INDEPENDENT SCIENCE PROJECT GUIDES
FOR GIFTED AND TALENTED
HIGH SCHOOL STUDENTS

An Action Learning Project
Presented to the Graduate Faculty
of the College of Education
University of Wisconsin - La Crosse

In Partial Fulfillment
of the Requirements for the Degree
Master of Education - Professional Development

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by
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UNIVERSITY OF WISCONSIN - LA CROSSE

COLLEGE OF EDUCATION

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I recommend acceptance of this action learning project in partial fulfillment of this candidate's requirements for the degree Master of Education - Professional Development.

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This action learning project was initiated to develop a format to be used in writing materials for gifted and talented students in science. The project guides were to provide the basis for the senior level science seminar course offered at La Crosse Central High School and to provide an alternative method of instruction for gifted students in other science courses. The guides provide the student with the basis for conducting an independent scientific investigation in a content area of science. Scientific content is learned by taking part in the process of science. Each project guide contains a student guide, and an instructor's guide. The student guide presents a topic and proceeds to ask open ended questions. Some suggestions are given to the student on possible procedures to follow. The instructor's guide contains a list of major concepts, objectives, suggested procedures, safety notes, and background references. These materials are intended to be implemented during the 1983-84 school year.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

Educational curriculum represents what will be learned in a course and how the learning process will occur. Revision and updating of curriculum is necessary for effective teaching regardless of the discipline, but this is especially true of science. The tremendous advances in science and technology and the resultant effects on society dictate that science curriculum constantly undergo evaluation and revision. With this in mind, the school board and administration of the School District of La Crosse authorized a curriculum study to be undertaken during the 1979-80 school year. The results of the study indicated that a coordinated K-12 curriculum revision was necessary.

The philosophy and goals of the school district were clarified in the fall of 1980 and the actual revision of course materials was completed by the summer of 1981. Implementation of the new curriculum was begun in the fall of the 1981-82 school year.

The K-6 component consists of a general science program adopted from the D.C. Heath Company. One supplier of materials was used to insure continuity of objectives and content. The philosophy of the district science curriculum was intended to emphasize the process of science as opposed to the content.

The seventh grade program is a life science course and the eighth grade program is an earth science course. There are no accelerated or remedial versions of these courses because it was believed that in the middle school format, provision could be made for individual learning styles and rated without grouping students by ability.

The ninth grade program is in the high school and consists of a physical science course. An accelerated version of this course is offered for those students who have in the past demonstrated the ability to excell in science. Students are placed into the accelerated course by referring to their standardized test scores, grades from previous science and math courses, and by recommendations obtained from the eighth grade teachers.

Biology is offered in the tenth grade and an accelerated option is again available. Remedial courses were not developed because of the problems associated with concentrating many underachievers and slow learners together in one section.

The eleventh and twelfth grades have several science electives available to students. Chemistry and physics are both offered for a full year and accelerated versions of both are also available. There are also one semester electives in environmental studies, astronomy, and anatomy and physiology.

A science seminar course has been outlined for the twelfth grade but has not been fully developed. This course and the enrichment necessary for gifted students will be the topic for this paper. The seminar course is intended to provide a student with the opportunity to pursue a specific topic to greater depth than can be dealt with in an introductory course. Students taking the course will be able to experience the process of science by conducting individual research projects.

The course is also intended to allow students to do college level work in chemistry and biology through the advanced placement program.

Need for the Project

Students planning on taking the advanced placement exam in chemistry and biology can be accomodated to a certain extent by commercially available materials, but there is a need for project related materials. The science seminar course is intended to be a project oriented course for seniors who have completed introductory elective courses in science. This course needs to be developed from the objective stage to the learning activity stage.

A related need is for an alternative method of instruction for gifted students enrolled in the introductory courses. Gifted students often do not achieve to their potential in a traditional classroom setting. A project approach to teaching science is one alternative that offers gifted students the opportunity to utilize their creative talents while learning science content.

The project format of the science seminar course and the planned use of projects to enrich the science education of gifted students emphasizing the need to develop a format to be used for research project instruction.

Statement of the Problem

The problem addressed in this paper is the lack of acceptable materials for those students who have elected to take the science seminar course. Gifted and talented students in other high school level courses are at times not challenged adequately by the materials used in the traditional classroom setting. Many times gifted students do not learn in a way that can be accomodated by the typical large group instruction often used in the classroom.

The use of research projects offers a reasonable alternative to conventional classroom instruction. Most high school students show an interest in the project approach but few of these same students have well developed research skills. The problem to be addressed is to develop a format to be used for project materials that will give guidance but will not thwart the creative talents of gifted students.

Purpose

The purpose of this action learning project is to develop a format for activity packets which can be used both for enrichment of gifted students in science and as the basis of the twelfth grade science seminar course. A series of open ended learning packets using the project approach will be developed.

CHAPTER 2

REVIEW OF RELATED LITERATURE

The purpose of this action learning project is to develop a format for learning activity packets to be used in the science seminar course at La Crosse Central High School. The packets will also be used as an alternative instructional technique for gifted and talented students.

A review of the literature was conducted to research the theories of learning as they apply to science instruction. The special needs of gifted students and the use of research projects as an instructional technique were examined.

In 1960, Bruner indicated that curriculum is the formalized statement of goals, objectives, and methods of teaching a subject. The curriculum should consist of the most fundamental priniciples that give structure to the subject. In the opinion of Bruner, knowledge acquired without structure is forgotten. Knowledge should be given at the point at which the learner can use it to compare his efforts with the stated goal to be reached. A year later, in 1961, Bruner said that the amount of scientific knowledge was increasing each year and therefore, it was nonproductive to teach only content. He said that it was far more effective to identify and teach the processes of the scientist. According to Bruner (1961), this could be done by the discovery method where the student uses the methods and reasoning patterns of the scientist to discover the concepts of science. These discoveries did not have to be original discoveries, but only original to the student (Edwards & Seanell, 1968).

In 1965, Bruner felt that teaching process rather than only content made it possible to teach any subject to any age child in some form that was honest and interesting. He believed that teaching irrelevant detail was non productive, harmed true science teaching, and that it was far better to identify the interrelated structures of the subject and teach those instead.

The ideas of Bruner, and indirectly, Piaget, were ascribed to by many other authors as well. In 1963, Butts saw the role of the teacher as that of clarifying relationships within the students' experience rather than that of information giver. He felt that a student should be exposed to a situation and then encouraged to examine and manipulate the data. According to Butts, true conceptual understanding is achieved only when the student can develop the hypothesis. This is consistent with the theories of cognitive development espoused by Piaget, who believed that a disequilibrium is produced by assimilation of new schema. The student will, then, by accomodation, produce a new equilibrium. This process, according to Piaget, is learning (Wadsworth, 1978).

Ausubel (1965) believed that each scientific discipline has its own content and methods but all scientific disciplines can be reduced in the basic processes to the same principles. Ausubel saw the laboratory as the place where most of the significant scientific principles would be learned. The student should be taught by the inquiry method using laboratory materials.

In response to the theories of Bruner, Piaget, Ausubel and others, the National Science Teachers Association in its 1971 position paper, School Science Education in the 70's, indicated that science should be taught as a unified discipline and that there should be an emphasis on science processes. In 1972, the National Association of Secondary School Principals said that the division of science into disciplines was uneconomical and that unified materials needed to be developed. The National Science Foundation in 1981 asked for a redefinition of basic skills to include self directed study and the relating of conceptual material.

Other authors have indicated a need to teach science with a more humanistic emphasis so as to produce personally concerned individuals (Birnie, 1975). In line with this view the emphasis on facts has been gradually phased out of many science curricula primarily because of the ever increasing number of facts. Some believe further that processes should be taught by the inquiry method and should relate to the students' environment (Matthews, Phillips & Good, 1969).

