8-1989

Integrating Process Skills with Content in Sixth Grade Science

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INTEGRATING PROCESS SKILLS WITH CONTENT IN SIXTH GRADE SCIENCE

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Submitted in partial fulfillment of the requirements
for the Master of Arts in Education degree
Lindenwood College
August, 1989

Abstract

This science curriculum on the flower and simple and compound machines was developed for sixth grade. It was designed to include the objectives suggested by the Core Competencies and Key Skills for Missouri Schools. It was designed to give practice in the process skills. The author felt the need for this curriculum to fill the gap between what our local science curriculum offers and what the State Department of Education suggests that we teach.

Research indicates that the sixth grade science curriculum should provide the opportunity for children to learn science concepts and conceptual schemes, and to become familiar with the scientific method through the use of the discovery and inquiry methods. This would provide the opportunity for children to become proficient in problem solving and critical and creative thinking.

Therefore, this curriculum was designed with many "hands-on" activities providing an opportunity for growth in using the process skills. They are a combination of structure with open-ended questions. They are to be used as an integral part of a developed content program. A specific set of goals, objectives, and evaluations are provided in the curriculum.

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CHAPTER I

Introduction

This author felt the need for this curriculum on flowers and simple and compound machines to help fill the void between the content areas of the local school district's sixth grade curriculum and the content suggested by the Core Competencies and Key Skills for Missouri Schools (1986). The MMAT scores would reflect the absence of these content areas being taught since they were not included in the school's present adopted curriculum and they did not have the materials to teach it.

"The Missouri Mastery and Achievement Tests are a battery of criterion-referenced achievement tests that evaluates educational objectives identified by the Missouri Department of Elementary and Secondary Education" (Osterlind, 1988, p. 3).

It is "the product of an expensive effort to fulfill the provisions of the state's Excellence in Education Act of 1985. The Missouri Department of Elementary and Secondary Education identified 'Key Skills' for the major subjects in grades 2 through 10" (Osterlind, 1988, p. 4). They "have since been brought together in Core Competencies and Key Skills for Missouri Schools" (p. 4). "The Department of Elementary and Secondary Education invited teachers and administrators from all over the state to participate in their development" (p. 4) so they would be "commonly recognized among Missouri educators as essential to the academic progress of the student and central to the respective subjects" (p. 4).

The MMAT has been devised "to encourage and promote quality in our schools" (Osterlind, 1988, p. 4). It serves as a "basis for monitoring scholastic progress in Missouri" (p. 5).

Testing Standards for Missouri Public Schools (1986) states that "the main purpose of testing is to assist teachers in making instruction more effective for each student" (p. 1). They are "used in the quidance and counseling of students" (p. 1). They "are used to monitor student performance and to check whether atudents have achieved certain levels of competence" (p. 2).

Section 4 of the Excellence in Education Act of 1985 "requires the Department of Elementary and Secondary Education"

> to identify 'key skills' or learner outcomes in prescribed subjects, test a sample of students throughout the State, and report the results to

> the General Assembly annually. Local school discticts are required to implement testing policies and programs to measure student achievement on the key skills using criterion-referenced tests. (p. 3)

After doing a review of research the author felt a need for a combination program using both the science processes and the basic content including concepts and skills. Basic content and hands-on activities for providing experience in the process skills have been included. These are designed to be carried out individually or in small groups at learning stations. This would allow practice in thinking critically and creatively and problem solving.

Materials for the activities can be found locally and are inexpensive. The activities are designed to make full use of the process skills and are simple and easy to set up which should appeal to anyone who feels uneasy about teaching the subject. It is hoped that the activities will help develop what Karplus and Thier (1967) call a functional understanding of scientific concepts, a scientific literacy and a love and appreciation for scientific processes that will carry the student through his/her school years and beyond.

Even though all students will not become scientists, they need a curriculum that gives them sufficient knowledge and experience to understand the scientific work being carried out by others. Many aspects of the natural environment are taken for granted and never questioned. To obtain scientific literacy the curriculum needs to provide the student with experiences that are different from his usual ones. The student needs to become acquainted with instruments or devices that extend the range of the senses. The curriculum needs to make him aware of unusual environmental conditions. The experiences should be real ones, not ones read in a book or told by the teacher. The experiences need necessary guidance and discussion (Karplus and Thier, 1967).

It is this author's hope that the activities will help the sixth grader who Wolfinger (1984) calls awkward, restless, lazy, changeable, overly critical, rebellious, uncooperative, self-conscious, independent and curious feel good about himself and science. Hopefully they will help fill his need for what Wolfinger (1984) calls independence and increased responsibility. The activities will provide the necessary observations and experiences needed in addition to pictures and content read in a book (Karplus and Thier, 1967).

The author used learning stations to help achieve the basis of concept formation through what Victor (1985) calls perceptual encounters, where emphasis is placed on hands-on learning involving the use of a large variety of materials. This gives the child the opportunity to explore and find out things for himself which seems to have a built-in motivation for him.

After reviewing sixth grade science texts from over twenty-five different representative curriculum series the author found about five each to contain units on simple and compound machines or flowers and their functions. Most curriculum guides reviewed had few activities set up for individual or small group student involvement.

Learning stations are used in this curriculum to help the teacher to organize instruction so that children can learn on their own and at their own pace. All learning stations are self-directing, promote independent learning, and help meet the individual strengths and needs of all the students in a class (Jacobson and Bergman, 1980).

