABLE TRAITS OF CHARACTER
The student:

1. Develops habits of reliability, honesty and loyalty.
2. Shows satisfaction in successful completion of activities.
3. Develops orderly work habits.
4. Exercises care and consideration in the use of personal and public equipment and materials.
5. Demonstrates increasing self-reliance and confidence.
6. Shows an understanding of the need for regulations.

TO DEVELOP CREATIVE THINKING AND PROBLEM SOLVING ABILITIES
The student:

1. Develops an awareness of the principles of good design.
2. Develops ability to select appropriate materials.
3. Develops ability to select appropriate methods.
4. Exhibits curiosity and imagination in expanding his interests.
5. Demonstrates the use of the problem solving approach in attacking problems.
6. Demonstrates ingenuity in solving design and construction problems.

TO DISCOVER ABILITIES AND APTITUDES THROUGH EXPLORATION
The student:

1. Recognizes his ability to do mechanical and/or technical work.

2. Identifies mechanical and/or technical interests.
3. Recognizes the need for development of abilities and aptitudes.
4. Becomes aware that individual differences exist in varying degrees of ability and aptitude.

TO DEVELOP DESIRABLE HABITS AND ATTITUDES WITH RESPECT TO HEALTH AND SAFETY
The student:

1. Abides by safety rules.
2. Demonstrates awareness of his responsibilities for the health and safety of others.
3. Uses tools, equipment and materials in accordance with their accepted use.
4. Exercises caution when exposed to hazardous situations that cannot be completely eliminated by protective devices.
5. Shows an awareness of the existence of occupational hazards.
6. Evidences a favorable attitude toward safety training and education.

TO DEVELOP A DEGREE OF SKILL AND UNDERSTANDING IN THE USE OF TOOLS, MACHINES, TECHNICAL EQUIPMENT AND PROCESSES.
The student:

1. Develops manipulative skills.
2. Develops skill in use of common hand tools.
3. Develops skill in use of machines.
4. Develops technical communication skills. (Drafting and Shop Drawings, electrical and electronics schematics.)
5. Demonstrates understanding of purposes of uses of drawings, tools, and machines.
6. Exhibits and understanding of a variety of materials used in the shop and laboratory.
7. Demonstrates increased skill in the use of English, mathematics and science as related to all work.
8. Develops skill in the use of scientific principles as applied to technical work.

TO DEVELOP THE ABILITY TO MAKE INTELLIGENT EVALUATION OF CONSUMER PRODUCTS AND SERVICES
The student:

1. Recognizes good design and good construction.
2. Recognizes how good craftsmanship increases value.
3. Recognizes appropriate use of materials.
4. Demonstrates understanding of production problems.
5. Realizes that prompt and proper maintenance and adjustment of equipment is essential.

TO DISCOVER AND DEVELOP THE INDIVIDUALS' ABILITIES AND TO RELATE THESE ABILITIES TO OCCUPATIONAL PURSUITS
The student:

1. Realizes the importance of the mechanical and technical fields of work.
2. Develops an awareness of working conditions in various occupations.
3. Develops an awareness of the occupational trends; opportunities and qualifications for various occupations.
4. Becomes increasingly aware of the need for better qualified craftsmen and technicians.
5. Explores a variety of technical fields.
6. Explores and develops selected areas of interest.

As Conant (7, p. 15) pointed out, "the whole development of our American public school system was predicated on the basis of the importance of the all-around education of all American youth."

He went on to state that "some critics of our schools attempt to place vocational education in opposition to academic education and that this is obviously incorrect." According to Conant, "at least half of the time of a youth in high school is devoted to English, the social studies, science, and mathematics.

This is as true of the pupil who, in his or her last year, spends the other half of the time on practical courses as it is of those who spend the corresponding time on foreign languages, chemistry, physics, and mathematics. Indeed, it can be argued that the advantage of our school pattern over the European lies in the very fact that our future skilled mechanics and technicians continue their general education through at least 12 grades. European formal full-time education for this group terminates, as a rule, two or three years earlier."

"In searching for various ways to strengthen research project activities in school programs, industrial arts and science teachers should evaluate their curriculum areas for possible integration of project activities," so states Bielefeld (4, p. 1).

AN ANALYSIS OF MATERIAL FROM COMPETENT AUTHORITIES IN THE FIELD

Much has been written by people holding responsible positions in industry today on the need for employees who can understand and use the principles of science and technology. Dr. Lawrence Hofstad (12, p. 24-26), vice-president in charge of General Motors Research staff recently made a plea for reviving classroom disciplines of science and mathematics for both technical and non-technical high school students. He explained that, "to reap full benefits of technology, a 'good society' not only must educate more scientists and engineers, but also must make the basic philosophies of science understandable to nontechnical people. In technology, if incentive is removed, so is struggle--and if struggle is stopped, so is progress."

Dr. Hofstad further stated "that the desire for progress cannot be reconciled with the lack of attention to, and incentive for, this desire, by students of exceptional ability. That is to say, these students who should be most concerned are likely to be least concerned. Similarly the desire for progress is inconsistent with the trend toward effortless education with the substitution of pastimes for disciplines."

Dr. Hofstad concluded with the statement that, "Even more acute than the current shortage of scientists and engineers is the shortage of people who can and will carry responsibility."

In a recent article appearing in Industrial Arts and Vocational Education, Doutt and Scriven (8, p. 15) delineated a program for integrating science, mathematics, and industrial arts. "The coordination of these three technical subjects can be accomplished by practical experiment," they stated. Professor Doutt is the industrial arts supervising teacher at University

School, Northern Illinois University at DeKalb, and Professor Scriven is a mathematics and science supervising teacher at the same school. Here is a working example of professional cooperation that is producing results.

Arthur W. Earl, Professor of Industrial Arts Education at Montclair State College, Upper Montclair, New Jersey, has published a new approach to an integrated science-industrial arts program in his current textbook, "Experiments with Materials and Products of Industry." In November, 1960, Professor Earl (9, p. 23-25) wrote an article on the research-experimental procedure for solving industrial problems. Professor Earl has produced some excellent ideas that will work as this researcher has found during the school year 1960-61 at Newport High School where numerous experiments were carried out.

The new editor of Industrial Arts and Vocational Education magazine, and author of many texts in this field, Dr. John Feirer (11, p. 13) prepared a timely editorial on integrating science with industrial arts in the April issue of that magazine. Mr. Feirer is for immediate action toward improving the science-industrial arts program. These articles of his have had much to do with influencing this researcher to carry out the work of this thesis.

Competent authorities on secondary schools such as James Conant, whose own work as a teacher was in the field of chemistry, have revised their thinking after extensive research and study. Conant (7, p. 2,3,5) recently stated:

> ...before I started my study of the American high school my knowledge was very slight of such matters as the Smith-Hughes Act and the difference between industrial arts and a trade and industry program.....
>
> I do not see how anyone who has visited the kind of practical courses I visited could recommend eliminating vocational and practical work from the high school.
>
> When I hear adverse criticism of vocational education, I cannot help concluding that the critic just has not taken the trouble to find out what he is talking about.
>
> ...Consider the highly important group who must develop the combination of manual and intellectual skills required by technicians in industry. This is the group with which the vocational educators are particularly concerned. Some of this group can go directly from high school into apprentice work and, I am told, can shorten the period of apprentice training by a year thanks to having spent half their time (or a little more) in grades 11 and 12 in shop work.
>
> Further...only a relatively small group of youth have the scholastic potentialities which enable them to complete the post-high school technical course of four, six, or eight years necessary for research scientisits or engineers.
>
> Finally...in those relatively few senior high schools where almost all the pupils wish to go to college (whether they can profit from college or not) industrial arts shops in grades 11 and 12 may be appropriate.

Seven industrial arts and science teachers serving as technicians worked with Abraham G. Beleson, workshop consultant and a member of the Bronx High School of Science faculty, in planning, designing and fabricating projects to assist in integrating the learning activities of industrial arts and science students.

According to Bielefeld (4, p. 1) many industrial arts and science teachers in an unofficial capacity promote student research in construction of scientific projects. The use of machines, tools and materials in the industrial arts shop by students enrolled in science classes fills a void for many who have learned only the scientific and mathematical principles without having had any previous opportunity for practical application.

He went on to say that most science projects contain the techniques considered basic industrial arts operations and processes.

Conant (7, p. 2) stated in his address to the American Vocational Association:

> ... I have in mind also, to be quite frank, that there has not been the close liaison, it seems to me, that one might have wished between the teachers of the general education subjects (language arts, social studies, art, music, science, and mathematics), the teachers of commercial subjects, and the teachers in the vocational subjects. And at the administration level, I seem to have detected something short of complete trust and understanding.

A bringing together or cooperative clarification of common goals and interests should be immediately undertaken so as to provide the best possible learning situation for the student. Technical mechanical skills could be integrated with problem solving and the scientific study approach. It is possible that the industrial arts program by helping this way could develop and upgrade itself tremendously through a closer relation with the science program.

Dr. Darrel Barnard (14, p. 2-6), Professor of Education and Head of the Department of Science Education at New York University recently made an analysis of "Problem Solving Behavior." A summary of his analysis follows in succinct form.

Through the science program the individuals behavior should be modified so that he is open-minded toward work, opinions of others, and information related to his problem. He should base his opinions and conclusions on adequate evidence. He should develop problem solving abilities and use experimental procedures appropriate to the problem.

Dr. Barnard goes on to say that the individual should be able to select the materials and equipment needed in solving problems and be able to manipulate the laboratory equipment. He should recognize capacities or limitations of equipment, be able to keep it in good condition so as to avoid hazards and consequent personal accidents.

Other leaders in science education have similar feelings along this line. Dr. Fred W. Fox, Associate Professor of Science Education at Oregon State University recently stated that, "science teachers need to be able to devise suitable demonstrations, select materials and equipment and be able to manipulate machinery and tools with sufficient skill to accomplish their objectives in science education."

A course has been established recently at Oregon State University in the Science Education Department. This is a science teacher preparation course and is devised to assist in filling the need for mechanical skills as well as developing laboratory procedures. An outline of the course follows as evidence that a very real effort is being made toward this end by one of the more advanced departments of science education.

SEd 592. Laboratory Practicum in Physical Science - 3 hours winter 2-1 1-2

Develop competencies in laboratory and demonstration skills, program planning, and in maintaining and designing laboratory materials. Prerequisite: 408g, 416, and a teaching major or minor in the physical sciences. Fox

I. Objectives for the Course

A. To help the student expand his understanding of the place and importance of the laboratory and demonstrations in high school science teaching.

B. To help the student develop a tentative program of laboratory instruction in the science he teaches or expects to teach.

C. To help the student develop, on the basis of laboratory work in the course and a search of pertinent literature, a number of demonstrations, laboratory experiments, and projects which he may use in carrying out his proposed laboratory program.

D. To provide opportunities for students to design, construct, and try out demonstrations and experiments which will provide him with skills and techniques necessary for working effectively in the secondary school science laboratory.