In 1972, Martorella said the goal of education was not to increase the amount of knowledge, but rather to create possibilities for the student to discover. Teaching, then, is creating such situations. Gallagher (1975) noted that the new science courses developed in the 1960's added structure to the curriculum and that the courses were developed in such a way as to create learning situations which use the inquiry approach. Gallagher (1975) pointed out that many of these courses did not meet the needs of those students who had failed to develop academic discipline. This group of students included those who had been labeled as gifted (Gallagher, 1975).

Scientific ability is usually linked with a good ability to handle spatial concepts and the person who excels in science will normally have sound judgement, persistence, organizational skills, and strong powers of inductive reasoning (Cole, 1956). While the gifted and talented student is capable of high performance by virtue of outstanding abilities and a desire to learn that student does not always perform consistently with those abilities, in part, because of a learning style that may be inconsistent with the teaching methods (Krueger, 1978).

Romey (1980) said that the development of a person's potential depends upon both aptitude, which the gifted student has, and upon motivation. Romey (1975), contends that motivation is by far the most important of the two factors. Gifted students usually learn because of natural curiosity, a desire to know, and for personal satisfaction rather than because of peer pressure or fear of failure (Edwards & Seanell, 1968.

Science courses often do not meet the needs of gifted students because of the regimented laboratory programs which fail to provide the gifted student the incentive to do any independent thinking (Faber & Martin, 1983; Thomas & Kydd, 1983). Several papers have indicated that the failure of the schools to properly motivate and to develop the academic potential of the gifted student is one of the most significant failures of our educational system (Burton & Staley, 1982; Romey, 1980; Schrepfer & Riley, 1982).

Newman, in 1980, said that superior students need more effective teaching techniques than those commonly used in the classroom today. Schrepfer and Riley (1980) agreed with the need for better teaching styles and added that teachers need to develop an awareness of individual needs.

The gifted student frequently becomes impatient with authority because of the teaching styles and classroom requirements commonly used (Romey, 1980). Since the gifted student is naturally curious, is able to skip steps in the problem solving process, and works at a faster rate than other students (Romey, 1980), many teachers respond by simply giving the gifted student more work and expecting higher performance. Romey (1980) further feels that this technique fails to properly motivate the student. He suggest that a better approach is to have available alternative activities which allow the gifted student to utilize his creative talents.

Follis and Krockover in 1982 had a number of suggestions for the science education of gifted students. They felt that the presentation of materials should be designed to capitalize on the strong curiosity of the student. There should be as much problem solving as possible, but that this problem solving should be open ended and flexible so as to allow the student to utilize creative talents. The activities should include all three domains of learning: cognitive, affective, and psychomotor. Follis and Krockover indicated that the inquiry technique should be used but that the role of the teacher should be that of a planner and facilitator.

Tamir and Lunetta (1981) indicated that classroom interaction is extremely important for the gifted student. The use of student seminar sessions has proven to be one effective way of allowing gifted students to interact with others and to gain recognition for their work (Thomas & Kydd, 1983).

Most authors agree that a curriculum plan for the gifted student must be activity oriented (Burton & Staley, 1982; Follis & Krockover, 1982; Romey, 1980). Faber and Martin (1983) suggest the use of projects in which students conduct a series of exercises with a common underlying purpose. A project approach offers a way of unifying laboratory procedures and improves student interest by simulating actual research (Splittgerber, MacLean &Neils, 1971). Projects encourage the student to imitate the process of the scientist by adding structure to the inquiry approach (Sellin & Birch, 1980). Projects also allow students to explore special interests in depth (Thurber & Collette, 1964).

Individualized instruction of any type needs a clear statement of purpose (Ruskin, 1982) and this especially true of projects such as those suggested by Romey in 1968. Such projects are most effective when the students, with guidance, choose their own topic, purpose, and method (Clemmer, 1975). Musgrave (1975) said that the most successful projects are those which are highly student centered.

Group interaction can be stimulated when projects are designed by small groups of students (Triezenberg, 1972). Leadership skills and cooperation are often benefits obtained from small group projects. Triezenberg claims that motivation is greatly improved when students feel that they have been a part of the planning and execution of a project.

Students should do the planning, lab work and most important, they should present both written and oral reports (Bell, Moe & Neidig, 1980). Projects help students improve their ability to identify objectives and to keep records (Faber & Martin, 1983). Thurber and Collette (1964) reported that project work tends to improve student writing habits, as well. Students also develop the ability to make good use of time, and project work tends to improve self confidence (Popp, 1983; Thurber & Collette, 1964). Writing, oral communication and organizational skills improve with the use of a project approach to science (Pyle & Trammel, 1982). In the opinion of the author, projects offer a method by which the student can be taught science concepts through a process approach and at the same time develop personal study habits. Gifted students can be better served with the project approach in that science concepts are being learned in a way which is not restrictive and allows the student to exercise greater creativity.

The author makes the following recommendations based upon the review of literature:

1. The process of science should be stressed rather than the content. The student should be taught the techniques of research and scientific inquiry.
2. The activity packets to be developed should be discovery or inquiry based.
3. The activity packets should utilize as much laboratory work as possible.

4. The packets should be as interdisciplinary as possible.
5. A project approach should be used so as to improve the capability of individualization.
6. Students should be required to report their findings both in writing and orally.
7. The planning of a project should represent a joint effort of the student and the instructor.
8. Student interaction should be encouraged with group activities.

CHAPTER 3 - METHODS

INTRODUCTION

This project was initiated to develop guides for student research projects. These project guides were intended to be used as an alternative to regular classroom instruction for gifted students and as a basis for the senior level science seminar course.

Procedure

The major goals and objectives of this instructional design were developed as follows:

(1) Students using these materials will gain experience using the process of science through independent research. The content of a topic will be learned as an integral part of the research process.

(2) Students will learn how to plan and conduct a scientific research study.

(3) The students conducting a research study will improve their organizational skills by properly collecting and recording experimental data.

(4) The writing ability of students will be improved by practicing proper writing techniques in preparing research reports.

(5) Students will improve their oral communication skills through group planning sessions and by presenting seminar sessions related to their research.

The project guides were developed to emphasize the process of science and to integrate, as much as possible, the various branches of science. Each project guide contains a student project guide and an instructors resource guide.

The student project guide begins with a short discussion of the topic and is designed more to raise questions than to impart information. The student is then given some suggestions of possible procedures to follow, but only in the very lowest level projects are the instructions specific. The student is encouraged to use his own creativity in developing a project procedure.

The instructor's guide is designed to provide the teacher with the information necessary to help the student plan and carry out the project. The instructor's guide consists of six sections:

1. Application

   A statement is made which suggests which courses the project will apply to, and in some cases, the level of difficulty is indicated.

2. Major concepts

   The scientific knowledge or content is described in several short statements.

3. Objectives

   The expected student achievement is described as performance objectives in the cognitive, psychomotor, and affective domains.

4. Suggested procedure

   Some suggestions are offered for the teacher to use in guiding the student into a productive and interesting procedure.

5. Safety Notes

Suggestions and warnings are made with respect to any hazards which may exist with a particular part of a project.

6. References

A list of literature sources pertaining to the project is included. These sources may be used as background for the instructor, or offered to the student for use in beginning a literature search.

The appendixes of this paper contain the course description and procedures (Appendix B), the introductory student training exercises (Appendix C), and some sample project guides (Appendix D). The project guides included in Appendix D should be considered to be examples of the format used in developing actual course materials. Additional guides will be written as dictated by student needs and interests. Appendix A is a table of contents for the science seminar course.

CHAPTER 4

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

This action learning paper is a report on the development of a format to be used in writing project guides for gifted high school students in science. The guides are to be used as the basis for the science seminar course at La Crosse Central High School and as an alternative method of instruction for gifted and talented students in other courses.

CONCLUSION

The format for the project packets has been developed and some sample project guides have been written. The author has used these sample guides in the science seminar course at La Crosse Central High School. This course has included a research component for several years but the use of the project guides has improved the efficiency and effectiveness of the research process.