Much research has been done concerning the effectiveness of an inquiry approach. Research shows it being effective in many areas of learning.

Shymansky, Kyle, and Alport (1982) analyzed 34 studies comparing

> the performance of students in [Elementary Science Study] ESS, [Science Curriculum Improvement Study] SCIS, or [Science - A Process Approach] SAPA classrooms with that of students in traditional, textbook-based classrooms. The average student in the ESS, SCIS, or SAPA classroom performed better than 62 percent of the students in traditional classrooms across all performance criteria measured. (p. 14)

Skymansky, et al. (1982) "analyzed 20 studies that compared student achievement in new science curricula with achievement in traditional programs" (p. 14). They "found that students using these three new programs actually outscored students in the more traditional classrooms - by as much as 34 percentile points" (p. 14).

They analyzed 21 studies comparing attitudes: "1) attitude toward the new course, 2) attitude toward science, 3) attitude toward self" (p. 14). In each category, "student attitudes were more positive toward the new programs than toward the traditional ones" (p. 14).

They "analyzed the results of 13 studies that focused on process skill development in new curricula versus traditional classrooms" (p. 15). In the three elementary science curricula they studied, "new curricula students scored at least 18 percentile points higher than traditional class students on measures of process skill development" (p. 15).

After analyzing 31 studies comparing student performance in reading, arithmetic computation, and communication they found the new science programs produced improved skills. They suggested that the new science curricula be re-examined for activities and teaching ideas and considered for incorporating into existing programs. Their quantitative analysis of research showed that these students "achieved more, liked science more, and improved their skills more than did students in traditional, textbook-based classrooms" (Shymansky et. al., 1982, p. 15).

This curriculum provides a specific set of long range goals and intermediate and performance objectives, as well as hands-on activities, questions, lists of trade books, and methods of evaluation. This curriculum will provide guided science experiences that will stimulate curiosity, enhance critical and creative thinking skills, and nourish intellectual development of common sense. It will foster the development of skills that will enable the sixth grader to interact, interpret and solve problems related to other persons and the environment.

Carin and Sund (1989) have broadly defined scientific inquiry as:

a search for truth and knowledge. If you are

> scientific, you are able to identify problems, make educated guesses or hypotheses, and investigate them. These attitudes influence scientists' discovery behaviors. The discovery behaviors of scientists in turn result in scientific methods, which are referred to in science for elementary school children as the processes of science. (p. 10)

Scientific inquiry has been referred to interchangeably as science processes, inquiry skills, thinking skills, critical thinking skills, process skills, inquiry processes, and problem-solving skills by researchers in this area. Many definitions were given for each skill as found in the research. A summary of the definitions of each skill that follows was taken mainly from Carin and Sund, 1989: Gega, 1986; and Gega, 1977.

OBSERVING - The use of any of the senses to identify properties, state noticeable changes, or state noticeable similarities and differences of an object or event.

MEASURING - The use of conventional or nonconventional standards of measurement to make quantitative observations, scale drawings or models, or simple samplings and estimations.

COMMUNICATING - Defining words through actions, describing objects or events, making charts and graphs, recording data, constructing exhibits and models, or drawing diagrams, pictures, and maps.

INFERRING - Making a conclusion based on reasoning to distinguish between an observation and an inference, interpret recorded data, interpret data received indirectly, or predict events, hypothesize, or draw conclusions from data.

INTERPRETING DATA - Analyzing relationships in data in order to draw conclusions from it.

GENERALIZING - Drawing a conclusion based on particular evidence acquired.

PREDICTING - Making a forecast from ones' data of future events or conditions that are expected to exist.

CONTROLLING VARIABLES - Finding out what makes a difference in an experiment by changing or varying that condition alone while other conditions remain constant or controlled.

DEFINING OPERATIONALLY - Defining an object by action rather than through words alone.

EXPERIMENTING - Stating a hypothesis or operational question to test, or designing a procedure in which variables are controlled.

DESCRIBING - Naming all of the categories of objects, or object or event properties that are relevant to the situation.

COMPARING - The recognizing and stating of similarities and differences between objects, events and places.

CLASSIFYING - Arranging, grouping, or distributing objects, events, or information representing objects or events in classes according to their property, function, or value.

FORMULATING HYPOTHESES - Constructing a testable answer, based on reasoning of what is thought to be true.

This science curriculum is designed to include activities which would require the use of process skills while teaching the basic science concepts and content. Hands-on activities have been included to provide experience in the process skills.

This science curriculum contains long-range goals and intermediate objectives. It contains performance objectives for each of the hands-on activities.

These activities are designed to be carried out individually or in small groups at learning stations. The intent is to provide hands-on activities utilizing easily obtained materials to teach concepts and content through the use of inquiry processes.

CHAPTER II

Review of Literature

This curriculum on the flower and simple and compound machines was developed to fill the gap between what our local curriculum offers and what the state department suggests that we teach.

This curriculum was designed with three imperatives in mind: "those that come from science as a discipline, those that reflect society's needs, and those that reveal how children develop and grow" (Gega, 1986, p. 4). The science imperatives are the product, the learning of key concepts and generalizations, and the process skills, observing, classifying, communicating, measuring, inferring and experimenting. Society's imperative is to link the concepts and generalizations to technological applications so sixth graders can see everyday devices as understandable and interesting. The childhood imperative is to try to bring a suitable match between the sixth grade pupils of varying abilities and characteristics and the curriculum (Gega, 1986).