II. Course Content Outline

A. Place of the Laboratory in the Physical Science Program
   1. Objectives of the laboratory
   2. Contributions of the science laboratory
   3. Facilities for laboratory instruction
      a. Rooms and furniture
      b. Equipment and supplies

B. Planning for Effective Use of the Laboratory
   1. Types of laboratory experiences
   2. Selecting and organizing experiments
   3. Planning supplementary experiences
   4. Planning for and using science projects
   5. Place of the demonstration in effective teaching.

C. Procedures for Conducting Laboratory Programs
   1. Place and use of laboratory manuals
   2. Student designed laboratory experiences
   3. The laboratory as a research center
   4. The inductive approach to the laboratory

D. Planning for Evaluation of the Laboratory Program
   1. Evaluation in terms of objectives
   2. Reporting laboratory experiences

III. The Laboratory Experiences

Laboratory experiences are an important and essential part of the course. Students will have experiences in the following:

1. Designing of new experiments and apparatus
2. Repair and maintenance of laboratory materials
3. Use of modern shop and laboratory techniques
4. Use of new equipment and materials
5. Developing skills essential for successful laboratory and demonstration programs

Representative activities may include such things as: soldering electrical connections, developing a simple spectroscope with diffraction grating, using the oscilloscope, developing elementary woodworking skills, preparing stock solutions, working with glass, etc.

IV. Additional Activities

1. Develop a complete laboratory program for the teacher's special field of interest
   a. Experiments
   b. Demonstrations
   c. Equipment and supplies needed

2. Visit college laboratories and consult with research scientists regarding new experiment materials and/or research problems suitable for high school classroom.

V. Discussion and laboratory time allotment.

Two periods per week will be devoted to discussion and two periods per week will be for laboratory.

SOME MECHANICAL PROBLEMS OF HIGH SCHOOL SCIENCE TEACHERS

There are numerous mechanical problems that will arise as a science teacher prepares for a demonstration.

It is the intent of this writer to bring out some of these problems and offer possible solutions to them to illustrate how simply some of them could be solved. By a coordinated mutual understanding between science teacher and industrial arts teacher and the student of both much good could come of solving these problems. It is hoped that all participants will look upon this as a learning experience.

As will later be born out in this research, many teacher-made or student-made demonstration devices are not constructed or used because of lack of time and/or skill in construction.

As Brown (2, p. 281) stated when discussing audio visual aids: "Demonstrating and experimenting are closely related as means of providing problem-solving learning experiences in the classroom."

It would seem reasonable to expect an improvement in learning were more demonstrations with visual aids and apparatus used. The whole intent of this study is to find ways to solve these little problems which by themselves are not too significant but as a whole tend to detract from an otherwise excellent science teacher's presentation.

The following eleven ideas are from: A Collection of Classroom Demonstration "Quickies" by Denman Evans, Oklahoma State University. They were set up as part of the "traveling science teachers" preparation. These ideas represent science demonstrations that can be used in class with the science teacher and industrial arts teacher cooperating on their construction.

The demonstration is outlined, then a possible solution to the construction is offered. The production of the device or apparatus offers a real learning experience as does the demonstration itself.

These particular demonstration "Quickies" were selected from the list of ideas by Denman Evans because they are representative of the type of problems with which science teachers may be faced. These problems are those that could readily be solved in the industrial arts area with the tools and materials available.

1. Carve a spoon mold in wood and fill with molten Wood's metal. The spoon will melt in hot water, coffee, or tea. Save the mold to recast the spoon as a part of the demonstration.

Solution: Related to foundry, parting line in pattern making and a split flask or mold. Make it in the wood shop.

2. Show action and reaction by standing on rotating platform and swinging a baseball bat vigorously at a pitched ball.

3. Turn around by swinging baseball bat in circles over head. Reversal of swing reverses motion of body. (Standing on rotating platform.)

4. Again on the rotating platform, pirouette. Hold heavy weights at arm's length, have someone to rotate you slowly. Bring weights close to body. Explain marked increase in speed.

Solution: Make in shop. Cut out plywood disc on band saw. Attach casters with wood screws. A good cooperative project.

5. Weld bicycle axle nuts in end of iron pipes. Screw the pipes on wheel axle for handles. This makes an excellent gyroscope; better when the rim is weighted by winding it with iron wire.

Solution: Construct in the metal shop. Either gas weld or electric weld.

6. Drill a brass rod for a screw in one end. Insert screw about half way. Balance rod at its center on a pivot. Throw off balance by moving small screw on one end. Heat one end of rod and it will come to balance again.

Solution: Drill hole in brass rod in shop. Select correct drill and tap for size screw used.

7. Units of work can be visualized with this device. Mount on a single base two pieces of 2 x 2 inch wood,

one 12 inches long and the other slightly over 9 inches long. Using a pound weight, lifting it from the base to the top of the one foot tower represents one foot pound of work. Lifting the weight to the top of the 0.76 foot tower represents one joule of work. A penny lifted from the table top on to a piece of paper laying on the table represents an erg of work. The new unit, electron volt, is 1.6×10^{-23} ergs.

Solution: Cut wood in wood shop.

8. Cut three discs from plywood; diameters about eight to twelve inches. Cut a three-inch circle out of the center of one piece and another circle of the same size within an inch of the outside circumference. Remove the intervening wood between tangent lines to the circles. Make a lead disc to fit the slot and sandwich the pieces between the other discs. When thrown into the air it can be made to rotate smoothly about its geometric center, or about another center of gravity in an eccentric manner. It can also be made to run up an incline, or down and then reverse to roll up. The same apparatus can be made with cardboard and a half-dollar.

Solution: Cut these three discs of plywood on the wood shop band saw. Cut out centers with saber saw or jig saw. Cut lead disc with tin shears in shop.

9. Prepare two small whistles with a screw in the end so that the length of the air column can be adjusted for different frequencies. Attach the whistles to a Y tube so that they can be blown simultaneously. Note that when the pitch of one is varied a low pitch "beat note" may be heard rising or falling in pitch.

Solution: Drill on drill press; select correct drill and tap for screws used.

10. Heat a spot on a cold light bulb with a blow torch and a dimple will form in the glass. Light the bulb and again heat a spot until a pimple forms.

Solution: Use acetylene "Presto" gas outfit from shop.

11. Cut a six inch circle of plywood or press board. Cement a small cork at its center. Drill a very fine hole through the disc and cork. Inflate a balloon and fasten its mouth over the cork. Place the apparatus on a smooth surface to see almost frictionless motion on the cushion of air.

Solution: Cut plywood disc on band saw in shop. Use drill press in shop to drill holes.

While no attempt is made to cite all the mechanical problems inherent in these science laboratory demonstrations, it is apparent that cooperative efforts through the industrial arts department would be of value in solving them.

Other problems follow that were encountered in the field during the period of this study. There are several solutions to these problems but for the purpose of this paper only two solutions will be presented for each mechanical problem stated.

PROBLEM: How to attach the wires in electronic circuits during demonstration so that they may be readily removed for a different set up.

SOLUTION I: Twist the wires together as is commonly done in some physics classes. This results in damage to the wire and inevitable replacement.

SOLUTION II: Build up a "bread board" circuit, drill holes in board using drill press, install spring slip connectors, insert the experimental wires after stripping end of insulation. This setup can be changed repeatedly without wear or damage to the wire.

PROBLEM: How to hold a preserved frog during dissection in a biology class.

SOLUTION I: Fasten with tape or adhesive to top of lab table or use plate, pan or other flat containers and have assistant hold the frog.

SOLUTION II: Surface white pine boards to ½ inch thickness, rip to width on table saw and cut to length suitable for specimen. Water-proof with proper finish to cut down liquid absorption. Hold frog during dissection with pins pressed into the soft pine. Can be reused. Science instructor should be able to accomplish this using industrial arts facilities.

PROBLEM: Repair the cracked glass rotor disc from a static electricity generator.

SOLUTION I: Physical science teacher may apply scotch tape to each side of glass over cracked area; however, he should be aware, through his training, that centrifugal force would cause the rotating glass to be hurled apart.

SOLUTION II: Go to industrial arts shop, cut a new piece of glass, first developing an undersize pattern of wood to allow for glass cutter. Drill hole on drill press, using copper tubing as drill and silicon carbide grit as an abrasive. Use water or light oil to lubricate and contain the lubricant by a dam of putty around the area to be drilled. Grind edges of glass smooth with silicon carbide paper and a curved block of wood. Reassemble machine.

PROBLEM: During unit on tree identification in biology need arises for visual aids to clarify internal tree structure.

SOLUTION I: Biology teacher refers to pictures in text and manufactured visual aid. The visual aid is a "blown up" section of a tree showing cell structure.

SOLUTION II: Biology teacher uses the same two devices but fills the void between these two aids with a large variety of wood identification samples that a boy could make in the industrial arts shops and have available for class.

PROBLEM: To preserve delicate specimens that need to be examined closely by students.

SOLUTION I: In biology class imbed specimens in polyester resin. Remove from molds and trim with science kit handsaw and sand on lab table top with sheet abrasive. It would be difficult to complete the polishing in the science area.

SOLUTION II: Bring cast pieces to shop to trim and polish thereby gaining knowledge of several power machines and holding devices. The machines for handling plastics such as polyester resin and "plexiglass" are often available in the wood shop or craft area where they are part of the regular program. Time would be saved, additional skills would be developed, and a superior product would be produced.

There is no attempt to belittle the science teachers abilities, only a sincere desire to aid them in preparing their demonstrations, and this in turn will give the industrial arts teacher and students more meaning in relating their work to science.

The high cost of many manufactured aids is an additional deterrant that often precludes the use of worthy visual-aids. It seems apparent that much saving of the taxpayer's money could be demonstrated through student-teacher construction of these devices. Concurrently, a richer learning experience will take place.

As Richardson (17, p. 11) stated:

> "...The period of formal college domination of high school science seems to be passing. The high school has become the general or common school, being essentially a required experience in some form in a very large majority of the nation's communities. As the general school, its major function is to serve the needs of young people in all aspects of living. Presently more than 75 per cent of those young people of high school age are in high school. Of those who graduated from high school more than 30 per cent go on to college. Many college students, perhaps most, study some science before graduating from college, since a minimum number of hours of science is required in many institutions. Only a limited percentage of those who do enter college follow scientific and technical pursuits. It is obvious that the high school is not justified in limiting its science courses to the preparation of those who will later enter scientific and technological studies in college."

Richardson (17, p. 29) further stated that "the quality of a science teachers teaching bears a direct relationship to the degree of a student's progress."

According to Wittich and Schuller (20, p. 512)

> "...The teacher has long been recognized as practically the determining factor in child development so far as the school is concerned. Teaching may well be defined as the stimulation of learning. Learning at its best is the process of discovery. It is therefore clear to a high degree the effectiveness of both teaching and learning is determined by the kind and adequacy of the instructional materials that are available. This is especially true of audio-visual materials and equipment."

CHAPTER III

THE STUDY

GENERAL PROCEDURES USED IN GATHERING DATA FOR THE STUDY

The author has learned by observation in the field that some high school science teachers are inadequately prepared to construct, repair, or maintain the apparatus in their area. This observation led to the first research questionnaire being submitted to 50 science teachers attending the 1961 Summer Session at Oregon State University. The questionnaire was designed to sample the mechanical skills that had been taught to the present science teachers already in the field. Further, it provided an opportunity for them to indicate those skills for which they now have a need.