By using this approach the instructor is able to spend more time working directly with the students and less time searching books and files because the instructor's guide gives instructions and references that can be used to begin the project.

Many students have the desire and ability to learn by way of a project approach, but simply lack the experience to effectively choose and define a topic. The project guides help them by giving a short introduction with many open ended and unsubstantiated statements; and following this with a series of questions designed to help the student choose a topic and plan a procedure. The use of this approach has greatly increased the efficiency of the process by reducing the time needed for choosing topics. Another benefit witnessed by the author is the improvement in student attitude. The students feel they are an integral part in the planning process and respond favorable to being included in the decision making.

RECOMMENDATIONS

In light of the limited successful field testing in the science seminar course, the author recommends that some selected materials also be developed and tested in other science courses which serve gifted and talented students. If these materials are successfully used in other courses, a file will need to be maintained on each student to aid in guiding a student through the science program. This would insure the student has, in fact, met the goals and objectives of the science program.

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APPENDIX A

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SCIENCE SEMINAR

APPENDIX B

SCHOOL DISTRICT OF LA CROSSE

Educational Philosophy

The science seminar course shall be consistent with the following educational philosophy of the School District of La Crosse.:

> The School District of La Crosse believes that the primary responsibility of the La Crosse community is to seek and provide excellence in education for all children. It is to this purpose that the School District of La Crosse will devote its energies and resources. Moreover, throughout the time children spend in school they will receive instruction in subjects which are thought necessary for providing skills necessary for successful and productive work lives, while encouraging their full intellectual and emotional development. Although the Board of Education endorses no specific instructional program, the School District of La Crosse will consistently strive to provide learning opportunities which enhance the uniqueness of each child, allow each to grow at his/her own rate, and provide activities which bring children together for mutual expressions of interest at all age levels. Additionally, the School District of La Crosse believes what we accomplish in schools directly affects the present and future quality of life in the community.
>
> The School District of La Crosse, then, believes the most important purpose it and its employees serve are the interest of children,

their social, emotional and intellectual growth and the future they represent. It believes that education is provided so that children may grow to be the persons they want to be, can be, and are able to be.

Mission Statement

The mission statement for the science curriculum of the School District of La Crosse is as follows:

> The mission for the School District of La Crosse science curriculum is to foster in our youth a desire and enthusiasm to learn about the scientific world. The program will provide the students with the basic concepts and skills necessary to function in the present and the future. The curriculum will foster student involvement, create scientific experiences relevant for the student, and develop an educational environment optimum to thinking.

Goals and Objectives of the Science Program

The science program of the School District of La Crosse is designed to engage the student as an active participant in the learning process. The process approach will be emphasized throughout the science program. Teachers will act as planners and directors rather than merely disseminators of information.

The science program will provide students with the skills and knowledge necessary to explore and understand their invironment.

The following skills will be reinforced at all levels in the middle and senior high schools:

APPENDIX D

(1) The proper use of the metric system

(2) Competency in the use of basic math skills

(3) Use of the scientific method

(4) Demand appropriate laboratory behavior

(5) Demand adequate care of equipment

(6) Reinforce basic writing skills

(7) Reinforce basic speaking skills

(8) Reinforce basic reading skills

Course Description

Science Seminar is a one or two semester course consisting of topics chosen cooperatively by the student and the teacher in one or more major areas of science. The emphasis of the course will be placed upon the use of the scientific method. Students will be taught to identify a problem, define its parameters, and execute an investigation leading to the formation of a hypothesis. The results of the research project will be presented both in a formal written lab report and in an oral seminar session.

Students will be encouraged to explore areas of interest in greater depth than would normally be possible.

Prerequisite

Students wishing to take science seminar will be required to have successfully completed physical science, and at least one course in the area to be emphasized. The consent of the instructor is required to take this course.

Course Introduction

The goal of this course is to involve students in research activities in which they design and conduct experiments in a content area related to their own interests and needs. Students will gain experience in research techniques and learn those skills necessary to conduct an investigation. Those students who are involved in this course will gain scientific knowledge by experiencing the process of science.

Procedure

The course will begin with an orientation and an introduction to the research process by using eight lessons (See Appendix C).

1) The research process will be presented as an organized method of study. Exercises will be conducted in which the proper attitudes toward research and causal relationships will be demonstrated.
2) The accepted methods of experimental design will be demonstrated.
3) The problems associated with measurement and collection of data will be examined.
4) Statistics and methods of analysis of data will be considered and explained.
5) The proper use of microcomputers will be demonstrated.
6) The accepted format to be used for written reports will be demonstrated. Instructions will be given for the oral presentation of reports.
7) The students will be given instruction in laboratory safety procedures and in the proper care and treatment of equipment.

8) A short research project will be conducted by the entire class as a method of gaining experience with the research process.

The eight lessons for orientation will be completed in approximately three weeks.

During the orientation period, students will meet individually with the instructor to determine the goals and objectives to be met by that student. These goals may include an in depth study of a specific topic, preparation for an advanced placement exam, or career exploration. The goals set by the student will be reviewed periodically by the instructor and the student. The goals may need to be clarified or revised as the student's interests and plans change.

At the completion of the three week orientation, the students will plan and complete investigations of their choice. These investigations can be done individually or in small groups. When a project is completed, it will be presented in both a written report and in an oral seminar session.

Evaluation of Student Work

The projects will be evaluated for adherence to research techniques, quality of oral and written reports, complexity of the project, and the degree of independence demonstrated in the research. The projects will be classified by the amount of guidance given to the student and the complexity of the project. The classifications to be used are as follows:

1) A teacher initiated, single concept project with a minimal amount of original thought is a level I investigation.
2) A level II investigation is student initiated and planned, but

is based upon a single concept. This project is somewhat limited in its complexity.

3) A level III project is teacher initiated, but cooperatively planned with the student. This type of project will be extensive in content.

4) The most extensive and highly interdisciplinary projects are level IV. These projects will be student initiated and planned. The content of this level of project will be extensive and the research design will include several inter-related steps.

Most students will be expected to start with a level I project, and then attempt higher levels as their research skills improve. The course will attempt to lead all students from level I projects to a point at which they will feel comfortable conducting a level IV investigation.

APPENDIX C

Introductory Activity I

The Nature of Science

Major concepts:

1. Science is not a collection of facts but rather a method of inquiry.
2. Science is a process of asking questions and systematically seeking answers.
3. Scientific theory is an interpretation of previously made observations.
4. Scientific theory is developed by
   a) observation of a phenomenon
   b) formation of an hypothesis
   c) testing and modification of the hypothesis
   d) examination of the results of the testing and then drawing of conclusions
5. Scientific knowledge can result from the examination of experimental error, chance, or circumstance.
6. Scientific experimentation can be considered to be causal anylysis.
7. Scientific inquiry depends upon quantitative methods.

Method of instruction:

Direct instruction and class discussion will be used to present this topic.

Objectives:

At the completion of this unit the student will be able to:

1. distinguish the knowledge or content of science from the process or method of science.
2. explain the method to be used in conducting an investigation.
3. explain the difference between a theory and an hypothesis.
4. describe a course of action to take when presented with a problem.

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Tolman, R. R., Mayer, W. V., & Meyer, D. E. Biological Science Interaction of Experiments and Ideas. Englewood Cliffs, New Jersey: Prentice-Hall, 1983.

Introductory Activity II

Experimental Design

Major concepts:

1. An hypothesis is a conditional explanation of observations which can be tested by experimentation.
2. An hypothesis can be reduced to an if-then statement using measurable variables.

Method of instruction:

Direct instruction and class discussion will be used with simulation exercises to present this topic.

Objectives:

At the completion of this unit the student will be able to:

1. use if-then statements to construct an hypothesis from an observed phenomenon.
2. identify the dependent and independent variables in a experimental design.
3. identify the variables in an hypothesis.
4. suggest an experimental procedure to measure the variables in an experimental design.