Many activities for providing experience in the process skills have been included. They are in ample number so that the classroom teacher can pick and choose activities that will fit his/her particular classroom situation and materials available. These activities are designed to be carried out individually or in a small group at learning stations. This will allow practice in thinking critically and creatively and problem solving.

Curriculum Development

In reviewing literature on what should go into a curriculum the author found varying views. The author agrees with Victor (1985) when he says there should be the following six broad goals for a sixth grade science curriculum:

1. Sixth graders should be helped to become scientifically literate and personally concerned citizens. When the child is a scientifically literate person he will have an understanding of the concepts, conceptual schemes, skills, attitudes, and values of science, and he will use them in making decisions as he interacts with other persons and with his environment.

2. Sixth graders should be taught to solve problems by thinking critically and creatively. They need to learn the same techniques and skills that scientists use to solve problems. This will enable them to develop the ability to think more critically, more abstractly, and

more creatively.

Children have inquiring minds. It will encourage them to look for the cause and effect of things that are happening to them. It will encourage real learning. It will sharpen their natural curiosity and enthusiasm.

3. The science curriculum should help the sixth grader to learn science concepts and conceptual schemes that will enable them to understand and interpret their environment.

Time should be provided so that there is an opportunity to reinforce the children's understanding of the concepts and their relationships.

The sixth grade science curriculum should be concerned with getting the children to learn both the nature of our environmental problems and the ways that are available for controlling these problems.

4. The sixth grade science curriculum should take into consideration the impact of science and technology on society. It [illegible] so that it not only includes the learning of science concepts and skills but also develop an awareness and understanding of the social and economic [illegible] ence and technology and [illegible] them.

5. The [illegible] children understand that [illegible] will change as more

evidence accumulates. It should play a role in helping children learn to expect and adjust to societal change. It should help them understand that change is an inevitable part of their lives.

6. The science curriculum should provide for the individual growth of children. It should offer a wide range of learning activities for children, making it possible for the school to provide for varied abilities, interests, and needs that children have. It should provide challenging experiences, stimulate children's interest, and sharpen their competencies, thus providing a basic foundation for future study in science.

Victor (1985) believes that the objectives of sixth grade science serves as a guide to decide which learning activities will be used and which skills need to be developed. They can be used as criteria for developing methods of evaluation.

Victor (1985) says that objectives of elementary science are to be used to help children learn science concepts and conceptual schemes--the content. They are to be used to help children become familiar with the key operations of science and the scientist--the process of science.

Wolfinger (1984) also feels that both content and processes should be used at the sixth grade level. The content should be the unifying theme with the processes of experimentation being used to generate information dealing with the content topic.

Victor (1985) believes that sixth grade science curriculum objectives should be geared to develop scientific skills, attitudes, appreciations and interests. The objectives should help sixth graders to grow in scientific literacy, become proficient in problem solving and critical and creative thinking. It should help them understand the differences and relationships between science and technology and the impact of these upon society.

Victor (1985) thinks that for sixth graders the content of a curriculum should include facts as well as major concepts. Facts are needed to understand concepts. Science content should be all-inclusive and interrelated so children will be better able to understand the nature of the universe.

It is the school's responsibility to provide the student with a conceptual framework that permits him to perceive phenomena in a meaningful way. This will help him to integrate his inferences into generalizations of greater value (Karplus & Thier, 1967).

According to Brunner the sixth grader is ready for concepts in the curriculum. He believes that a student is always ready to learn a concept in some form or manner. He says that any subject can be taught in some form to any child at any stage of development. He believes that the basic ideas of science are simple and that only when placed in complex statements is the student unable to comprehend them. He learns then in whatever stage of intellectual development he is in at the time. The teacher can help the student progress from one stage of intellectual development to the other by providing challenging opportunities and problems that tempt the student to go ahead into the next stage of development. This enables him to develop a deeper understanding of science and concepts and conceptual schemes. The science curriculum should be developed around conceptual schemes, skills, and values that society considers to be of vital importance and as early as possible consistent with the students stages of development and forms of thought (Victor, 1985).

The National Science Teachers Association (NSTA, 1964) committee believes that the conceptual schemes and the inquiry processes provide the necessary framework for curriculum design and for developing courses of study at each grade level. Criteria for selecting curriculum material should be consistent with the purposes of teaching science and the structure of science. Knowledge must be familiar to the student and useful in advancing his understanding of science. The content should serve the future as well as the present. All fields of science have a basis in experimental and investigative processes. There should be connections between the sciences themselves and between the sciences and other subjects.

According to NSTA (1964) curriculum material should require the student to continually reorganize, synthesize and use his knowledge. It should have unity resulting from a coherent structure and continuity. The curriculum needs to provide for increasingly complex inquiry skills and growth in the meaning of significant concepts.

Besides physiological maturation Karplus & Thier (1967) believe that active physical and mental exploration of reality and social interactions with parents, teachers, and peers are two other significant influencing factors that affect a sixth grade curriculum. The teacher needs to be aware to advocate mental flexibility and independence and to provide experiences that nourish the pupils intellectual development of common sense rationality.