From the experience gained on this first questionnaire, a second was developed to go out to secondary science teachers in the state of Oregon. This second questionnaire (see Appendix) was mailed out to 95 Oregon secondary science teachers to ascertain if there were any mechanical skills which they lacked or felt a need for in accomplishing their laboratory experiments. An attempt was also made to determine what period in school would be the best time to develop these skills.

A questionnaire was submitted to a sampling of industrial arts teachers to ascertain their feelings in relation to this study.

The questionnaires to both groups were essentially the fill in blank Yes-No type with space for appropriate comment. They were designed to be easy to answer and many of the questions were arranged with a group of answers that could be selected to suit.

The questionnaires going out in the mail to secondary science teachers were accompanied by a letter of introduction (see Appendix). A stamped return addressed envelope was also enclosed.

SOURCES OF DATA

The science teachers who answered the first questionnaire were attending 1961 Summer Session at Oregon State University. The second questionnaire for science teachers was mailed during the school year of 1961-62 to secondary science teachers located in Oregon. The selection of recipients was arranged to sample small, medium, and large high schools.

The experiments at Newport yielded the data included in the section of this study that demonstrates what can be done in a medium size high school.

The questionnaire to secondary industrial arts teachers was submitted to 38 teachers attending 1961

Summer Session. These teachers were to a great extent enrolled in a graduate program. Their experience covered a wide span of years, some being beginners and some with over 20 years experience.

Letters (see Appendix) were written to eleven colleges offering science education in the state of Oregon. These letters were addressed to the heads of the science education departments and sought to determine what is being done statewide in the offering of a mechanical skills program for science teaching majors.

The return on these letters was good as 50 per cent had returned in one week. These letters are offered as indicators of what is being done or has been done or is being contemplated by science education departments around the state of Oregon.

The information regarding the program of science education at Oregon State University as related to this study was obtained by interview and observation.

METHODS OF GATHERING DATA

Best (3, p. 184) lists data gathering devices that have proven useful in educational research. The devices among them that this writer considered using are: schedules, questionnaires, opinionnaires, observation, document or content analysis and interviews.

After testing various data gathering devices as related to this study, the author decided upon questionnaires, observation, content analysis and interviews. These devices were used in varying degree as they seemed applicable.

The questionnaire device was tested in the summer of 1959 and the decision was made to use it as an instrument of gathering data.

Personal interviews and correspondence with leaders in science education determined what is currently being done to develop the mechanical skills of novice teachers.

In the school year 1961-62 an experimental study was undertaken in Newport High Industrial Arts Department to determine if a technical training program for science students was feasible.

The device of observation was used in the school years 1960-61 and 1961-62 wherein the writer developed a list of useful and pertinent objectives as related to this study and sought to fulfill them. The science teachers of two high schools and one junior high were observed during classwork, during demonstrations, during production of aids and apparatus, and for the period of time during preparation for the annual local science-industrial arts fairs and county science-industrial arts fairs. The writer served as chairman of the county combined fair so as to be in a position to observe closely.

Content analysis was used to determine what is currently being done toward relating industrial arts and science in curriculum development by others and as Rummel (18, p. 111) stated, "...its [content analysis] major importance in education research is in curriculum development." This writer served on the curriculum committee of the Lincoln County School District during the school years 1960-61 and 1961-62 with the purpose in mind of relating this study to the new Lincoln County curriculum guide.

The use of interviews was considered at length and nearly dropped because of scheduling, transportation, and certain limitations of this data gathering device. The interviewing of secondary science teachers was dropped as being unsatisfactory from the standpoint of scheduling and personal reluctance on the part of the interviewee to admit lack of skill to an outsider. This was dropped after sampling in the field.

Some interviewing of leaders in the field of science education at the college level was kept in the study.

PERSONAL INTERVIEW PROCEDURE

The author of this research decided to draw upon the personal experience of authorities in the science education field. Assistance was asked for in determining what is being done, or what is projected, for mechanical skills development of science teacher trainees on the college level.

Personal interview, where a mutual exchange of ideas can develop and rapport is established, is of much greater value than a questionnaire according to Best (3, p. 167).

A suitable list of pertinent questions was developed and memorized in order to avoid the usual interrogative atmosphere. Limited notes were made, only those necessary to reinforce memory, and this was done in an unobtrusive manner.

At no time was the interview allowed to approach the place where any possible insinuation or blame could be inferred as to why science teachers have not been prepared in mechanical skills in the past. That is not a part of this research.

STATEMENT OF EXPERIMENTAL STUDY IN NEWPORT HIGH SCHOOL

This is a brief statement of the method that was used in the industrial arts department of Newport High School, Newport, Oregon, for the express purpose of developing mechanical skills in science students going into science teaching. The author does not take full credit for this method and acknowledges the use of a similar idea as a guide.

Herbert Johnson (13, p. 456-458), assistant professor of mechanical engineering in the University of Wyoming at Laramie, made these statements regarding laboratory teaching:

> The laboratory assignment is strictly a "snow job" lightning lecture at the beginning of the period on what was involved and what data to take, followed by a horsewhipping through the actual "experiment" to finish by the end of the period. This is extremely undesirable for several reasons. The student's lab time is poorly invested if not used effectively. Moreover, the student may not develop an appreciation for experimental work which is as important as analytical work.
>
> With a suitable background, a senior mechanical student should be able to carry out basic test assignments on conventional mechanical machinery with a minimum of supervision.

With Professor Johnson's (13, p. 457) remarks in mind a revised method was developed for use in this study where two industrial arts advanced students worked with two advanced science students, who have had previous industrial arts instruction, on a group experimental project. No specific time limit on an assignment was made, rather requirements were established cooperatively with the instructor. Following this, one of the group was elected leader. The balance of the methods is presented in succinct outline form.

1. Group leader correlates group's entire activity and brings group together with instructor for conferences when desirable.

2. An experiment is assigned to the group, or they may select from a preferred list.

3. Group establishes a procedure sheet, materials list and equipment list. Group meets with instructor for check conference, group leader directs the conference. Revisions and adjustments, if any, are made at this time. Instrumentation is completed.

4. The group completely familiarizes themselves with the apparatus and procedure by inspection, study of manuals, and filling out question sheets.

5. A detailed conference is now held with instructor on how apparatus is operated, taking into account limitations and safety. This conference concludes with instructor demonstrating the operation.

6. The group then plans the experiment test, submits a written outline of the test, indicating what data are to be recorded and the range of the independent variables. The third conference is now held to go over the test outline with the instructor to check on limits of operation and eliminate possible damage to equipment.

The responsibility rests on the group, the instructor merely checks.

7. The group then proceeds with the test or operation of apparatus, all data are recorded and original copy of data sheet goes to instructor.

8. Group completes calculations and submits a set of pencilled results along with data sheet to instructor. The fourth conference is now set to discuss results.

9. The test or experiment is now written up in ink individually following a prescribed report form and is due one week from the day the pencilled results are turned in. Typing is encouraged if available.

The group leader system has proved quite satisfactory and has been very successful in the author's other programs in personnel management.

The procedural and instrumentation session is quite beneficial as mistakes are discovered and corrected. There is much to be gained by learning to make decisions.

According to Johnson (13, p. 458), "...the familiarization procedure also fills in a big gap. Student planning has proved to be very effective. Not, this is the way to do it--but rather, how many ways can you think of to accomplish this experiment or test?"

In general, the objective of shifting the initiative to the student, and therefore improving morale has been accomplished. This is not an easy assignment, but with this procedure, the students know what they are doing and why, and act accordingly.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

A questionnaire (see Appendix) was developed to ascertain the need for an industrial arts-related science program in Oregon secondary schools. It was designed to bring out the need for mechanical skills associated with science apparatus construction, manipulation and repair. Further the questionnaire sought to determine the preparation secondary science teachers had received along these lines during college education.

An attempt was made to determine what mechanical technological skills were being offered currently or in recent years at the college level specifically for science teachers. The questionnaire also sampled opinions on the value of mechanical skills as offered by regular industrial arts high school programs. This was in relation to its value to a science program.

The question was put forth as to whether mechanical skills could best be obtained in high school or in a college survey course.

A special effort was made to send questionnaires only to those teachers working at the secondary level. The questionnaire was mailed to the heads of the various science departments and in the largest high schools two questionnaires were enclosed. A total of 95 questionnaires was mailed. Sixty were returned; all were usable, although some were not complete. This was a 63 per cent return.

The material is considered to be reasonably accurate despite the prevailing factor of uncertainty that the questionnaire method presents. The writer believes most science teachers, because of their constant search for the truth, are essentially honest people.

The length of time to complete the questionnaire was printed on it. This was pretested and apparently was not too unsatisfactory as only one science teacher crossed it out and wrote in his own time. It was felt that establishing a period of time might lead to a better feeling regarding questionnaires.

RESULTS OF SCIENCE TEACHER QUESTIONNAIRE

All 60 respondents answered the question, "What branch of science do you teach?" Their answers fell into the following categories: physics, chemistry, biology, physical science, general science, advanced mathematics, advanced biology, natural science.

The purpose here was to determine not only the area taught by the respondents, but to find out the number of areas taught by the various science teachers.

Table 1 indicates how these were distributed.

Table 1

AREAS OF SCIENCE TAUGHT

Area	Number of Teachers	Per Cent of 60 Respondents
three areas	9	15
two areas	21	35
one area	30	50

The importance of this question will be brought out in later tables. It should be noted that 50 per cent of the respondents teach in only one area.

Of those people teaching in only one area, 28 are teaching physics. This amounts to 46 per cent of the total respondents.

In answer to the query, "Number of years taught this branch of science," all respondents stated an answer except one. The total number of years of teaching experience expressed by the respondents is 511 years. The range is from one to 27 years. The average is 8.6 years.

The total enrollment of respondent's schools is 47,030 students. The range of enrollment is from 100 to 2200, with the average enrollment numbering 811 students.

The school sizes were arbitrarily set up in five categories as shown in Table 2.

Table 2

SCHOOL SIZE

Category of High School	Enrollment	Number of Schools	Per Cent Total Schools
very small	100-200	4	7
medium	201-500	23	38
large	501-1200	15	25
very large	1201-2000	10	17
super	2001-2220	6	10
unclassified	not stated	2	3

A large number of science teachers use apparatus that is manufactured commercially. This was revealed by answers to the question, "do you generally use commercially manufactured apparatus?" Of the 60 respondents, 57 (95%) said yes and only three said no.

A majority of the teachers surveyed believed there to be advantages in using commercially manufactured apparatus. Of the 60 respondents, 57 (95%) of them indicated there were advantages in using such equipment, while only three indicated there were no such advantages.

In Table 3 are presented the answers to the question, "What are the advantages of using commercially manufactured equipment." It is possible the item "convenience only" could be grouped with "time saver;" however, the possibility exists that "convenience only" may imply that the science teacher would rather not use commercially manufactured apparatus. However, most of the answers fell into groups as indicated in Table 3.