References:

Tolman, R. R., & Mayer, W. V., & Meyer, D. E. Biological Science Interaction of Experiments and Ideas. Englewood Cliffs, New Jersey: Prentice-Hall, 1983.

Introductory Activity III

Measurement and Collection of Data

Major concepts:

1. The dependent and independent variables will suggest the type of measurements to be made.
2. Metric system (SI) units should be used for all measurements.
3. The units used for a measurement should be those which are the most convenient to take as well as the most meaningful to interpret.
4. The units used for a measurement should reflect an accuracy in accord with all of the measuring devices.
5. The measurements should be recorded so as to reflect the maximum sensitivity of the devices used.
6. The uncertainty of a measurement should be recorded with the measurement.
7. All Calculations should reflect the appropriate number of significant figures.
8. Data should be recorded in an organized manner.
9. All data which is collected should be recorded even if it will not be used.

Method of instruction:

This topic will be presented by direct instruction and class discussion. A laboratory exercise in measurement will be used to give practice with measuring devices and recording techniques.

Objectives:

At the completion of this unit the student will be able to:

1. identify the data which needs to be taken for a specific experimental design.

2. accurately record data from all common laboratory measuring devices.

3. use the metric system for all measurements.

4. demonstrate the proper use of significant figures.

References:

Tolman, R. R., Mayer, W. V., & Meyer, D. E. Biological Science Interaction of Experiments and Ideas. Englewood Cliffs, New Jersey: Prentice-Hall, 1983.

Introductory Activity IV

Analysis of Data

Major concepts:

1. The use of data tables will help to organize data in terms of dependent and independent variables.
2. Graphs can be used to give a visual depiction of data.
3. The independent variable is plotted on the x axis and the dependent variable is plotted on the y axis.
4. The mean, median, and the mode describe the central tendency of raw data. Sets of raw data can be compared using these values.
5. The standard deviation, and the standard error of the mean allow for data to be examined for variability.
6. Chi-square and t-tests allow the researcher to determine whether a significant difference exists between two sets of data.

Method of instruction:

This topic will be presented by direct instruction and will be reinforceed with written exercises.

Objectives:

At the completion of this unit the student will be able to:

1. prepare data tables given sample data and an experimental design.
2. graph sample data using dependent and independent variables.
3. calculate the mean, median, and the mode for a sample set of data.
4. calculate and interpret the standard deviation, variance, and the

standard error of the mean for a sample set of data.

5. calcualte and interpret a Chi-square determination for a sample set of data.

6. calculate and interpret a t-test given a sample set of data.

References:

Lyon, L. A. Guidelines For High School Students on Conducting Research in the Sciences. Durham, North Carolina: Moore Publishing Co., 1980.

Tolman, R. R., Mayer, W. V., & Meyer, D. E. Biological Science Interaction of Experiments and Ideas. Englewood Cliffs, New Jersey: Prentice-Hall, 1983.

Introductory Activity V

Computer Operations

Major concepts:

1. The use of the computer allows large amounts of data to be handled quickly and efficiently.
2. The computer can be used to develop models for use in testing hypotheses.
3. The Apple II-plus computer operates with BASIC language.
4. The disk operating system (DOS) is a fast method of storage and retrieval of information.

Method of instruction:

Direct instruction with demonstrations will be used to teach this unit. The students will be required to become familiar with the general operations of the computer and to write some simple data handling programs.

Objectives:

At the completion of this unit the student will be able to:

1. demonstrate the operation of an Apple II-plus microcomputer.
2. demonstrate the operation of the DOS system.
3. write and operate simple programs to store and retrieve data.
4. use prepared software to process data.

References:

Apple II Reference Manual. Cupertino, California: Apple Computer, 1981.

Applesoft II Basic Programming Reference Manual. Cupertino, Cal.: Apple Computer, 1981.

Soltzberg, L., Shah, A. A., Saber, J. C., & Canty, E. T. BASIC and Chemistry. Boston: Houghton Mifflin, 1975.

Wilkins, C.L., Klopfenstein, C. E., Isenhour, T. L., Jurs, P. C. Introduction to Computer Programming for Chemists-BASIC Version. Boston: Allyn and Bacon, 1974.

Introductory Activity VI

Preparation of Research Reports

Major concepts:

1. A major part of any scientific study is communicating the results to others.
2. The title of a report should be as explicit as possible, but at the same time, as short as is practical.
3. The abstract is a short summary of the purpose of the study, method to be used, and the results that were obtained.
4. The introduction includes the statement of purpose and a review of any related literature.
5. The experimental portion of the report contains the data which has been collected and the methods used to collect it.
6. The results of the experimental work should be presented in a separate section of the report.
7. The discussion of the results, or the conslusion, relates the experiment to the purpose and to other similar studies.
8. An oral seminar session provides an opportunity to discuss the findings of an investigation with other students.

Method of instruction:

This topic will be presented by direct instruction using examples of reports submitted by students.

Objectives:

At the completion of this unit the student will be able to:

1. use the library to conduct background research.

2. organize and write a research report.

3. prepare and present an oral seminar session.

References:

A Chemistry Project From Start to Finish. Washington, D.C.: American Chemical Society, 1982.

Day, R. A. How to Write and Publish a Scientific Paper. Philadelphia: ISI Press, 1979.

Lyon, L. A. Guidelines For High School Students on Conducting Research in the Sciences. Durham, North Carolina: Moore Publishing Co., 1980.

Tolman, R. R., Mayer, W. V., Meyer, D. E. Biological Science Interaction of Experiments and Ideas. Englewood Cliffs, New Jersey: Prentice-Hall, 1983.

Introductory Activity VII

Laboratory Safety

Major concepts:

1. All laboratory activity has some inherent danger associated with it.
2. Most laboratory hazards can be identified.
3. The use of proper laboratory technique can eliminate most hazards.
4. Laboratory safety is the result of thinking before acting.

Method of instruction:

Demonstrations and direct instruction will be used to teach this unit.

Objectives:

At the completion of this unit the student will be able to:

1. identify those factors which lead to most common laboratory accidents.
2. demonstrate the proper method of handling laboratory materials and equipment.
3. analyze a procedure for hazard potential.

References:

Gerlovich, J. A., Down, G. E. Better Science Through Safety. Ames, Iowa: Iowa State University Press, 1981.

Lyon, L. A. Guidelines for High School Students on Conducting Research in the Sciences. Durham, North Carolina: Moore Publishing Co., 1980.

Prudent Practices for Handling Hazardous Chemicals in Laboratories. Washington, D. C.: National Academy Press, 1981.

Introductory Activity VIII

Conducting a Class Project

The final activity to introduce the student to the research process will be a directed project conducted by the entire class. A topic will be presented to the class in the form of a problem. The students, through directed class discussion, will define the problem and suggest possible methods to use. It is extremely important that adequate class discussion time be provided so as to allow the students to develop the procedure instead of the instructor. Time will be allowed for the students to conduct a library search, prepare the experimental materials, and conduct the experiment. The class will prepare a written report of the work completed.

Instructional goal:

The student will gain enough experience in the process of conducting a research project to be able to work independently on a project of his or her choice.

Instructor's Guide

Eutrophication and Phosphates

Application:

This project can be used as a topic for the science seminar course or as a gifted and talented alternative in environmental studies.

Major concepts:

1. Man has greatly accelerated the natural process of eutrophication.
2. The trend of rapid aging of lakes can be reversed by decreasing the amount of nutrients being discharged into natural waters.
3. Increased phosphate levels in a water system will accelerate the growth of aquatic plants.
4. Detergent companies add phosphates to detergents to counteract the effect of hard water.

Objectives:

After completing this project the student should be able to:

1. describe the process of eutrophication.
2. explain how increased phosphate levels can accelerate the process of eutrophication.
3. explain the relationship between phosphates as water softeners and hard water.
4. quantitatively determine phosphate levels in detergents and water samples.
5. explain why premature eutrophication is undesirable.