A main objective of the sixth grade curriculum should be to provide a diversified program based on concrete experiences. It needs to be presented in a context that helps to build a conceptual framework for operations with abstractions. The student needs a conceptual structure and a means of communication that will enable him to interpret information provided by others and to benefit from reading textbooks and other references as though he had obtained it himself. Karplus and Thier (1967) calls this functional understanding of scientific concepts, scientific literacy.

Even though all students will not become scientists, their curriculum should give sufficient knowledge and experience for them to understand the scientific work being carried out by others. Many aspects of the natural environment are taken for granted and never questioned. To obtain scientific literacy the curriculum needs to provide the student with experiences that are different from his usual ones. He needs to become acquainted with instruments or devices that extend the range of the senses. It needs to make him aware of unusual environmental conditions. The student needs observations of living organisms not pictures. The experiences should be real ones not ones read in a book or told by the teacher. The experiences need necessary guidance and discussion. An effort should be made to relate the unusual experience to the usual experience.

A link should be formed between his earlier experiences and later experiences so the student can bring his knowledge to bear in a systematic way, reducing the gulf between scientific thinking and common sense thinking (Karplus & Thier, 1967).

Importance of Sixth Grade Science

Because of a sixth graders particular characteristics and stage of development he is ready for continued discovery and inquiry into varied areas of science.

Jean Piaget calls the seven to eleven years the concrete operations stage. The sixth grade student can now perform logical operations. He can observe, judge, evaluate and formulate more objective explanations. This enables him to solve physical problems. He is limited to problems dealing with actual concrete experiments. The student can center his thinking on two or more properties or aspects of an object at one time. He is able to understand multiple relationships and can combine parts into a whole. He is acquiring good motor skills and can manipulate objects. The sixth grader can make multiple classifications, arrange objects in a long series, and place new objects in their proper place in the series. The student is beginning to understand geographical space and historical time

(Victor, 1985).

Karplus and Thier (1967) believe that continued intellectual stimulation during the sixth grade is very important in determining the future achievement of that student.

Science consists of concepts and their relationships that man has obtained from his environment over the years. Sixth grade students are engaged in this kind of abstracting process in their own natural environment. They accumulate experiences as their thinking goes through a gradual transition from the concrete to the abstract (Karplus & Thier, 1967).

According to Wolfinger (1984) abstract thought begins to develop among some eleven and twelve year olds. This means the sixth grader has an ability to learn more from written materials which can help them determine how to plan for an experiment and find missing theoretical information that will allow understanding of experimental results. There is a greater need for a variety of textbooks, tradebooks, magazines, and films or film strips.

Piaget feels that a student's intellectual capacity passes through a number of qualitative contrasting stages before adulthood. Therefore a sixth grade student's interaction with his environment plays a significant role in his changing from one stage to the next (Karplus & Thier, 1967).

Piaget calls the eleven to fifteen years of age the formal operations stage. Therefore, a sixth graders thinking is beginning to change from being concrete to being more formal and abstract. He is now able to relate one abstraction to another and is growing in his ability to think conceptually. He can develop hypotheses with controlled experiments in which all the variables are identical except the one to be tested. When approaching a new problem, the student begins by stating all the possibilities and then determining which ones are verified through experimentation and consistent analysis. After he has solved the problem, he can reflect upon or rethink the thought processes he used (Victor, 1985).

Robert M. Gagné believes that learning is becoming capable of doing something that the student was not capable of doing before. Learning a capability depends upon having already learned one or more simpler capabilities (Victor, 1985).

According to Victor (1985) Gagné emphasizes the product of learning whether it is by discovery, review or practice. Bruner exphasizes the process of learning, learning by the discovery method.

Gagné says problem solving is the highest level of learning. A child must learn the levels in order. Bruner says a child should start with problem solving by discovery which will lead to the development of necessary skills (Victor, 1985).

Piaget, Bruner, and Gagné differ in their attitude about the child's readiness to learn. Piaget feels that readiness depends upon a child's maturation and intellectual development. Bruner thinks that a child is always ready to learn a concept in some form or manner. However, Gagné believes that a child's readiness is related to the development of subskills and subconcepts rather than to the child himself (Victor, 1985).

Bruner, Piaget, and Gagné all feel that elementary science should be taught and learned as a process of inquiry. This would give the student the opportunity to carry out inductive thinking, make hypotheses, and test the hypotheses in the laboratory, classroom, and individual study. Gagné believes, however, that the child must have a broad science background and be able to discriminate between a probable successful course of action and an unsuccessful one (Victor, 1985).

Gagné believes the child should go through four levels of science instruction. The second level should begin in the sixth or seventh grade. At this level the child should be provided with the opportunity to acquire a broad background of knowledge in all science areas. He should be given the opportunity to participate in activities that use, in a wide variety of contexts, the skills he has learned at the first level (Victor, 1985).

All three of these theories can help serve as guidelines in developing a sixth grade science curriculum. The child's readiness must keep up with, and continue within the framework of, Piaget's and Bruner's stages of intellectual development. If, according to Bruner's belief, a child is always ready for a concept in some form or manner, then the teacher needs to be sure to bring the concept down to the child's level of understanding. In keeping with Gagné's belief the teacher needs to make certain that the child has mastered the necessary subconcepts and subskills before the child can be ready for learning any higher level concepts and skills (Victor, 1985).