Of the several advantages of commercially manufactured apparatus, one major advantage stands out. According to the respondents, the "time saver" advantage was most important to 42 (70%) of them. Next in importance was "reliability." This was indicated by 25 (42%) of the respondents. Fifteen (25%) of the science teachers listed "better built" as an important advantage. Other advantages of minor importance to the respondents were "functional", five per cent, "have instructional aids with them," 1.6 per cent. There were a few isolated items that are not advantages as such, but rather reasons for using commercial equipment.

Some of the respondents wrote in comments on this question such as ...federal funds available on manufactured apparatus ... gives student appreciation of manufacturing methods ... unable to make chemistry glassware.

Table 3

ADVANTAGES OF COMMERCIALLY MANUFACTURED APPARATUS

Advantage	Number	Per Cent
Time saver	42	70
Reliable	25	42
Better built	15	25
Convenience only	9	15
No material for teacher made	7	12
Functional	5	8
No equipment for teacher made	2	3.3
Have instructional aids with them	1	1.6
Some respondents checked several advantages		
		176.9

The question, "Do you feel there is an advantage in teacher-made or student-made apparatus over the commercially manufactured apparatus?" was asked. Apparently there is a real advantage in using this type of apparatus. Most of the respondents felt the educational benefits were valuable, and this of course has to balance out with time available. The results were: 47 (78%), said yes, 13 (22%) said no. The advantages listed for teacher-made or student-made apparatus are presented in Table 4. The advantage most often listed by the science teachers was the student "learning experience." This was listed by 57 per cent of the respondents. "Fits program" and "interest-challenge" were the next most frequently listed advantages.

According to literature in the field there is a pupil learning-experience that is quite valuable when devices are student made. The respondents tend to bear this out.

Table 4

ADVANTAGES OF TEACHER-MADE OR PUPIL-MADE APPARATUS

Advantages	Number	Per Cent
Learning experience	34	57
Fits program	15	25
Interest-challenge	15	25
Low cost	8	13
Pride of student	5	8
Material available and familiar	3	5
Pride of teacher	2	3
Attention getter	2	3
Some respondents checked several advantages		139

To the inquiry, "If you feel that commercially manufactured apparatus is best, is it because you personally do not have the:

-- mechanical ability to construct or repair your own apparatus?
-- machine tools to construct apparatus?
-- hand tools to construct apparatus?
-- knowledge of industrial to construct apparatus?
-- no access to machine tools, i.e., no cooperation from industrial arts department?
-- other. what?"

Respondents' answers fell into several groups. The item "other problems and what are they" received the largest response. Apparently lack of time to construct apparatus ranks as the major reason for using apparatus which is manufactured. This was indicated by 55 per cent of the respondents.

"Not having any machine tools" was the second largest group with 43 per cent of the respondents indicating this problem. "Lack of knowledge of industrial processes" was cited in third place with 27 per cent of the respondents stating this answer. Twenty-one per cent selected "lack of hand tools and 20 per cent selected "lack of mechanical ability." When queried as to "cooperation from the industrial arts department" only 12 per cent of the responses indicated an unfavorable attitude here.

Other write-in reasons such as "lack of money," "no easy access to machinery during class time," and "no industrial arts department" were indicated as having minor importance.

This question is handled under two tables. Table 5 describing the first five items of choice in the question and Table 6 describing the possible answers under the last item of choice where the respondent could write in his answer.

Table 5

NEGATIVE FACTOR AFFECTING A CHOICE OF COMMERCIALLY MANUFACTURED APPARATUS

Factor	Number	Per Cent
No machine tools	26	43
Lack of industrial process knowledge	16	27
No hand tools	13	21
Lack of mechanical ability	12	20
No access to machine tools (no cooperation from IA Dept.)	7	12
Some respondents checked several factors		123

Table 6

"WRITE IN" NEGATIVE FACTORS AFFECTING A CHOICE OF COMMERCIALLY MANUFACTURED APPARATUS

Factor	Number	Per Cent
Lack of time	33	55
Lack of money	4	7
No easy access to machinery during class time	1	2
No industrial arts department	1	2

Under comments several science teachers wrote that they did make their own demonstration apparatus. It is interesting to note that they are in high schools of approximately 400.

Two science teachers make most of the equipment they use and two teachers state that they make some of it.

The secondary science teachers were asked if the construction of teacher-made apparatus and repairs to it would be more acceptable if they had sufficient practical training and experience to do this type of work. The science teachers were also asked if practical training and experience would help in maintaining and repairing manufactured apparatus. The above two questions were combined on the questionnaire.

The respondents expressed a positive attitude as 43 (71%) stated yes and 13 (22%) stated no. Approximately 7 per cent did not respond. There were several comments such as ... need more time ... depends on equipment ... etc.

In your opinion would a survey course in the industrial arts area on college level, along with your science teaching major, have helped you in preparation of apparatus as a science teacher?

The answers were similar to the previous question as 40 (66%) of the answers were yes and 18 (30%), were no with 2 (3%), not answering. Some of the respondents qualified their answer by stating "probably" or "maybe" or "some" and one stated that he "took industrial arts in high school."

In the second part of this question was a note as here indicated:

> We fully realize the heavy load in a science major already and believe science teachers themselves recognize a need, but
>
> --didn't have time for it.
> --wouldn't have improved me.
> --knew how already.
> --was not offered at _______college when graduated in ____________.

Tables 7 and 8, that follow, present the answers given by science teachers as reasons why they took no industrial arts in their college preparation, as well as what colleges they attended. Many of the colleges did not offer industrial arts.

Table 7

WHY INDUSTRIAL ARTS SURVEY COURSE WAS NOT TAKEN IN COLLEGE

Item	Number	Per Cent
Didn't have time for it	25	42
Wouldn't have improved me	4	7
Knew how already	17	28

It is possible that the teacher preparation curriculum was structured in such a way as to perhaps preclude this type of study.

Among the 60 respondents there were 21 who stated that there was no opportunity for industrial arts training during their college preparation.

Table 8

COLLEGES NOT OFFERING INDUSTRIAL ARTS SURVEY COURSE TO SCIENCE MAJORS

College	Dates Not Offered		
Eastern Oregon College of Education	1956		
Northwest Nazarene College	1950		
Lewis and Clark College	1960		
Cascade College	1960	1956	
Oregon College of Education	1958	1952	1951
Willamette University	1925		
Utah State College	1950		
Southern Oregon College of Education	1958	1953	
University of Oregon	1957	1956	1953
		1952	1951
Jamestown College	1947		
Linfield College	1957		
Portland State College	1957		
Montana State College	1951		

The next questionnaire item asked secondary science teachers if they believed that a regular high school industrial arts course would benefit science students were they to continue on into science education. This question was stated in such a way as to cause a choice to be made between a college industrial arts survey course and a regular high school industrial arts course.

The responses were generally affirmative with 42 (70%) stating yes and 11 (18%) stating no. This tends to indicate that the science teachers responding were generally favorable to including an industrial arts course for science students.

Various comments were made by respondents such as ... not time enough ... all boys should take shop ... electronics, yes, etc.

The science teachers were asked if there were a "science-related" industrial arts program in their high school for advanced science students working with advanced industrial arts students in the school shops, would they consider this as a help?

The answers to this question ran 49 (82%) yes and 8 (13%) no, with 3 not answering.

Some comments were ... science students do not have time, they are the school leaders and they have too many classes now ... if we had an adequate shop ... do high school students have time?

There follows an outline of a proposed science-related industrial arts course in high school.

OUTLINE OF PROPOSED COURSE IN INDUSTRIAL ARTS AREAS FOR HIGH SCHOOL SCIENCE STUDENTS

First Six Weeks Unit

The advanced science student would come into the industrial arts shop and be paired off with an advanced industrial arts student. Enough pairs of these students would then be admitted to the program to fill the class.

Learning would take place in the high school on the following basis: First semester, teacher guided, industrial arts-science student team.

<u>Course Content</u>:

> Methods in woodworking and metalworking using hand tools. Content: gluing processes; mechanical fasteners; shaping and finishing wood devices; types of joints and uses; abrasives; wood identification; cutting metal; soldering (soft and hard); threading, tapping, forming metal; cutting and shaping glass; drilling and filing metal.

The outline as here presented was included in the questionnaire.

From the first six weeks program, as stated, certain items on the questionnaire were underlined by respondents indicating a current need for them in their area of science teaching. These items are tabulated for reference in Table 9.

The most needed specific mechanical skill out of the first six weeks unit is that of cutting and shaping glass; as 23 per cent of the respondents indicated. Next in order of need was soft and hard soldering. This item being selected by 21 per cent of the science teachers. Cutting and forming metal was cited as a need by 17 per cent and drilling and filing metal rated fourth place with 13 per cent indicating a need. Shaping wood was selected by 5 per cent and wood identification was only 1.6 per cent indicating little expression of need in this area.

A need indicated by 5 per cent or three respondents out of 60 was for all the first six weeks unit. Eight of the science teachers did not indicate any need for these basic mechanical skills.

Table 9

AREAS OF MECHANICAL SKILLS CURRENTLY NEEDED BY SECONDARY SCIENCE TEACHERS

Areas Needed	Number	Per Cent
Cutting and shaping glass	14	23
Soldering, soft and hard	13	21
Cut and form metal	10	17
Drilling and filing metal	8	13
Shaping wood	3	5
Need all first six weeks	3	5
Wood identification	1	1.6
Eight respondents did not indicate any need	52	85.6

<u>Second Six Weeks Unit</u>

The students would be paired off as they were in the first six weeks.

Care and maintenance of hand and machine tools. Content: Various cleaning materials; reshaping tools, that is, grinding new points on screwdrivers, etc.; sharpening tools; lubrication with powders, oils, greases; adjustment of bearings and working parts; safety procedure; load limits for various tools and machines.

The respondents expressed a need for various mechanical skills in the second six weeks area. These are tabulated in Table 10 for easy reference.

Out of 60 respondents 10 per cent indicated they were in current need of the complete mechanical skills program of the second six weeks. "Safety procedure" was indicated as a specific need by 10 per cent of the 60 respondents. "Reshaping of hand tools" and "grinding" were cited by 7 per cent and 5 per cent respectively. Other areas receiving minor expression of need were "cleaning materials, lubrication, and load limits of machines and tools." Those respondents that did not indicate any need in this area were tabulated as 38 out of 60 or 63 per cent.

Table 10

ADDITIONAL AREAS OF MECHANICAL SKILLS NEEDED

Areas Needed	Number	Per Cent of 60 Respondents
Need all second six weeks	6	10
Safety procedure	6	10
Reshaping of hand tools	4	7
Grinding	3	5
Cleaning material	1	1.6
Lubrication	1	1.6
Load limits of machines and tools	1	1.6
Thirty-eight or 63 per cent of the respondents did not indicate any need.		36.8

Third Six Weeks Unit

The students would be paired off as they were in the first and second six week units.

Introduction of machine tools, both wood and metal. Content: operating the table saw, radial saw, band saw, scroll saw, sanders, drill, lathes with thorough safety instruction. Production methods explained, with emphasis on drill press,

> grinders, shear, brake, crimpers, etc.; understanding of safe handling of electricity with practical application of Ohm's Law; handling of molten metals.