6. explain how premature eutrophication can be prevented.

7. comprehend and explain the conflicting views of the environmentalists and the detergent producers.

Procedures:

The student should be encouraged to do an extensive background search of this topic. The laboratory work could include:

1. a colorimetric determination of phosphate
2. a titrimetric determination of phosphate
3. a titrimetric determination of hard water
4. the comparative growth rates of algae in varying nutrient levels
5. the comparative complexing ability of phosphate as a water softener in various types of hard water

Safety Notes:

The laboratory procedures for this project are relatively safe but good laboratory practice should be maintained.

References:

Gordon, G. The Delicate Balance. New York: Harper and Row, 1973.

Hered, W., Nebergall, & W. H. Basic Laboratory Studies in College Chemistry. Lexington, Massachusetts: D.C. Heath, 1972.

Turk, A., Turk, J., Wittles, J. T., & Wittes, R. E. Environmental Science. Philadelphia: W. B. Saunders, 1978.

Water Technology. Rochester, New York: Bausch and Lomb, 1974.

Student Project Guide

Eutrophication and Phosphates

Eutrophication is the natural process which occurs as a lake changes into a marsh. This process should be considered normal unless it is accelerated by the activities of humans. If excessive amounts of plant nutrients, such as phosphates and nitrates, are dumped into a water system, the eutrophication process will be accelerated.

Phosphates were recognized as pollutants in the 1960's and many states, including Wisconsin, passed laws limiting the amount of phosphates in detergents. This law was allowed to expire in Wisconsin in 1982.

Questions to consider:

1. Why are phosphates used in detergents?
2. What economic factors are involved in the ban of phosphates in detergents?
3. What are the political considerations of this law and its expiration?
4. What are normal levels of phosphate in lake and river water?
5. What are the present levels of phosphate in the water of this area and has it changed?
6. What are the phosphate levels of the commonly used detergents?
7. How much phosphate enters the water from detergent and how much from fertilizer?

8. Do sewage disposal plants remove phosphate from waste water?

Suggested procedure:

1. Conduct a literature review of the political and social considerations of this topic.
2. Design and conduct an experiment to measure the rate of algae growth at controlled phosphate levels.
3. Conduct an experiment to determine the amount of phosphate in various brands of detergent.
4. Construct a computer model of a lake to project the effects of added phosphate.
5. Conduct a survey of local water systems to determine phosphate levels.

Instructor's Guide

Caffeine

Application:

This project can be used as a topic in science seminar as well as an alternative method of instruction in biology and the anatomy and physiology course.

Major concepts:

1. Caffeine is both a physiological and psychological stimulant.
2. Many common foods, beverages, and drugs contain caffeine.

Objectives:

After completing this project the student should be able to:

1. describe the physiological effects of caffeine.
2. explain the process of solvent extraction.
3. conduct a solvent extraction of caffeine from a liquid sample.
4. determine blood pressure, heart rate, and rate of respiration.
5. explain the stimulant effects of caffeine and the potential health problems that can result from its use.

Procedures:

The student should be encouraged to conduct an extensive review of the literature on this topic. The laboratory work will include:

1. solvent extraction determination of caffeine in various commercial products.

2. the effects of caffeine on physiological parameters in living subjects.

3. the effects of caffeine on the ability to learn using living subjects.

Safety notes:

1. The solvent extraction process uses methylene chloride which should be used only in a fume hood.

2. The use of living subjects, whether they be students or animals, requires special care. The amount of caffeine ingested should be closely monitored so as to keep the blood concentrations at acceptable levels. This should be done only with parental consent.

References:

Evans, W.F. Anatomy and Physiology. Englewood Cliffs, New Jersey: Prentice-Hall, 1983

Helmkamp, G.D. & Johnson, H.W. Selected Experiments in Organic Chemistry. San Francisco: W.H. Freeman, 1968.

O'Connor, R. Natural Product Chemistry. Journal of Chemical Education, 1965, 42, 492.

Sienko, M.J. Plane, R.A., & Marcus, S.T. Experimental Chemistry. New York: McGraw-Hill, 1976.

Student Project Guide

Caffeine

Caffeine is a naturally occuring alkaloid which has properties that classify it as a physiological stimulant and as a diuretic. Several of the commonly available nonprescription medications contain caffeine as do many soft drinks and natural beverages like coffee and tea. Caffeine is normally used as a stimulant or as a diuretic.

The widespread use of caffeine has prompted some researchers to study the physiological and psychological effects as well as its effect on learning.

Questions to consider:

1. What is the content of caffeine in tea, coffee, and soft drinks?
2. Is there any difference in the amount of caffeine found in different brands of coffee?
3. Is decaffeinated coffee really caffeine free?
4. Why do beverage companies add caffeine to soft drinks when it does not occur naturally?
5. What physiological effects result from the intake of caffeine?
6. Students often use caffeine containing products to stay awake while studying for exams. What is the effect on the ability to learn while under the influence of caffeine?

Suggested procedure:

1. Conduct a review of the literature pertaining to the effects of

caffeine.

2. Design an experiment to test the effects of caffeine on physiological factors such as heart rate, blood pressure, and rate of respiration.

3. Find a procedure for the isolation and measurement of caffeine in liquid samples.

4. Design and conduct an experiment to determine the effects of caffeine on the ability to learn.

Instructor's Guide

Nitrogen Oxides in the Air

Application:

This project is best suited to the science seminar course but it can also be used as an alternative method of instruction for gifted and talented students in environmental studies or chemistry.

Major concepts:

1. Nitrogen and oxygen will combine at high temperatures and pressures. These conditions can be found in the internal combustion engine.
2. The automobile is one of the major contributors to air pollution in the United States.
3. Nitrogen oxides represent a major contributor to the problems of acid rain and photochemical smog.

Objectives:

After completing this project the student should be able to:

1. write chemical equations showing the formation of nitrogen oxides, nitric acid, and peroxyacetyl nitrates.
2. define photochemical smog.
3. define acid rain.
4. relate compression ratio in internal combustion engines to the formation of nitrogen oxides.
5. conduct an experiment to determine the amount of nitrogen oxide in

an air sample.

6. design and conduct an experiment to relate nitrogen oxide levels to other parameters such as the model of automobile, compression ratio, type of fuel, or weather conditions.
7. explain the social consequences of acid rain and photochemical smog.
8. describe the relationship that exists between photochemical smog and automobile use.

Procedure:

The student should be encouraged to do an extensive review of the literature related to the chemistry of nitrogen oxides, acid rain, and photochemical smog. The laboratory work should be based upon a colorimetric determination of nitrogen oxides in air samples.

Safety Note:

The laboratory procedures for this project are relatively safe but good laboratory practice should be maintained.

References:

Gorson, G. The Delicate Balance. New York: Harper and Row, 1973.

Merrill, P. Parry, R. W., Tellefsen, R. L., & Bassow, H. Chemistry: Experimental Foundations Laboratory Manual. Englewood Cliffs, New Jersey: Prentice-Hall, 1982

Pryde, L. T. Environmental Chemistry. Menlo Park, California: Cummings, 1973.

Water Technology. Rochester, New York: Bausch and Lomb, 1974.

Student Project Guide

Nitrogen Oxides in the Air

Nitrogen and oxygen normally do not react with each other but at high temperatures and pressures, nitrogen oxides can form. Conditions like these can be found in the internal combustion engine as well as some high temperature furnaces. Considering the infatuation many Americans have with automobiles, it is no wonder that nitrogen oxide pollution has become so prevalent.

Acid rain is in part due to the reaction of nitrogen oxides with water to form nitric acid. Photochemical smog can be produced when nitrogen oxides react with hydrocarbons and ozone.