Wolfinger (1984) describes eleven and twelve year olds as awkward, restless, lazy, changeable, overly critical, rebellious, uncooperative, self-conscious, independent, and curious. This makes them a very challenging and interesting age group to teach.

Peer pressure becomes highly valued. It can cause a negative effect when the student goes along with the group instead of standing on his own two feet (Wolfinger, 1984).

Their curiosity is high. Curiosity is highly correlated with self-exteem. They're more self-reliant, less prejudiced, more socially responsible and have a greater sense of belonging (Wolfinger, 1984).

According to Victor (1985) the sixth grade student is curious about things in every field of science. He is more interested in things that move, objects that make things happen, and things that seem mysterious and magical. Everything is important to the student if it relates to him. He tends to interpret the environment in light of how it affects him. The student is very energetic and loves to investigate.

Wolfinger (1984) believes the preadolescent is making a change from thought stimulated by concrete objects to thought using abstractions permitting the student to think and learn in an adult manner. He has a need for independence, increased responsibility, treatment as an adult, and freedom from being criticized for acting like a child. His independence and responsibility needs to develop among affectionate and humorous adults without nagging.

According to Gega (1986, p. 29) "how effectively we teach science to children is linked to our understanding of children's characteristics, including how they learn."

Techniques or Activities

Inquiry or Discovery Approach

Victor (1985) believes that the sixth grade curriculum should use an inquiry and discovery approach so the student will learn and not just memorize. This approach lends itself to open-ended experimentation.

NSTA (1964) indicates that it is necessary for the teacher to teach the inquiry process of science which will give the learner the necessary tools for independent learning. Inquiry experience enables the child to place objects and events in categories or classes and discover the utility of coding systems. The student will acquire a conceptual framework that will allow him to focus his attention on other phenomena and to build new categories that are more comprehensive or more abstract. The conceptual structure will fasten past experiences to the present. It is a guide for understanding and assimilating new facts and concepts. It is a basis for predicting what will happen in a new problem or situation.

The committee reports that facts which have meaning for the learner need to be tied into a logically related conceptual pattern, insuring improvement in retention and insight is more likely to occur. This understanding of conceptual structure and training in inquiry will help the student to select what is pertinent in a new situation. The student needs to learn a pattern of delaying responses and tolerating uncertainty until enough data has been collected and alternative hypotheses have been evaluated. The teacher should develop a range of inquiry skills within the structure of a discipline which will permit not only problem solving but the students ability to increase his own efficiency in knowing (NSTA, 1964).

Victor (1985) states that the vital objective is learning the key operations of science and the scientist. This gives students insight and practice in the different methods that scientists use to solve problems. They will learn effective ways of working and develop experience in thinking critically and creatively. This helps them to develop necessary scientific behaviors. Textbook series and curriculum projects are concerned with the teaching of science as a process of inquiry and discovery.

Brunner feels science should be taught in a manner that allows the student to discover concepts for himself. He believes this will result, first, in an increase in intellectual potency. That the student will learn how to learn, how to solve problems, develop inquiry skills, arrange and apply what he has learned to new situations, and therefore learn new concepts. Second, discovery learning will change motives for learning away from satisfying others to that of internal self-rewarding satisfaction. Third, he has the opportunity to learn methods on how to find out things for himself. Fourth, knowledge gained from discovery learning is more easily remembered and more easily recalled when needed (Victor, 1985).

In a sixth grade science curriculum the concepts to be learned, the problems to be solved, and the skills to be developed should be arranged in a sequence that proceeds from the very simple to the most complex (Victor, 1985).

The objectives of the learning activities should be stated clearly in terms of desired behavioral outcomes. Discovery learning gives a child the opportunity to learn on his own through activity and direct experience with science materials. Discovery learning should not be the only teaching strategy used. The teacher needs to use the appropriate strategy to accomplish the learning of the concept being taught. In free discovery the child is given the opportunity to explore at will, pace himself, and make his own decisions in what to do. He uses the teacher as a resource person. In guided discovery the teacher takes on a more controlling role by helping the child make the right decision and by supplying necessary information at the right time (Victor, 1985).

Victor (1985) believes that since the basis of concept formation is through perceptual encounters, emphasis should be placed on hands-on learning involving the use of a large variety of materials. Giving a child the opportunity to explore and find out things for himself seems to have a built-in motivation for him.

Victor (1985) feels that internal rewards of interest and selfaccomplishment instead of external rewards, such as pleasing parents or teachers, helps the child's learning to be much more efficient. The teacher should arrange the learning situations to permit social interaction among the students. This will provide an opportunity for learning from each other. The student will have the opportunity to become familiar with the views and ideas of other children.

Laboratory and field work should be the center of teaching science. While working in the laboratory the student can relate concepts, theories, experiments and observations to the process of science experimenting and problem solving. The laboratory gives the student a chance to explore his ideas, test his theories and ask necessary questions. It gives him the opportunity to apply rational thinking to his observations, data, and facts (NSTA, 1964).

A variety of dimensional experiences using scientific inquiry should be provided for the student in the laboratory. Gathering data is only the preliminary step to understanding science. The student needs to be allowed to formulate statements based on data and to test them against theory. It is then the interpretation of that data that generates new questions, suggests further inquiry, helps solve problems and leads to refinement of his theories (NSTA, 1964).

The NSTA (1964) committee thinks that laboratory work is a means of relating the science concepts, inquiry processes, observations, and experiments. It is necessary to have proper sequencing of experiments and data to make it possible for the pupil to use earlier learning to solve the upcoming increasingly complex problems.