There were several areas in the third six weeks that respondents indicated a current need for. These are tabulated in Table 11.

Out of the total of 60 respondents, 17 per cent indicated they had a need for all of the third six weeks unit. Of the specific single items listed, 10 science teachers or 17 per cent of all the 60 that were surveyed expressed a need for Ohm's Law and the practical application of electricity. Instruction in the handling of molten metal was cited as a need by three respondents and two felt a need to learn operation of a machine lathe. Thirty-six of the respondents did not express any need for the skills as listed in the third six weeks unit. This amounts to 60 per cent of the total of 60 respondents.

When asked the question, "do you feel there are other units that would be more usable than those presented," five of the respondents answered yes that there were other units and 29 out of 60 appeared satisfied with the course as outlined. Thirty-four did not answer this question. One comment was made:

...sounds okay.

Table 11

AREAS IN INTRODUCTION OF MACHINE TOOLS THAT ARE CURRENTLY NEEDED BY SECONDARY SCIENCE TEACHERS

Areas Needed	Number	Per Cent of 60 Respondents
Need all third six weeks	10	17
Ohm's Law and the practical application of electricity	10	17
Handling of molten metal	3	5
Operation of machine lathe	1	2
Thirty-six of the respondents did not express a need.		

The five respondents who suggested additional units of study indicated some grouping. Apparently there is a need for mechanical drawing, sketching, blueprint reading, electrical and electronic schematic drawing and reading. These are listed separately in Table 12 for clarity, however, they are very much related and could be handled as a unit.

Glass blowing and welding as well as working with plastic were cited as separate units by three different teachers. That is to say, one teacher wanted glass blowing out of 60 respondents, one out of 60 wanted welding added and one out of 60 wanted working with plastics.

Table 12

ADDITIONAL AREAS OF STUDY NEEDED

Area	Number	Per Cent of 60 Respondents
mechanical drawing	3	5
blue print reading	1	1.6
electrical and electronics schematics	1	1.6
glass blowing	1	1.6
welding	1	1.6
working with plastics	1	1.6

The final question that was asked on the secondary science teacher's questionnaire was, "After reading the proposed course, do you feel this would be a real help to those average-to-above high school students contemplating a career in science or science teaching?"

The course outline for the second semester is as follows:

<u>An Industrial Arts-Related Science Program</u>: Second semester, 18 weeks unit.

Content: A science-industrial arts related course utilizing the problem-solving approach and experimentation to demonstrate laws, principles, etc. of science. The facilities of the shop would be available, material in reasonable quantity provided with certain exceptions to facilitate the learning of field expedients as substitution takes place. The instructor would be available for counseling and guidance with the burden of proof resting on the small group led by their chairman.

Content: Some examples of research and experimentation that would be undertaken

> are: electrical conductivity of metals, holding power of fasteners, lamination characteristics of various materials and properities of adhesives, melting point of alloys compared to pure metals, mechanical efficiency of various power transmissions.

Out of 60 respondents, 51 answered this question and there were nine science teachers who did not answer. Of the total of 60 respondents in this study, 43 (72%), stated "yes" that they felt this course would be of real help for students considering a career in science or science teaching.

On the negative side, seven secondary science teachers representing 12 per cent of the 60 that were queried stated, "no", they did not feel this course would help. One respondent stated "somewhat."

This information is presented in Table 13.

Table 13

WOULD AN INDUSTRIAL ARTS-RELATED SCIENCE PROGRAM BE OF BENEFIT TO HIGH SCHOOL STUDENTS CONTEMPLATING A SCIENCE OR SCIENCE TEACHING CAREER

Answer	Number	Per Cent of 60 Respondents
yes	43	72
no	7	12
somewhat	1	1.6
did not answer	9	15

There was a need indicated for some of the instructional units that were in the proposed second semester industrial arts-related science program. Of 60 respondents, seven of them had underlined the program content indicating a need for the entire second semester course. In addition, certain specific units were checked such as "mechanical efficiency of power transmissions," and "electrical conductivity of metals."

The questionnaire concluded with a large space for comment. These comments were evaluated on the basis of being generally favorable to this program or being generally unfavorable to this program. Of the 60 respondents, 37 (62%) were generally favorable and 10 (17%) were generally unfavorable. With 21 per cent of the science teachers not indicating either a favorable or unfavorable attitude.

Some of the negative or unfavorable comments that were made are as follows:

1. "Student better off taking liberal arts, literature or advanced math."

2. "The academic student is too busy with courses and activities to do this."

3. "Advanced industrial arts student needs to learn more, rather than attempt to help science student learn mechanics."

4. "One doesn't experiment to demonstrate laws, principles, etc." "Poorly constructed questionnaire."

Some of the positive or favorable comments that were made are as follows:

1. "Such a program could also develop needed equipment."

2. "Such an integrated program long overdue."

3. "Kids need to know how to build things, substitute this program for Latin as an example."

4. "This program would be an asset to anyone--if not in teaching, then in plain living."

5. "Generally a good idea, has some real merit."

6. "Good idea, go to it, skills helpful."

7. "There is a real lack of such a practicum in our educational system."

8. "I know of no area of study that can not be used to advantage in science teaching."

9. "Sound curriculum."

10. "College survey course is not enough help, this type of longer course would be better."

11. "All good content."

12. "Sounds like a good program."

13. "This type of course would be real useful."

14. "Great! Include mechanical drawing so the science student can put his ideas on paper in an understandable form.

15. "This course would be especially valuable to the science student who is a senior."

16. "Any applied learning will help."

17. "Student needs to work with these materials, more learning will take place."

SUMMARY OF THE SCIENCE TEACHER QUESTIONNAIRE

A questionnaire was developed to ascertain the need for an industrial arts-related science program for Oregon secondary schools. This data gathering instrument was mailed to 95 secondary science teachers in the state of Oregon. Out of the total mailed, 60 were returned and were found to be usable in this study.

The information stated on the questionnaire that respondents returned was found to be essentially complete and extremely valuable to this research. It can be assumed then that the questionnaire was successful in that it did what it was designed to do.

Of the 60 respondents, 28 teach physics; 26 teach chemistry; 17 teach biology; 15 teach physical science; six teach general science; four teach advanced math; two teach advanced placement biology; and one teaches natural science.

Generally, the sampling could be said to be effective. The questionnaires were addressed to the heads of science departments so they could be distributed in a random way to various science teachers. It was the intent of this study to sample as widely as possible in all fields of high school science.

High schools of various sizes were selected from the list of Oregon secondary schools. The purpose of this was to gather information that could be used in planning an eventual industrial arts-related science program that would likely work in any size high school in Oregon.

The science teachers, by and large, felt that commercially manufactured apparatus had a good many advantages. The most often stated answers were that it saved time, was more reliable and better built, in that order of importance.

Although 95 per cent of the respondents felt that commercially manufactured apparatus had advantages, 78 per cent of the respondents stated that pupil-made or teacher-made apparatus had many advantages also. The most often stated advantage for this type of apparatus was the learning experience associated with it. It was also stated that it fitted the program better and provided an interest and challenge to the student and teacher. Low cost was selected by 13 per cent of the respondents as an advantage of pupil-made or teacher-made apparatus. This could help a science budget.

Apparently lack of time was the major reason for using apparatus that is manufactured. It should be noted that nine out of the 60 respondents, teach three science subjects, 21 teach two areas, and 30 teach one area of science. At this time it could be pointed out that with more mechanical skills a science teacher could build more in less time. It could also be stated that anything constructive that could be done to ease the load of a science teacher, handling two or more areas of science, would be of real help.

Lack of machines, tools, and mechanical ability weighed heavily as factors against science teacher-made apparatus. Perhaps through this integrated program, teachers of both areas of science and industrial arts could become skilled in the use of their respective equipment and materials.

Satisfaction with an industrial arts survey course during science teacher preparation on the college level was indicated by 40 of the respondents. Learning the mechanical skills in a regular high school industrial arts class was indicated as being suitable by 70 per cent of the respondents.

In regard to a high school science-related industrial arts program, integrating advanced science students with advanced industrial arts students, 82 per cent of the respondents looked with favor upon this.

Many fine suggestions were made as to which areas of mechanical skills science teachers currently felt a need for in their daily preparations. Some of the most often selected skills are:

cutting and shaping glass, soft and hard soldering, cutting and forming metal, drilling and filing metal, shaping wood, safety procedure, care and maintenance of hand and machine tools, Ohm's Law and the practical application of electricity.

Generally, about 10 per cent of the respondents indicated a need for the entire mechanical program as stated in this study. Perhaps an area to receive first attention should be secondary science teachers in the field with an appropriate in-service skill building program. They in turn could lend more assistance to a skill building program for high school science students.

About 72 per cent of the respondents indicated they felt a program as stated in this study would be of real help to secondary science students contemplating a career in science or science teaching.

RESULTS OF PERSONAL INTERVIEW AND CORRESPONDENCE

The personal interviews were made at Oregon State University in the science education department. They were made for the express purpose of finding out what is being done on the college level toward developing mechanical-technological skills for secondary science teachers.

Dr. Fred Fox demonstrated the laboratory equipment, wood and metal working machines, and hand tools that are in the science education department. These facilities are used by students engaged in science teacher preparation.

There were many useful experimental devices, visual aids, and demonstration setups under construction or completed. According to Dr. Fox this area of learning is proving to be quite useful. As explained earlier in this study, there is a laboratory practicum in science being offered at Oregon State University through the science education department.

Dr. Stanley Williamson indicated the work being done to improve the mechanical-technological skills of science teachers was making headway. Some of the fine biological experiments could be done with apparatus and equipment constructed in the department's mechanical facility.

According to a course outline that was received during the interview it is believed that many science teachers hesitate to carry out or perform laboratory activities they would normally use because they lack skills, practical understandings, or familiarity necessary to "feel at home" with such activities.

The laboratory practicum portion of the course in the science education department at Oregon State University is designed to overcome these short comings through development of necessary skills and abilities.

From the many fine experimental projects being constructed and the enthusiasm of the people working in this area, it would appear to be a very worthwhile program.

Dr. Stanley Williamson is head of the science education department at Oregon State University and Dr. Fred W. Fox is associate professor in this department.

From correspondence with leaders in science education at other colleges in the state of Oregon, it has been determined that some colleges and universities offer skill building programs for science teachers that are of real value.

In response to a request letter (see Appendix), six heads of science education departments wrote replies (see Appendix) explaining what is currently being offered at their respective schools toward developing mechanical skills for teachers.

All six correspondents indicated that they are offering some units along this line. Some of the science departments indicated they were interested in expanding their program of skill building, while others felt what was offered was sufficient.

Four of the colleges offered glass cutting, shaping and bending. This was usually in chemistry studies. Five colleges offered soldering, either in physics, or in electronics courses. Some colleges offered wood and metal cutting, milling, shaping.

From the letters it appears that some colleges have tried this type of program off and on. It seems apparent that finances have quite a bit to do with continuing a program. There is a matter of college transfer credit for such a course that is a factor to be considered when establishing it.