Questions to consider:

1. What are the reactions which produce acid rain and photochemical smog?
2. What concentration is necessary for the formation of these pollutants?
3. What are the allowable limits of nitrogen oxides as set by the Environmental Protection Agency?
4. How is compression ratio of an engine related to the level of nitrogen oxide emissions?
5. Do different kinds of fuel (unleaded vs. regular) have any effect on the nitrogen oxide emissions of an engine?
6. How do the nitrogen oxide levels of La Crosse compare to other

parts of the country?

7. What are the environmental effects of acid rain and photochemical smog?

Suggested procedure:

1. Conduct a review of the literature pertaining to acid rain, photochemical smog, and nitrogen oxides.
2. Examine an internal combustion engine and determine what is meant by compression ratio.
3. Consult the literature for nitrogen oxide levels of various parts of the country as established by the Environmental Protection Agency. Try to correlate this information with data on acid rain and photochemical smog levels.
4. Conduct an experiment to determine nitrogen oxide levels in various parts of La Crosse.
5. Conduct an experiment to relate nitrogen oxide emissions of various models of automobiles.
6. Conduct an experiment to relate nitrogen oxide emissions of an automobile to the type of fuel used.

Instructor's Guide

Physical Behavior of Gases

Application:

This project is best suited as a method of instruction for gifted and talented students in chemistry or accelerated chemistry. If supplemental problems are provided, this project can also be used as a method of instruction for students preparing for the advanced placement exam in chemistry.

Major concepts:

1. The kinetic molecular theory is a model to help explain the behavior of gas molecules in terms of energy and motion.
2. The four measurable parameters of a gas are mass, volume, temperature, and pressure.
3. Pressure and volume are inversely proportional to each other (constant temperature and mass).
4. Volume and temperature are directly proportional to each other (constant pressure and mass).
5. Pressure and temperature are directly proportional to each other (constant volume and mass).
6. Temperature is a measure of the average kinetic energy of the molecules.
7. Pressure and volume are both directly proportional to the mass of gas.

8. Absolute zero is the lowest possible temperature and it represents a state of zero kinetic energy.
9. The various relationships of gases can be summarized in the ideal gas law.
10. The relative rate of diffusion of two gases is inversely proportional to the square root of the ratio of their molecular weights.
11. The van der Waals correction to the ideal gas law takes into consideration the effect of varying the identity of the gas.

Objectives:

After completing this project, the student should be able to:

1. explain the points of the kinetic molecular theory.
2. explain the observed behavior of confined gases in terms of the kinetic molecular theory.
3. explain the relationship between the pressure, volume, temperature, and mass of a confined gas.
4. explain the concept of absolute zero.
5. describe the ideal gas law in mathematical terms.
6. design and conduct experiments relating the volume, temperature, pressure, and mass of a confined gas.
7. effectively measure the pressure of a gas.
8. effectively measure the volume of a gas.
9. effectively measure the temperature of gas.
10. collect data and graphically treat that data.
11. calculate the pressure, volume, temperature, or mass of any gas given the other three.

12. use conceptual models as a method of explaining an abstract idea
13. demonstrate the mathematics used to utilize the kinetic molecular theory.

Procedure:

The student should be encouraged to do extensive background research in conjunction with the laboratory work. The laboratory work should include:

1. the determination of the relationship between pressure and volume (Boyle's Law).
2. the determination of the relationship between temperature and volume (Charles' Law).
3. the determination of the relationship between pressure and temperature (Guy Lussac's Law).
4. the determination of the relationship between molecular weight of the gas and the rate of diffusion.
5. the determination of absolute zero.

Safety notes:

The students should be reminded to wear safety goggles. Any glassware used should be free of scratches or cracks when pressure changes are being considered.

References:

Brown, T.L., & LeMay, H.E. Chemistry The Central Science. Englewood Cliffs, New Jersey: Prentice-Hall, 1981.

DeVoe, H., Hoffman, C., Everhart, W., & Weile, P. Communities of Molecules. New York: Harper and Row, 1973.

Hered, W., & Nebergall, W.H. Basic Laboratory Studies in College Chemistry. Lexington, Massachusetts: D.C. Heath, 1972.

Parry, R.W., Bassow, H., Merrill P., & Tellefsen, R.L. Chemistry Experimental Foundations. Englewood Cliffs, New Jersey: Prentice-Hall, 1982.

Seinko, M.J. Plane, R.A., & Marcus, S.T. Experimental Chemistry. New York: McGraw Hill, 1976.

Student Project Guide

Physical Behavior of Gases

The kinetic molecular theory is a conceptual model consisting of a set of assumptions to explain molecular motion in a gas.

Questions to consider:

1. What assumptions are made by the kinetic molecular theory?
2. In terms of the kinetic molecular theory, how can we define pressure, volume, temperature and moles of gas?
3. What is the relationship between the pressure of a gas and its volume?
4. What is the relationship between temperature and the volume of a gas?
5. What is the relationship between the pressure of a gas and its temperature?
6. If more molecules of gas are added to a system, what will happen to the pressure, temperature, and volume?
7. Does it make any difference what gas is used?
8. What is gaseous diffusion?
9. Is there any minimum or maximum allowable temperature?

Suggested procedure:

1. Review the literature to become familiar with the kinetic molecular theory.

2. Design and conduct an experiment to relate the pressure of a confined gas to its volume.
3. Design and conduct an experiment to determine the relationship between the volume of a confined gas and its temperature.
4. Design and conduct an experiment to determine the relationship between the pressure exerted by a gas and the temperature of that gas.
5. Design and conduct an experiment to determine the factors that will affect the rate of diffusion of a gas.
6. Conduct a review of the literature pertaining to the ideal gas law.

Instructor's Guide

Amino Acid Content of Protein

Application:

This project should be used with the science seminar course, but could be used as an alternative for gifted students in chemistry, or anatomy and physiology.

Major concepts:

1. Proteins are polymeric biomolecules formed by linking amino acids with peptide bonds.
2. Amino acids are molecules containing a carboxyl group and an amino group.
3. Proteins can be hydrolyzed to amino acids with acids, bases, and enzymes.
4. Thin layer chromatography is an analytical technique used to separate and identify a mixture of compounds.
5. The amount and chemical quality of protein is important to good nutrition.
6. Of the twenty amino acids included in human protein, ten must be included in the diet because the body cannot produce them.

Objectives:

After completing this project the student should be able to:

1. identify the twenty amino acids important to humans.

2. identify the essential amino acids.
3. describe the structure of proteins.
4. explain the chemistry of a peptide linkage.
5. explain the process of chromatography.
6. perform a protein content determination.
7. use chromatography to separate and identify the amino acids found in a protein sample.
8. explain the importance of protein content in the diet.
9. relate quantity and quality of protein reserves to the problem of world hunger.

Procedure:

The student should be encouraged to do extensive background research on protein structure, the methods of chromatography, and techniques for the determination of protein content. Research should also be done with respect to protein in human nutrition and the sociological aspects of world hunger. Laboratory work should be based upon:

1. methods of protein hydrolysis.
2. methods for determining protein content.
3. chromatography of amino acid mixtures.

Safety Notes:

1. The hydrolysis of protein will involve the use of an autoclave, and therefore should be closely supervised by the instructor. Safety goggles should be worn during this process.
2. Many of the solvents used in chromatography are flammable, and

represent an inhalation health hazard. These should be used in a fume hood.

References:

Bobbitt, J.M. Thin Layer Chromatography. New York: Reinhold Publishing Company, 1963.

Clark, J.M. Proteins and Amino Acids. San Francisco: W.H. Freeman, 1965.

Hectlinger, A. Biochemistry Units For the High School Biology Teacher. West Nyack, New York: Parker, 1973.

Heiman, W. Fundamentals of Food Chemistry. West Port, Connecticut: AVI Publishing Company, 1980.

Smith, I., & Feinberg, J.G. Paper and Thin Layer Chromatography and Electrophoresis. London: Shandon, 1965.