Since the preadolescent can be responsible and irresponsible, mature and immature, independent and dependent, cooperative and uncooperative the science program needs to be open and accepting with discussions demonstrating a wide variety of opinions and activities leading the child toward more adult modes of thought

(Wolfinger, 1984).

Wolfinger (1984) suggests that since preadolescents have such a wide range of interests and maturity levels greater individualization of content and activity is needed. They need to be allowed to develop as individuals and to pursue topics of interest while the teacher provides advice and assistance.

Since peer pressure to conform is so strong attention during science should be given to collecting factual data, drawing conclusions and supporting one's conclusions with factual data. Discussion not concerned with hard data from experiments or reading matter should allow a variety of opinions without any final absolute decision possible. The student needs to know that it is normal and natural to have a variety of opinions on science-related topics. The students need to listen to one another with respect and wait to present their opposing data and opinions (Wolfinger, 1984).

Related Research

Kyle, Bonnstetter, McCloskey & Fults (1985) set up a study to assess the effectiveness of the *Science Curriculum Improvement Study* by comparing the attitudes toward science of SCIS students and teachers with those of students and teachers in non-SCIS classes. They surveyed 109 teachers, grades K-6, and 456 students, grades 2-6. The data gathered overwhelmingly supported students' preference for science that emphasized inquiry and process. Research showed that SCIS teachers spent more time teaching science and that they preferred the SCIS program to material previously used.

Shymansky, Kyle, and Alport's "research (cited in Kyle, Bonnstetter, McCloskey, & Fults, 1985, p. 41) also shows that students exposed to inquiry oriented, process-approach science perform better on measures of general science achievement, process skills, analytic skills, and related skills such as language arts and mathematics."

Rodriquez and Bethel (1983) set up a study for the purpose of determining the effectiveness of an inquiry approach to science and language classification and oral communication skills. They used third-grade Mexican American children that were enrolled in a bilingual education program. They emphasized classification and oral communication skills through the manipulation of concrete objects, exploration, and interaction. Improvement over the control group was found in both the classification and oral communication skills of the bilingual students.

This study by Shymansky, Kyle, & Alport, (1983) summarizes the effects of new science curricula associated with process objectives where learning how to learn science was stressed, versus the traditional methods stressing facts, laws, theories and some application, on student performance. They used 105 experimental studies involving more than 45,000 students. The results of the meta-analysis revealed definite positive patterns of student performance with the new science curricula. They out performed students in traditional courses in general achievement, analytic skills, process skills, and related skills such as reading, mathematics, social studies, and communication. They also developed a more positive attitude toward science.

In another experimental study a meta-analysis was done on the effects of various science teaching strategies on achievement. Focusing and Questioning had a relatively high effect size. Wait-Time Strategies had the largest impact but they also accounted for the fewest number of studies reviewed. The effective science classroom appeared to be the one in which students were kept aware of instructional objectives and given feedback on their progress toward the objectives. The students got opportunities to physically interact with the instructional materials and engage in varied kinds of activities. It reflects considerable teacher planning but students have some responsibility for defining tasks. They manipulate materials and plan activities (Wise & Okey, 1983).

Three activity-based elementary science programs, the Elementary Science Study (ESS), Science - A Process Approach (SAPA), and the Science Curriculum Improvement Study (SCIS), were selected to research the effects of the activity based programs on student outcomes. Research indicated "that the more activity-process-based approaches to teaching science result in gains over traditional methods in a wide range of student outcome areas at all grade levels" (Bredderman, 1983, p. 513).

The major objective of Kyle, Bonnstetter, and Gadsden's (1988) study was to compare Science Curriculum Improvement Study (SCIS) student and teacher attitudes toward science to those of students and teachers in non-SCIS classes. The data overwhelmingly supported the fact that students in the inquiry-oriented, process-approach science classes had greatly enhanced attitudes toward science and scientists when compared to the students in the textbook-oriented science classes.

Padillo, OKey, and Dillashaw (1981) set up a study to examine the integrated process skills and formal thinking abilities of middle and high school students who had not undergone any special training on science process skills and determine the relationship between the two. The process skill achievement data showed that older students scored higher than younger students (as expected) except for slightly lower scores for grade eight students. The logical thinking data also showed progressively higher scores for older students. The study showed a definite "relationship between the process skill and logical thinking abilities" (p. 7). There was "evidence of a substantial relationship between a student's ability to use science process skills and to think logically" (p. 7).

According to Padilla et al. (1981, p. 4) "Tobin and Capie found a significant inter-correlation (r=.60) between formal reasoning ability and process skill achievement among middle school students."

Learning Centers

Since a class of around 30 students contains a wide range of abilities and interests some teachers compliment whole class science instruction with individual or small group activities. Since different children learn in several ways and through varying interests, providing choices can boost morale and build lifelong interests.

Individualized activities can be used to cultivate an open form of inquiry and independent learning (Gega, 1986).

Learning stations are used in this curriculum to help the teacher to organize instruction so that children can learn on their own and at their own pace. All learning stations are self-directing, promote independent learning, and help meet the individual strengths and needs of all the students in a class (Jacobson & Bergman, 1980).

They provide opportunities for "hands-on" experiences. They provide individualized instruction for the slow or fast learner and handicapped children. They provide opportunities for creative experiences as pupils work by themselves or in small groups (Blough & Schwartz, 1984).