Generally, the correspondents indicated they believed their program was successful. The science department heads recognize a need for such a skill building program. Two of the correspondents would like to have the results of this survey.

A letter (see Appendix) was written to the Superintendent of Public Instruction, Dr. Leon Minear, to ascertain if the State Department of Education was interested in this study relating industrial arts to science. According to the Assistant Superintendent's reply (see Appendix) the State Department would like very much to have a report of the findings of this study.

RESULTS OF INDUSTRIAL ARTS TEACHER QUESTIONNAIRE

A questionnaire (see Appendix) was used in determining if secondary industrial arts teachers are interested in a program of mechanical skills improvement for science students.

Of the 40 industrial arts teachers surveyed five were disqualified because it was indicated that they were junior high industrial arts teachers. This study is limited to secondary teachers of grades 9-12, in the industrial arts area.

As stated previously in this study, these results are from a survey made in 1961 summer session at Oregon State University. The 35 respondents were enrolled in industrial arts classes and represented 295 years of teaching experience in this field. The average number of years taught is 8.5 years.

In answer to the question, "At present do science students utilize shop facilities to construct science class projects?", 22 of the respondents stated that they did and 13 stated that the science students did not use the shop facilities.

The industrial arts teachers were asked if they had to show the science students how to operate shop equipment when the students came in to use it. Of the 35 respondents, 21 stated they did have to give instruction and six stated they did not have to help the science student.

There was a total of 344 industrial arts students enrolled with 34 instructors and one instructor was unusual in that he had 220 students in this category. His school required all students to take both science and industrial arts. For the purposes of this study this teacher was left out because it was felt his situation did not represent a standard high school.

When asked if many of their industrial arts students also took physics, physical science, and/or chemistry, 24 of the respondents stated yes, and 10 indicated no. The number of industrial arts students taking both science and industrial arts averaged 20 students per industrial arts teacher.

The secondary industrial arts teachers that assisted science students were asked if this interfered with their present heavy industrial arts load. Twenty-seven of the respondents answered this question with 21 stating, yes, it did interfere. Six of the industrial arts teachers stated it did not interfere.

To the question, "Do you assist the science teachers in construction, repair or assembling of their experimental apparatus?" the respondents stated that 22 of them did assist and 13 did not assist.

The following table will summarize various answers that occur in the questionnaires as indicated by industrial arts teachers. Since the arrangement of the answers parallels the questionnaire, no attempt was made to arrange this table in descending order of frequency.

Table 14

COOPERATION OF SCIENCE AND INDUSTRIAL ARTS DEPARTMENT

Answers from 35 I.A. Teachers	f	%
Yes, science students use shop facilities	22	63
Science students do not use shop facilities	13	37
Yes, have to instruct science students on shop equipment	21	60
Science students do not have to be instructed	6	17
Have IA students who also take science	24	68
Do not have this type of IA student	10	28
Helping science students interferes with IA program	21	60
Helping science student does not interfere	6	17
IA instructor assists science teachers	22	63
IA instructor does not assist science teacher	13	35

The secondary industrial arts teachers were then asked to <u>assume</u> they taught an industrial arts-related science course to a select group of science students. This course should be a science related survey course that would include six weeks of methods in woodworking, six weeks of hand and machine tool maintenance, and six weeks of introduction to wood and metal machine tools. When the industrial arts teachers assumed that they were teaching such a course they were asked if they would look with favor upon a following semester course. This would be a course where their most able industrial arts students could work with industrial arts-oriented science students in the shop on scientific-technical-mechanical problems to be solved by experiment and manipulation of equipment.

There were 21 (60%) of the industrial arts teachers in favor of this program. Eight (23%) favored the program but stated they did not have time for it at the present. Of the 35 respondents 6 (17%) indicated they were in favor of such a program but felt that their industrial arts students were not well enough prepared to work with a science student.

The respondents who indicated they would not favor this program were three in number or 8.5 per cent. They selected one or more reasons for not being in favor of it.

The most often checked reason was that of not being able to tolerate a science student using the shop equipment unless he has had a year of shop. This answer was indicated five times. The second most checked reason for not favoring this program was that the industrial arts department already had a full load. "Let the science teacher do his own work" and "we prefer to keep our department separate from the science department" each were indicated only once in this survey. Table 15 summarizes how the answers to the whole question regarding this stated industrial arts-related science course were indicated.

Table 15

HOW INDUSTRIAL ARTS TEACHERS VIEW THE PROPOSED INDUSTRIAL ARTS-RELATED SCIENCE COURSE

Indicated Answers of 35 Respondents	f	%
Yes, favor this course	21	60
Yes, but no time	8	23
Yes, but IA student not sufficiently prepared	6	17
No, do not favor this course because:	3	8.5
Let science teacher do our work	1	3
We already have full load	2	6
Science student needs full year of IA before using equipment	5	14
We prefer keeping separate from science department	1	3

Some respondents marked several answers

The final item on the questionnaire to secondary industrial arts teachers was a space for comments. The general feeling of the teacher's comments was favorable to this program. The favorable comments numbered nine and there was one unfavorable comment. There was no comment expressed by 25 of the respondents.

Some of the comments are as follows:

"Cooperation with all departments is good."
"IA and science instructors should work hand in hand toward this course."
"Would work well with proper supervision."
"Very nice, if it could be worked."
"We work closely with all departments in our school."
"All students taking physics should have mechanical drawing."
"Science and industrial arts teacher should only get together to correlate their separate courses so as to avoid duplication of effort."

SUMMARY OF INDUSTRIAL ARTS TEACHERS QUESTIONNAIRE

The results of the questionnaire submitted to 35 industrial arts teachers, attending summer session 1961 at Oregon State University, tend to indicate a favorable attitude on their part toward an industrial arts related science program.

The respondents have a total of 295 years of teaching experience ranging from one year to 35 years. The average teaching experience is 8.5 years.

In general, the atmosphere appears favorable to allowing science students access to the school shops. A large percentage of industrial arts teachers let science students in the shop and instruct them in operation of the shop equipment. Sixty per cent of the industrial arts instructors indicates this interferes with their shop program but are apparently willing to allow it.

Science teachers receive assistance also, as 63 per cent of the industrial arts teachers indicated they helped them.

In conclusion, there were 60 per cent of the industrial arts instructors in favor of having an industrial arts-related science program in high school.

There were 23 per cent more in favor of the program, but stated they did not have the time at present. There were some industrial arts teachers who favored this program but felt that their industrial arts students were not well enough prepared to venture on such a cooperative effort. This group accounted for 17 per cent of the total respondents.

The three industrial arts instructors who did not favor this program gave as reasons, "We already have a full load", "Science student needs a full year of regular industrial arts before using the shop equipment."

RESULTS OF EXPERIMENTAL STUDY IN NEWPORT HIGH SCHOOL

The experimental study at Newport High School as projected in this research did not materialize in as complete a condition as intended.

The problem of scheduling science students into the industrial arts area presented unsurmountable difficulties in this past year. Possibly a better schedule can be arranged for the next school year.

There were several science students that enrolled in an industrial arts course. They were enrolled in physics or physical science also. Special arrangements were made whereby these students could come in after school and complete their experiments that were started in class. The industrial arts shop was kept open by the instructor for one hour after school each night to accomplish the objectives.

Many worthwhile experiments were conducted and much demonstration apparatus was built by students and instructors.

This laboratory atmosphere prevailed throughout the school year 1961-62 and much learning took place. The scientific, problem-solving approach was used as well as a practical common sense approach.

Mechanical-technological skills were gained to a marked degree which leads to a possible conclusion that brighter students tend to pick up any knowledge faster if properly motivated.

The experiments, projects, and team cooperative efforts are arranged in loose groups (see Appendix) as a means of giving them some identification. Those projects that were essentially physical science were grouped as were those of biology, chemistry, physics and industrial arts and science writing.

The following are specific examples of such projects that were carried on in various areas.

Physics Area Projects

Constructed lenses of "plexiglass" as substitute for broken glass lenses. The glass lenses could not be readily replaced because of cost. General Science and Industrial Arts (IA) instructors cooperated on the project.

The school PA system was rebuilt as a group physics and IA project.

Industrial arts students with science students and IA instructor completely disassembled a 2400 volt oil bath line transformer donated by the local utility crew. It is arranged and labeled for further study.

General Science Area Projects

The general science teacher and IA teacher, with students of each, worked together to install a weather station at the school.

Physical Science Area Projects

Physical Science teacher and IA teacher did team teaching with a combined class to thoroughly cover the subject, "properties of metals." Films, models, objects and specimens are representative Audio-Visual aids that were utilized.

Biology Area Projects

Industrial Arts students joined with science students, in close cooperation, to put on a Science-Industrial Arts Fair. Many of the devices in the science display were constructed in the shop with IA student assistance.

Industrial Arts and Science Writing Area Projects

Senior technical reports in industrial arts had to be on a scientific aspect or principle related to machinery in use in the school shops. These were jointly evaluated by science and IA instructors so that student could receive extra credit in both areas of study.

Students were encouraged to develop skills in writing about their experiments and many worthy papers were written.

This experimental study, while not following the preplanned program, was considered to be successful and indicates what can be done by interdepartmental cooperation.

CHAPTER V

SUMMARY AND CONCLUSIONS

RESTATEMENT OF THE PROBLEM

The problem was to determine the need for an industrial arts-related science program for Oregon secondary schools. This study sought to determine what mechanical skills are needed by the secondary science teachers of today, and how these skills could be developed. The study sought to determine what mechanical technological skills secondary science teachers received in their college preparation and what is currently being offered along these lines by colleges in Oregon.

Further, the study sought to determine if these before mentioned skills could be gained at the high school level by a student concurrently enrolled in a science program.

Finally, this study sought to determine if secondary industrial arts teachers are interested in helping to better prepare the student bound on a science or science teaching career.

DESCRIPTION OF PROCEDURES USED

Questionnaires were designed to gather most of the data presented in this study. Two questionnaires were used. One was mailed to 95 secondary science teachers in the state of Oregon in 1962. There were 60 respondents. The other questionnaire was administered on the Oregon State University campus to 40 secondary industrial arts instructors attending summer session 1961. There were 35 respondents.

Interviews with leaders in the field of science education gathered additional information. This was accomplished essentially in Oregon State University.

Correspondence with other science education departments at six colleges and universities in Oregon provided more information for this study.

An experimental study at Newport High School, Newport, Oregon was developed to test out some possibilities for establishing a technical training program in the industrial arts area to help prepare science students for a career in science or science teaching.

Observation in the field and review of significant literature were the other procedures used to gather data.

PRINCIPAL FINDINGS AND CONCLUSIONS

The principle findings indicate that many Oregon science teachers on the secondary level generally feel a need for some mechanical skills improvement. The degree of skill improvement varies somewhat; from science teachers needing a fair amount, to those science teachers needing little or none.

Science teacher respondents were generally in favor of a skill-building program for students preparing to go into a career of science or science teaching. The respondents indicated they would be satisfied with accomplishing this objective on the high school level or on the college level, however, most of them agreed that the high school program would be more beneficial and help a greater number of students.