Martin, D., Sampugna, J. & Sandoval, A. Molecules in Living Systems. New York: Harper and Row, 1978.

Student Project Guide

Amino Acid Content of Protein

World hunger is becoming one of the major problems to be faced in the next few decades. The population of the world keeps increasing, but the food supply is not keeping pace. More significant, is the fact that the amount of protein is even more limited.

In the United States, eating habits have changed drastically. There seems to be an increasing number of vegetarians and many of the younger Americans seem to be addicted to "junk food".

Protein is a necessary component of the human diet and where the total protein intake is limited, the amino acid content of the protein becomes extremely important.

Questions to consider:

1. What is an essential amino acid?
2. What is the composition of a protein?
3. Why are some amino acids more important than others in human metabolism?
4. How much protein is in common foods?
5. Are the protein and amino acid requirements for dogs and cats the same as for humans?
6. What does world hunger have to do with protein quality and quantity?
7. Many commercially available foods have the protein content printed on the label. Does the protein contain any of the essential amino acids?

Suggested procedure:

1. Conduct a review of any literature pertaining to protein requirements of human beings, the chemical structure of proteins, and any analytical techniques that can be used to measure protein content or amino acid content.
2. Determine the protein content of some common foods or pet foods. These can usually be checked against the label values.
3. Hydrolyze some food samples and conduct an experiment to determine the amino acid content.

Instructor's Guide

Lead in the Environment

Application:

This project can be used as a topic for the science seminar course or as an enrichment project for chemistry, anatomy and physiology, or environmental studies.

Major concepts:

1. Lead has in the past been a major pollutant.
2. The major source of lead pollution at the present time is from automobile exhaust resulting from the use of unleaded gasoline.
3. Lead interferes with the formation of red blood cells and the normal functionaing of the central nervous system.
4. Lead Poisoning is a problem that can be eliminated.

Objectives:

After completing this project the student should be able to:

1. describe the physiological effects of lead poisoning.
2. list sources of lead pollution.
3. measure the lead content of samples.
4. construct a statistically sound experiment showing the existence of abnormal levels of lead.
5. explain the social morality of limiting lead emissions into the environment.
6. explain the environmental wisdom of using unleaded automobile fuel.

Procedures:

The student should be encouraged to conduct a review of literature pertaining to lead poisoning, health effects of lead, the use of lead in industry, the use of lead in automobile fuels. The laboratory work should be based upon a quantitative analysis of lead samples.

Safety note:

Students doing this project should be reminded that most lead compounds are toxic.

References:

Gordon, G. The Delicate Balance. New York: Harper and Row, 1975.

Water Technology. Rochester, New York: Bausch and Lomb, 1974.

Student Project Guide

Lead in the Environment

Lead was used for many years as a paint pigment, and is still used as an anti-knock ingredient in some gasoline. The health hazards of lead were recognized many years ago and a concerted effort was made during the 1960's and 70's to eliminate lead wherever possible. These efforts resulted in nearly all lead being removed from the commercial markets.

Questions to consider:

1. How much lead is still in the environment?
2. What are the health effects of lead?
3. How is lead ingested into the human body?
4. What happens to the lead in gasoline?

Suggested procedure:

1. Review the literature to determine how lead affects human beings.
2. Measure the lead content of soil samples from along various highways and compare it to soil from areas not exposed to automobile exhaust.
3. Measure the lead content of paint samples from older houses.
4. Is there any exposure to lead in occupational settings such as electronics, plumbing, or auto repair.
5. Contact a local hospital lab to obtain information for construction of a case history model.

Instructor's Guide

Identification of an Organic Unknown

Application:

This project is most appropriate for use with the science seminar course, but some application might be made with students preparing for the advanced placement exam in chemistry.

Major concepts:

1. Organic aldehydes and alcohols can be oxidized to acids.
2. The identification of an unknown compound can be made by use of melting point, boiling point, equivalent weight, and a variety of simple chemical tests.
3. The infrared spectrum of a compound gives much information about the functional groups present.

Objectives:

At the completion of this project the student should be able to:

1. explain the chemical reactions involved in the oxidation of organic compounds.
2. explain the principles of infrared spectrophotometry.
3. determine the melting point of an organic compound.
4. determine the boiling point of an organic compound.
5. plan and follow an organic qualitative analysis scheme.
6. synthesize the oxidation product of an organic aldehyde or alcohol.

7. purify an unknown by recrystallization.

8. interpret a simple infrared spectrum.

9. determine the equivalent weight of an unknown organic acid by titration.

10. correctly and effectively use the Chemical Rubber Company Handbook of Chemistry and Physics.

11. demonstrate the research approach to solving problems.

Procedures:

The student should be encouraged to become familiar with organic chemical reactions. A bottle containing an aldehyde or an alcohol can be given to the student as an unknown. (Benzaldehyde or benzoic acid work very well for this procedure.) The student can then be instructed to design a procedure to follow based upon the review of literature. The following laboratory procedures will probably be used:

1. melting point determination
2. boiling point determination
3. organic qualitative analysis
4. equivalent weight determination by titration

If possible, the student can be taken to a local college to use an infrared spectrophotometer and a refractometer.

Safety notes:

1. The students design most of their own procedures and use those found in the literature. This results in many situations which could be potentially hazardous, so it is extremely important that

all procedures be reviewed and approved by the instructor before the student begins.

2. The hot oil used in the melting point and boiling point determinations could cause severe burns. The student should be warned of the danger of burns and should be given instruction in the proper use of hot oil baths.

3. Safety goggles should be worn at all times.

References:

O'Connor, R. Analysis of Monofunctional Organic Compounds. San Francisco: W.H. Freeman, 1971.

Morrison, R.T., & Boyd, R.N. Organic Chemistry. Boston: Allyn and Bacon, 1973.

Sienko, M.J., Plane, R.A., & Marcus, S.T. Experimental Chemistry. New York: McGraw-Hill, 1976

Splittgerber, A.G., MacLean, & D.B. Neils, J. A Unified Chemistry Laboratory, Journal of Chemical Education, 1971, 48, 330-332.

Weast, R.C. Handbook of Chemistry and Physics. Cleveland, Ohio: The Chemical Rubber Company, 1972.

Windholz, M. The Merck Index. Rathway, New Jersey: Merck, 1976.

Student Project Guide

Identification of an Organic Unknown

Analysis of an unknown is always an intriguing activity and when the unknown compound is organic it adds a little extra challenge. Your instructor will give you an unknown compound with only one instruction which is to identify the compound. You will then review the literature to find the procedures you can use to identify the unknown. It should be remembered that the identity of this compound is not as important as the way in which you conduct your research and the laboratory procedures you become familiar with.

Questions to consider:

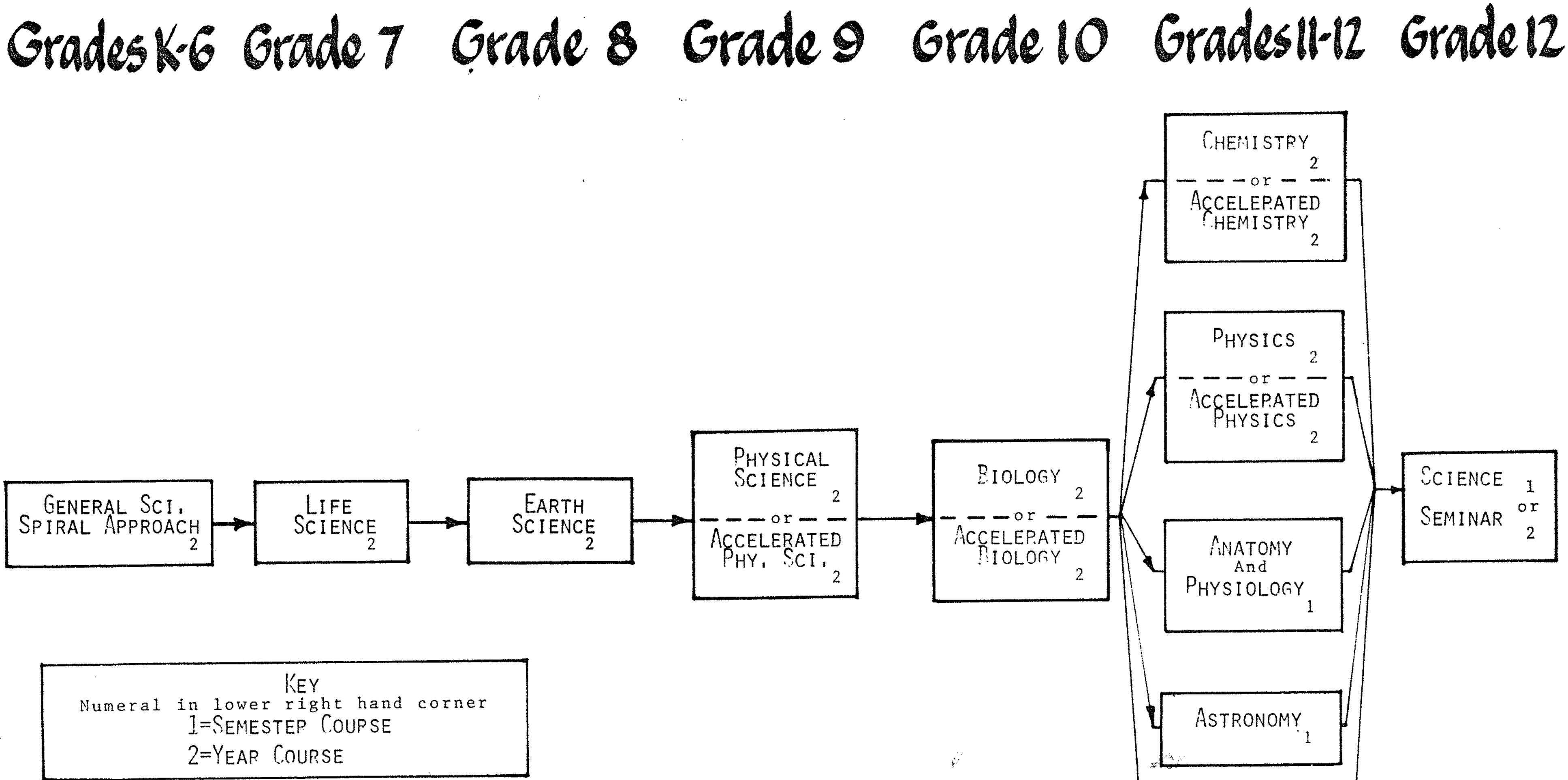
1. What type of information would be useful in identifying an unknown compound?
2. What sources of statistical information about chemical compounds exist?
3. Is your unknown organic? How can you tell?
4. Can the compound be oxidized?
5. Will the compound react with bromine?
6. What reactions will it undergo with common laboratory reagents?

Suggested procedure:

1. Conduct a review of the literature to determine the tests which would be the most productive.

2. Determine if the compound is organic or inorganic.
3. Use the results of your preliminary tests to plan your subsequent tests and procedures.
4. Be sure to consult your instructor before conducting any test or procedure.
5. Consult with other students, teachers, and local college faculty members.

School District of La Crosse
DISTRICT SCIENCE PROGRAM
Grades K-12



Two high school science credits are required for graduation.

Recommendations Based Upon the Review of the Literature

1. The process of science should be stressed rather than the content. The student should be taught the techniques of research and inquiry.
2. The activity packets to be developed should be discovery or inquiry based.
3. The activity packets should utilize as much laboratory work as possible.
4. The packets should be as interdisciplinary as possible.
5. A project approach should be used so as to improve the capability of individualization.
6. The planning of a project should represent a joint effort of the student and the instructor.
7. Students should be required to report their findings both in writing and orally.
8. Student interaction should be encouraged with group activities.

Project Approach to Science Instruction
Major Goals

1. Students using these materials will gain experience using the process of science through independent research. The content of a topic will be learned as an integral part of the research process.
2. Students will learn how to plan and conduct a scientific research study.
3. The students conducting a research study will improve their organizational skills by properly collecting and recording experimental data.
4. The writing ability of students will be improved by practicing proper writing techniques in preparing research reports.
5. Students will improve their oral communication skills through group planning sessions and by presenting seminar sessions related to their research.

SCIENCE SEMINAR

Course Description

Science Seminar is a one or two semester course consisting of topics chosen cooperatively by the student and the teacher in one or more major areas of science. The emphasis of the course will be placed upon the use of the scientific method. Students will be taught to identify a problem, define its parameters, and execute an investigation leading to the formation of an hypothesis. The results of the research project will be presented both in a formal written lab report and in an oral seminar session. Students will be encouraged to explore areas of interest in greater depth than would normally be possible.

Prerequisite

Students wishing to take Science Seminar will be required to have successfully completed physical science, and at least one course in the area to be emphasized. The consent of the instructor is required to take this course.

Course Introduction

The goal of this course is to involve students in research activities in which they design and conduct experiments in a content area related to their own interests and needs. Students will gain experience in research techniques and learn those skills necessary to conduct an investigation. Those students involved in this course will gain knowledge by experiencing the process of science.

SCIENCE SEMINAR

Introductory Activities

The Science Seminar course will begin with an orientation and an introduction to the research process via the following eight lessons:

1. The Nature of Science: The research process will be presented as an organized method of study. Exercises will be conducted in which the proper attitudes toward research and causal relationships will be demonstrated.

2. Experimental Design: The accepted methods of experimental design will be demonstrated.

3. Measurement and Collection of Data: The problems associated with measurement and collection of data will be examined.

4. Analysis of Data: Statistics and methods of analysis of data will be considered and explained.

5. Computer Operations: The proper use of microcomputers will be demonstrated.

6. Preparation of Research Reports: The accepted format to be used for written reports will be demonstrated. Instructions will be given for the oral presentation of reports.

7. Laboratory Safety: The students will be given instruction in laboratory safety procedures and in the proper care and treatment of equipment.

8. Conducting a Class Project: A short research project will be conducted by the entire class as a method of gaining experience with the research process.

The eight introductory lessons will require approximately three weeks to complete.

During the orientation period, students will meet individually with the instructor to determine the goals and objectives to be met by that student. These goals may include an in depth study of a specific topic, preparation for an advanced placement exam, or career exploration. The goals set by the student will be reviewed periodically by the instructor and the student. The goals may need to be clarified or revised as the student's interests and plans change.

At the completion of the three weeks of orientation, the students will plan and complete investigations of their choice. These investigations can be done individually or in small groups. When a project is completed, it will be presented in both a written report and in an oral seminar session.

Project Approach to Science Instruction

Student Project Guide

The student project guide begins with a short discussion of the topic and is designed more to raise questions than to impart information. The student is then given some suggestions of possible procedures to follow, but only in the very lowest level projects are the instructions specific. The student is encouraged to use his or her own creativity in developing a project procedure.

Instructor's Project Guide

The instructor's guide is designed to provide the teacher with information necessary to help the student plan and carry out the project. The instructor's guide consists of six sections:

1. Application: A statement is made which suggests which courses the project will apply to, and in some cases, the level of difficulty is indicated.
2. Major concepts: The scientific knowledge or content is described in several short statements.
3. Objectives: The expected student achievement is described by way of performance objectives in the cognitive, psychomotor, and affective domains.
4. Suggested procedure: Some suggestions are offered for the teacher to use in guiding the student into a productive and interesting procedure.
5. Safety notes: Suggestions and warnings are made with respect to any hazards which may exist with a particular part of a project.
6. References: A list of literature sources pertaining to the project is included. These sources may be used as background for the instructor, or offered to the student for use in beginning a literature search.