The stations are set up for the purpose of permitting individual or small groups of students to work independently. They are a combination of structure with open-ended questions. They are used as an integral part of a developed content program (Esler, 1977).

They are set up as what Esler (1977) calls an inquiry learning center where the teacher organizes the material and spends a designated time introducing the lesson, and after a period of time when all the children have had a chance to do the science activities, another period of time is spent discussing the results. They are designed for the student to achieve the desired learning objective and to complete the work independently.

Regulations and Guidelines

The Core Competencies and Key Skills (1986) were written by representatives from the public schools of Missouri. It focuses on curriculum and the identification of key skills called for in the Excellence in Education Act. The Core Curriculum Competencies and Key Skills are listed in terms of learner outcomes. This is a list of skills and knowledge considered essential to further learning in each of the subject areas.

"The Excellence in Education Act (Core Competencies and Key Skills, 1986) states that the key skills identified by the Department of Elementary and Secondary Education are to be included in the local school district testing program and these test results are to identify areas for instructional improvement" (p. v). Thus, providing "an opportunity for school districts to align their objectives, teaching activities and testing to a much greater extent" (p. v). "A major purpose for this publication is to provide teachers with ideas to improve curriculum allignment and, as a result, improve learner competence" (p. 7). The key skills are to "serve as a framework of interrelated and interdependent skills permeating the entire curriculum" (p. v).

The _Educational Goals for the State of Missouri_ state that the science educational goal for Missouri is for each individual student to have the opportunity to develop proficiency in, and a positive attitude toward: life sciences, earth sciences, and physical sciences. Therefore extending his intellectual development to include scientific understanding.

The Missouri Department of Elementary and Secondary Education published _Educational Objectives for the State of Missouri_ in 1974. This publication was written "to assist the local school district in establishing or reviewing educational objectives for instruction within the local school district."

One of the long-range educational goals stated was intellectual development. One subgoal under this was scientific understanding. Some of the objectives for scientific understanding were: a) "appreciate the importance of individual initiative, curiosity, enthusiasm and creativity in inquiry." b) "understand and apply skills of observing, classifying, and measuring." c) "understand and apply skills of collecting, organizing, computing, interpreting, and communicating information." d) "understand and apply skills of hypothesizing, predicting, and inferring."

The author's school district regulations and guidelines in science are based on the objectives in the basal series chosen by the teachers and purchased for grades K-6.

Curriculums

Teaching situations vary from district to district. Some districts have programs with teacher manuals and kit materials. Some curriculum guides contain resource units accompanied by many instructional aids. But most guides are used mainly to supplement an adopted textbook series using locally available teaching resources. The great majority of schools use a chosen textbook series for science. Some of the editions offer a wealth of teaching aids. However, any series can be improved by adding local resources, integrating science with other school subjects and making some of the activities open-ended. The children should be able to apply their knowledge and processes within a context of appropriate attitudes (Gega, 1986).

There were three major elementary school science programs that emerged as a result of public concern in the 1960's: Science - A Process Approach (SAPA), the Science Curriculum Improvement Study (SCIS), and the Elementary Science Study (ESS). These are nationally known, compreshnsive science programs (Gega, 1986).

Science - A Process Approach uses the process skills as a base for their scope and sequence. They select subject matter mainly to aid in developing the process skills. Gagné feels that when a student is systematically taught skills, he learns to cope better with the subject matter. Therefore, if he is taught science processes in an organized way he will achieve improved results. In K-3 eight "basic" processes are taught: observing, using space/time relationships, using numbers, measuring, classifying, communicating, predicting, and inferring. Five "integrated" processes are taught in grades four through six: formulating hypotheses, controlling variables, interpreting data, defining operationally, and experimenting. SAPA II, a newer version, has a more flexible structure.

In the Elementary Science Study attention is given to discovering ways to test questions that arise as the student manipulates materials instead of using problem-solving for the specific purpose of learning subject-matter principles. The instructional units stand alone. They use no scope and sequence. Each unit has a teacher's manual and most contain an accompanying kit of materials. Many units are designed to arouse curiosity in the child and to teach skills and basic concepts. Most of the classroom procedures are open-ended and exploratory.

Science Curriculum Improvement Study bases the overall organization of their program on concepts. Science processes and scientific attitudes are integrated into the learning activities and learned with the concepts.

Although the use of these three programs has decreased, the unique rationales and basic approaches offer excellent sources of ideas for science instruction. Many districts have kept some parts to supplement their textbook programs. "The weight of tradition, the programs' high cost, extensive in-service requirements, the back-to-basics movement, and other factors combined to keep their adoptions down." They "have strongly influenced many science text and curriculum writers," consequently "upgrading the quality of what has been produced" (Gega, 1986, p. 116).

Ausubel feels that "effective discovery or problem-solving is more likely to occur with children who have learned main subject-matter concepts and generalizations within major areas of science." He "believes that children can learn when their teachers and textbooks present subject matter to them in organized and meaningful ways." He believes in emphasizing subject-matter content rather than thinking skills or processes (Gega, 1986, p. 28).

"Textbook programs are generally consistent with Ausubel's ideas. They contain much well-organized verbal material and a variety of aids, activities, and familiar examples to help make the material meaningful" (Gega, 1986, p. 28).