The industrial arts teacher respondents indicated a favorable attitude toward this skill building program. A favorable attitude on the part of industrial arts instructors would appear to be essential. It seems reasonable that a mechanical-technological program for science students to help them develop skills that would complement their scientific knowledge would be of real value in the public school system in Oregon. According to the respondents there exists a need, and they furhter indicate that the program this research study proposes might have some merit.

RECOMMENDATIONS FOR FURTHER RESEARCH

Some possible areas of further research that may have beneficial results are as follows:

1. Query students in high schools in Oregon to ascertain their feelings in relation to this mechanical-technological skill building program.

2. Survey the possibilities of including such a program into the college curriculum for science teachers.

3. Survey colleges in other states to compare the science teacher preparation offered there with that offered in colleges in Oregon.

4. Try the program that this study proposes in your own high school and report your findings.

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APPENDIX

2050 Van Buren
Corvallis, Oregon
July 6, 1962

Head, Science Education Department

Dear Sir:

It has been suggested by my advisor at Oregon State University that I contact you for some help on my thesis. We are trying to evaluate the interest in teaching mechanical skills to secondary science teachers during their college preparation. By mechanical skills we mean use of common hand and power tools used in wood and metal working, electricity and electronics. Others might be glass cutting, bending and shaping; use of adhesives; tool care and safety procedures.

We have surveyed 60 Oregon secondary science teachers and find that they generally express a need for such skills in their classrooms in the preparation of their experiments.

Our question then: What is offered along these lines in your current science education program or what is contemplated?

We sincerely appreciate your assistance in this matter and will send you the results of our survey if you wish.

Yours respectfully,

Charles R. Easley

Copies of this letter were sent to: Williamete University, Salem; Southern Oregon College of Education, Ashland; Pacific University, Forest Grove; Central Oregon College of Education, Bend; Oregon College of Education, Monmouth; Eastern Oregon College of Education, LaGrande; Lewis and Clark College, Portland; Portland State College, Portland; University of Oregon, Eugene; Reed College, Portland; Portland University, Portland.

CENTRAL OREGON COLLEGE
A Community College Serving Central Oregon
Bend, Oregon

July 16, 1962

Mr. Charles R. Easley
2050 Van Buren
Corvallis, Oregon

Dear Mr. Easley:

We feel that there is a need for teacher training in mechanical skills. However, since we are only a junior college and limited to lower division courses, there are at present no transfer courses in this area which we can offer. In the summer of 1961 we did offer terminal courses in "Electricity for Teachers" and "Electronics for Teachers." This was the result of numerous requests from teachers in our area. However, there was not sufficient enrollment to justify running the courses (as I remember, there were only 5). It appears that the teachers were not interested in the information without transfer credit. We have a very well equipped electronics technology facility which would also be fine for the teacher training.

I am very much interested in your project and would appreciate receiving the results of your survey.

Very truly yours,

/s/ Philip Ryan

Philip Ryan, Chairman
Science Division

PR:mb

LEWIS AND CLARK COLLEGE
0615 S. W. Palatine Hill Road
Portland 19, Oregon

July 7, 1962

Mr. C. R. Easley
Corvallis
Oregon

Dear Mr. Easley:

We have offered a course in Laboratory techniques at different times. Some of our Physics majors have taken it. Here they learn to use power tools like lathe, shaper, milling machine, etc. They also learn some glass blowing. Electronics circuitry they get in our electronics course. We are not planning any additional work in this line.

Sincerely yours,

/s/ A. A. Groening

A. A. Groening
Prof. of Physics

SOUTHERN OREGON COLLEGE
Ashland, Oregon

July 11, 1962

Mr. Charles R. Easley
2050 Van Buren
Corvallis, Oregon

Dear Mr. Easley:

Thank you for your letter inquiring about the preparation for teachers to use various kinds of mechanical equipment. We have recognized this as a problem and have taken some action toward training in some skills. However, we are not at present operating to provide the students with them. We have probably produced more questions than answers.

We prepare secondary science teachers for mathematics, biological sciences, and physical sciences, and most of these satisfy teaching norms in two or more of the fields listed by the State Department of Education. Almost always the student would satisfy general science norm. We find these students have a considerable variation in these skills; some have had military service experience and carry ratings dependent upon proficiency in some of these; some have had junior high or senior high courses in shop or related work; and some have had no training in tool skills. As you indicated there are a good many tools now available for use with a wide variety of materials and the selection of the skills to produce poses considerable of a problem.

You mention tool operation, care, and safety procedures, and one of the difficulties encountered concerns the difference in skill required for tool operation to the satisfaction of the teacher who is trying to build something and tool care to the satisfaction of the employee who is responsible for machine or hand tools. Often this is either a shop teacher or a non-teaching maintenance employee. We have no very satisfactory answer concerning the degree of skill desirable for various kinds of equipment. We have not found that schools are apt to provide many tools specifically for the use of science teachers, although such tools are usually in school systems and may or may not be available to the science teacher. The availability may depend upon the skill either in handling the tools or in socializing with the shop teacher.

We have started two plans to provide tool skills. The first was done in conjunction with an N.S.F. Summer Institute for junior high science teachers here last summer. Equipment for a shop to handle wood, light metal, simple electrical or electronic equipment was ordered, but a sufficient amount of it did not arrive in time to make the planned use during the institute. The second plan was to make this kind of equipment available on a volunteer basis to teachers in this vicinity. Neither of these plans has been executed. We find that employing personnel to carry these out is not easy to do nor to fit into our budget in competition with more common academic programs. This does not mean that we will not continue efforts to establish such a program. The equipment has been used to a considerable extent and primarily in connection with stage craft or other type of theater productions. Much of this use has been by people who were not particularly trained but had sufficient skill for the operation of this equipment. We do have some courses into which this work fits. You mention that science teachers express need for these skills according to your survey. I think it is probable they would express need for almost any skill which you might ask.

There are some courses in which some of these skills get attention. The chemistry courses provide some work in the handling of glass in the first year courses. Use of equipment such as soldering irons for students in first year physics courses provides some skill, but is incidental and does not necessarily cover each of the students in the course. In general we have looked upon other kinds of activities as being more important to the student and less apt to be acquired outside of the course work.

There has for a number of years been a thought and paper type of planning which would provide more technician type of training on our campus, however, this does not lie within our present allocation specifically, and we have no definite time schedule for establishing this kind of work. I also do not know that if such were established that the students in secondary education would include it in their undergraduate curriculum.

To the extent that Oregon Technical Institute would serve as a reference for providing skills of this kind, the expense incurred would be considerably greater per unit of student training than in the current offerings. This does not mean that such training should not be offered, but probably means that it should be offered with specific recognition by the State Department of Higher Education, rather than as an addition of other regular courses, based on our present teaching costs.

We have found that without making any definite plans for use, some few of our students have used the equipment purchased last year and mentioned above. I will admit that the use without training in safety procedures invokes some worry. If I can be of further help, please let me know, and I shall be interested in what develops from your program.

Sincerely yours,

/s/ Elliott B. MacCracken

Elliott B. MacCracken, Chairman
Science-Mathematics Division

EBM:jd

OREGON COLLEGE OF EDUCATION
Monmouth, Oregon

July 11, 1962

Mr. Charles R. Easley
2050 Van Buren Street
Corvallis, Oregon

Dear Mr. Easley:

The teaching of the mechanical skills which you mentioned in your letter of July 6 is accomplished to some extent in our courses as follows:

Chemistry Courses - glass cutting, bending, etc.
Physics Courses - elementary electrical skills exclusive of soldering and electronics
Computer Laboratory - electrical skills to include soldering and some electronics
Preparation of Biological Materials - plastic embedding and simple mounts
Natural History - more complex mounts

At present we have no single course which attempts to cover the mechanical skills requisite to teaching the sciences. We would like to have laboratory practicum which would include these skills. However, we would be required to have sufficient enrollment in order to support a class, and at this time we are not able to do so. The college will be offering a course in electronics for the first time during the coming school year.

Sincerely yours,

/s/ E. L. Cummins

Ernie L. Cummins,
Associate Professor

EASTERN OREGON COLLEGE

La Grande, Oregon

July 10, 1962

Mr. Charles R. Easley
2050 Van Buren
Corvallis, Oregon

Dear Mr. Easley:

At the present time we do not offer any of the mechanical skills you mentioned as a required part of the secondary curriculum. We do offer an elective (under ScMth 407 seminar) in electronics where the student gains "practical" experience in circuit wiring. Some experience in glass cutting and bending is of course obtained in chemistry.

We do not contemplate adding any of the remainder in the near future.

Sincerely,

/s/ R. E. Badgley

R. E. Badgley, Chairman
Department of Physical Science
and Mathematics

REB:nw

2050 Van Buren
Corvallis, Oregon
July 6, 1962

Head, Science Education Department
Pacific University
Forest Grove, Oregon

Dear Sir:

It has been suggested by my advisor at Oregon State University that I contact you for some help on my thesis. We are trying to evaluate the interest in teaching mechanical skills to secondary science teachers during their college preparation. By mechanical skills we mean use of common hand preparation. By mechanical skills we mean use of common hand and power tools used in wood and metal working, electricity and electronics. Others might be glass cutting, bending and shaping; use of adhesives; tool care and safety procedures.

We have surveyed 59 Oregon secondary science teachers and find that they generally express a need for such skills in their classrooms in the preparation of their experiments.

Our question then: What is offered along these lines in your current science education program or what is contemplated?

We sincerely appreciate your assistance in this matter and will send you the results of our survey if you wish.

Yours respectfully,

/s/ Charles R. Easley

Charles R. Easley

NOTE: July 10, 1962

I have given instruction in glass cutting, shaping and bending in Physical Science for elementary teachers.
/s/ Professor J. Bauer, Dept. Biology

2050 Van Buren
Corvallis, Oregon
July 6, 1962

Dr. Leon Minear
Superintendent of Public Instruction
State Department of Education
State Office Building
Salem, Oregon

Dear Dr. Minear:

In the interests of education and especially industrial arts education, I felt that you might wish to evaluate the results of my thesis.

As I understand it, the State Department is working on a curriculum for secondary industrial arts, and possibly this material could be of help.

We have received a return of 60 questionnaires sent out to secondary science teachers in Oregon and a good number express a need for mechanical skills as developed in industrial arts.

A copy of our questionnaire is enclosed; we recognize its weakness, but do believe it has some merit. Oregon State University presently has a program in their science education department to develop some mechanical skills, and possibly this is the level upon which this should be done instead of high school.

The thesis should be completed this August, 1962. Please advise if you would like to have the results.

Yours for better education,

Charles R. Easley

Enclosure

P.S. I teach industrial arts at Newport High School.

STATE OF OREGON
State Department of Education
Public Service Building
Salem 10, Oregon

July 16, 1962

Mr. Charles R. Easley
2050 Van Buren
Corvallis, Oregon

Thank you for your recent letter to Doctor Minear calling our attention to your study pertaining to relationships between industrial arts and science education. The State Department of Education would very much like to have a report of your findings in this connection. In looking at your questionnaire, it occurs to me that it would have been interesting to have asked the science teachers if they are using one of the new approaches such as BSCS Biology and PSC Physics. These and other new approaches require the use of much construction of apparatus as opposed to use of commercially prepared materials and it would be expected that there would be some relationship to responses. However, this may show up to some extent anyway where you ask whether or not the respondent generally uses much commercially manufactured apparatus.

When the state handbook for industrial arts teachers is revised, in the near future we hope, the implications of your study should certainly be taken into consideration.

/s/ Willard Bear

WILLARD BEAR
Assistant Superintendent

WB:bw

NOTE: Letter of introduction sent with questionnaire

1022 E. Newport Street
Newport, Oregon
April 25, 1962

Gentlemen:

It is our earnest desire to help improve the training and preparation of people entering science education. The fact that we wish to help does not mean that we minimize the preparation of those already in the field.

As times change and more of a burden is placed upon all teachers to teach more, and that more skillfully, we feel anything that could make our job easier and our lessons more effective would indeed be an asset.

Our questionnaire is set up to determine if a deficiency exists in past preparation in the mechanical areas which science teachers need. We would also like to know as a homely example, could such a situation exist as a science teacher needing to solder conductors on an electrical experiment in class and being unable to do this while one of his trained students could.

The emphasis today is toward tracking high school students into a straight academic program and away from any mechanical courses. We feel this is a handicap to those students the same as a lack of math and science is to a mechanical or technical student.

This research is intended to find ways to help the student bound on a science or science teaching career better prepare himself mechanically and technically for his job.

If you have read this far we know you are as interested as we are and you will complete the questionnaire and return it today. Thank you.

Yours for better education,

/s/ Dick Easley

Questionnaire: To Science teachers, secondary level
Time: 10 minutes

1. What branch of science do you teach? ________________
2. Number of years taught this branch of science? _______
   Total enrollment of your school? ____________________
3. Do you generally use commercially manufactured apparatus? Yes ____ No ____
4. Do you feel there are advantages in using manufactured apparatus? Yes ____ No ____
5. What are these advantages? _________________________
6. Do you feel there is an advantage in teacher-made and student-made apparatus over the commercially manufactured apparatus? Yes ____ No ____
7. What are these advantages? __________________________
8. If you feel commercially manufactured apparatus is best, is it because you personally do not have the

   ____mechanical ability to construct or repair your own apparatus
   ____machine tools to construct apparatus
   ____hand tools to construct apparatus
   ____knowledge of industrial processes to construct apparatus
   ____no access to machine tools, i.e. no cooperation from industrial arts department.
   ____other. What? ______________________________
9. If you had the practical training and experience necessary would you feel teacher-made apparatus and repairs to both it and commercially manufactured apparatus would be more acceptable? Yes ____ No ____
10. In your opinion would a survey course in the industrial arts area on college level, along with your science teaching major, have helped you in preparation of apparatus as a science teacher? Yes ____ No ____
    Note: We fully realize the heavy load in a science major already and believe science teachers themselves recognize a need, but
    ____didn't have time for it
    ____wouldn't have improved me
    ____knew how already
    ____was not offered at _____ college when graduated in ______
11. If you do not believe an industrial arts survey course for preparation of science teachers in college would help, do you feel science students taking a regular course in industrial arts at the high school level would be benefitted were they to continue on into science education? Yes____ No ____

12. If there were a "science-related" industrial arts program in your high school for advanced science students working with advanced industrial arts students in the school shops, would you consider this as a help? Yes ____ No ____

13. There follows an outline of a proposed science-related industrial arts course in high school. The advanced science student would come into the industrial arts shop and be paired off with an advanced industrial arts student. Enough pairs of these students would then be admitted to the program to fill the class. Learning would take place in the high school on the following basis: first semester, teacher guided, industrial arts-science student team. NOTE: Please underline any of the following that you personally feel a need for in your area of science teaching now.

1st 6 wks. Methods in woodworking and metalworking using hand tools. Content: gluing processes; mechanical fasteners; shaping and finishing wood devices; types of joints and uses; abrasives; wood identification; cutting metal; soldering (soft and hard); threading, tapping, forming metal; cutting and shaping glass; drilling and filing metal.

2nd 6 wks. Care and maintenance of hand and machine tools. Content: Various cleaning materials; reshaping tools; that is, grinding new points on screw-drivers, etc.; sharpening tools; lubrication with powders, oils, greases, adjustment of bearings and working parts; safety procedure, load limits for various tools and machines.

3rd 6 wks. Introduction of machine tools, both wood and metal. Content: operating the table saw, radial saw, band saw, scroll saw, sanders, drills, lathes with thorough safety instruction. Production methods explained, with emphasis on safety, to economically produce a specific part. Operation of machine lathe, drill press, grinders, shears, brake, crimpers, etc.; understanding of safe handling of electricity with practical application of Ohm's Law; handling of molten metals.

Do you feel there are other units that would be more usable than those presented? Yes____ No ____ What? ____________

____

Second Semester

18 wks. A science-industrial arts related course utilizing the problem-solving approach and experimentation to demonstrate laws, principles, etc. of science. The facilities of the shop would be available, material in reasonable quantity provided with certain exceptions to facilitate the learning of field expedients as substitution takes place. The instructor would be available for counseling and guidance with the burden of proof resting on the small group led by their chairman.

Content: Some examples of research and experimentation that would be undertaken are: electrical conductivity of metals, holding power of fasteners, lamination characteristics of various meterials and properties of adhesives, melting point of alloys compared to pure metals, mechanical efficiency of various power transmissions.

After reading the proposed course, do you feel this would be a real help to those average-to-above high school students contemplating a career in science or science teaching? Yes ____ No ____

COMMENTS: ____

____

Please return questionnaire to Charles R. Easley
1022 E. Newport Street
Newport, Oregon

Questionnaire: To Industrial Arts teachers, secondary level

Time: 3 minutes

No. of years taught ____________

It is felt by this research that great good can come to the Industrial Arts departments through closer association and greater cooperation between the high school science department and the Industrial Arts department. There are various way this may be accomplished. Would you kindly check those items concerning your department in your high school.

1. At present do science students utilize shop facilities to construct science class projects? Yes ____ No ____

2. If science students do operate shop equipment, do you have to show them how? Yes ____ No ____

3. Do you have many Industrial Arts students who also take physics, physical science, and/or chemistry? Yes ____ No ____ How many per year? ____________

4. If you do assist science students who do not take Industrial Arts, does it interfere with your present heavy IA load? Yes ____ No ____

5. Do you assist the science teachers in construction, repair or assembling of their experimental apparatus? Yes ____ No ____

6. Now, assuming you teach a semester of six weeks Methods in Woodworking, six weeks Hand and Machine Tool Maintenance, and six weeks Introduction to Wood and Metal Machine Tools to a select group of science students, would you look with favor on following with a second semester course where your most able IA students could work with these (semi-trained in IA) science students in your shop on scientific-technical-mechanical problems to be solved by experiment and manipulation of equipment?

    _____ yes, we would favor this.
    _____ yes, but we don't have the time at present.
    _____ yes, but our IA student isn't this well prepared to work with a science student.
    _____ no, we would not favor this plan because:

____Let the science teacher do his own work.
____We already have a full load.
____Can't see a science student using our equipment unless he has had a year of shop.
____We prefer to keep our department separate from the science department.

COMMENTS ____

____

Please return to C. R. Easley, Industrial Arts Department
Oregon State University

PROJECTS, APPARATUS AND DEMONSTRATIONS FROM THE EXPERIMENTAL STUDY AT NEWPORT HIGH SCHOOL

Physics Area

1. Constructed lenses of "plexiglass" as substitute for broken glass lenses. The glass lenses could not be readily replaced because of cost. General Science and Industrial Arts (IA) instructors cooperated on this project.

2. General science instructor built new wood tripod and ball joint for photography work with cooperation of IA instructor.

3. Science student enrolled in IA to experiment on radio and electronics concurrently with his physics class. He constructed a single side band transmitter with voice modulated microphone. Much mechanical skill was developed in this young man.

4. The school PA system was rebuilt as a group physics and IA project.

5. Physics, general science and IA instructors with interested students from each area constructed new apparatus and repaired old apparatus used in high voltage electrical experiments.

6. Industrial arts students with science students and IA instructor completely disassembled a 2400 volt oil bath line transformer donated by the local utility crew. It is arranged and labeled for further study.

7. As an integrated science - IA project, an occilloscope was built. An audio signal generator was later designed for it.

8. Science students and IA students reduced to components a quantity of exotic electronic equipment donated by a commercial electronic research firm.

9. Students salvaged and identified usuable components out of obsolete T.V. sets. The students learned safe handling procedure for T.V. picture tubes as these are extremely hazardous to handle.

General Science Area

1. The general science teacher and IA teacher, with students of each, worked together to install a weather station at the school.

2. Cooperation was demonstrated throughout the year in arranging schedules of units such as basic electricity. An effort was made to cover the same areas, that is to say, theory and demonstration in general science and practical application with Ohm's law in the IA department, concurrently. A student enrolled in both courses could thus gain reinforcement and real understanding.

3. Industrial arts students worked with general science students to produce demonstration devices to determine the specific gravity of various woods.

Chemistry Area

1. Chemistry teacher and IA teacher with help of students developed a better storage system for science department.

Physical Science Area

1. Repaired to workable condition the Wimshurst static electricity generator. This was a cooperative project between physical science instructor and IA instructor.
2. Students and instructors of physical science and IA department made a group study of subsonic, transonic, and supersonic sound. This was a team teaching experience.
3. Following a combined class study of principles of flight, using Shell Oil Company films, the students and IA instructor developed numerous boomerangs as experimental test devices.
4. Physical science teacher and IA teacher did team teaching with a combined class to thoroughly cover the subject, "properties of metals." Films, models, objects and specimens are representative Audio-Visual aids that were utilized.

Biology Area

1. Biology instructor and IA instructor with paired students, designed, constructed, and installed a swinging hanger for display of the human skeleton in biology class.

2. Industrial Arts students joined with science students, in close cooperation, to put on a Science-Industrial Arts Fair. Many of the devices in the science display were constructed in the shop with IA student assistance.

3. As a group Biology-IA project, selected students prepared and planted a tree identification arboretum. In conjunction with this a wood identification teaching aid was developed.

4. During the time of the "Traveling Science Teacher" visit, the IA Department assisted the science department in the preparation, instruction, etc. of plastic imbedding of fragile biological specimens. The shop machines such as band saw, disk and belt sanders, and buffer were used to real advantage to complete this work in the allotted time. The IA instructor and IA students cooperated fully with the science department during this vital time. Assistance was also given on the beef heart demonstration.

Industrial Arts and Science Writing Area

1. Senior technical reports in industrial arts had to be on a scientific aspect or principle related to machinery in use in the school shops. These were jointly evaluated by science and IA instructors so that student could receive extra credit both areas of study.

2. Science students who had a special interest in a mechanical device were encouraged to write technical reports on their project. The mechanical-technological content was evaluated by the IA instructor. One such mechanical device was a five inch reflecting telescope built by one of the students at Newport High.