After reviewing over twenty-five textbook series and as many curriculum guides the author found only about five textbook guides containing units on simple and compound machines on the sixth grade level and only two curriculum guides with very little coverage on the subject. The same held true for flowers and their functions. Since most series cover areas of life, earth, and physical science at various levels from kindergarten through sixth grade, each series presented different topics at different grade levels. Some series presented simple and compound machines and parts of flowers and their functions at fourth grade level, some at fifth, and some at sixth.

Considering the research that was reviewed and the curriculum guides and textbook programs that were studied, this researcher feels as others do, that "there are three kinds and sources of imperatives in science teaching: those that come from science as a discipline, those that reflect society's needs, and those that reveal how children develop and grow" (Gega, 1986, p. 4). "Understanding these imperatives enables us to judge what is relatively enduring, usable, and learnable. Effective teaching fosters whole learning in children--the attitudes, ways of thinking, and integrated knowledge base that transfer successfully into the real world" (Gega, 1986, p. 29).

Many researchers feel the science program should be a balanced presentation of scientific ways of thinking and subject matter. The science program should have a definite purpose and a definite place in the sixth grade curriculum. The curriculum should help the student extend his intellectual development to include scientific understanding.

CHAPTER III

Methods

This curriculum was developed to help fill the void between the content areas of the Wentzville R-IV School District's sixth grade curriculum and the content and concepts suggested by the Core Competencies and Key Skills for Missouri Schools.

The present sixth grade curriculum does not have units on flower parts and their functions or simple and compound machines. The other representative curriculums reviewed by the author contained few if any "hands-on" activities related to the above topics set up for individual or small group involvement.

Since most researchers and the developers of the objectives for the Missouri State Board of Education feel that the concepts and content of these topics and the teaching of process skills are necessary at the sixth grade level, this author felt it necessary and appropriate to develop activities in these content areas.

Victor (1985) feels that sixth grade children should learn the same techniques and skills that scientists use to solve problems so they will be able to think more critically, abstractly, and creatively. This author feels, as cited in research, that the sixth grade science program should focus on the science processes being used through the inquiry and discovery methods. Thus the goals and objectives for this curriculum were chosen to help develop these concepts.

This curriculum, therefore, has been developed to prepare our children for tomorrow by integrating the process skills of observing, measuring, communicating, inferring, interpreting data, generalizing, predicting, controlling variables, defining operationally, experimenting, describing, comparing, classifying, and hypothesizing into the already existing content areas.

The activities in this curriculum deal with the content areas of simple and compound machines, and flower parts and their functions. They are set up for individual or small group participation. The process approach has been integrated into the content to bring about a more scientifically well-rounded individual.

The process skills of science have been defined in varying ways. According to Esler (1973) "the most widely accepted definitions are those given by The Commission on Science Education of the American Association for the Advancement of Science" (p. 58). The process skills are grouped into eight primary processes and five integrated processes. "The primary processes are generally introduced in K-3, while the integrated processes are developed by exercises designed for grades 4-6" (p. 58). The primary processes are: observing, classifying, measuring, communicating, inferring, predicting, recognizing space-time relationships, and recognizing number relations. The integrated processes are: formulating hypotheses, making operational definitions, controlling and manipulating variables, experimenting, and interpreting data. These integrated processes can be viewed as combinations of the primary processes. These integrated process skills are the skills used in the units in this curriculum since it is designed for sixth grade students. These integrated processes are employed through the many activities developed in this sixth grade curriculum. They are used to generate information needed in dealing with the concepts and concept schemes. The activities have been organized by unit of study. They are presented with introductory types first and graduate to more thought provoking activities that require more student involvement and a variety of science processes.

The long range goals were taken from the already existing state objectives, Science Objectives for Missouri Students, K-6, 1984, because they reflect what researchers consider to be important components of a sixth grade science curriculum. They are supported by the following sources as cited in Chapter II:

I. Gega, 1986; Victor, 1985; Karplus and Thier, 1967

II. Victor, 1985; Wolfinger, 1984; Karplus and Thier, 1967

III. Gega, 1986; Victor, 1985; Wolfinger, 1984; NSTA, 1964; Karplus and Thier, 1967

IV. Gega, 1986; Victor, 1985; NSTA, 1964

V. Victor, 1985; NSTA, 1964; Karplus and Thier, 1967; Wolfinger, 1984

VI. Victor, 1985; NSTA, 1964

VII. Victor, 1985; Karplus and Thier, 1967; NSTA, 1964

VIII. Victor, 1985; NSTA, 1964; Wolfinger, 1984

The intermediate range objectives were developed by the author from the summary of the definitions of each science process skill as noted in chapter 1. The summary of definitions was developed from Carin and Sund, 1989 and Gega, 1977 and 1986. The objectives are supported by the following sources in chapter 2: Science Objectives for Missouri Students, K-6, 1984; Victor, 1985; Wolfinger, 1984; Karplus and Thier, 1967; and NSTA, 1964.

Sources from which material, activities, and ideas for activities were developed for simple and compound machines include:

Activity 1:
Concepts in Science, 1975, numbers 1, 2, 3(a, b, c)
Gateways to Science, 1983, numbers 2, 3(a-g), 5

Activity 2:
Concepts in Science, 1975, numbers 1-4, 6
Gateways to Science, 1983, number 5
HBJ Science, 1985, numbers 1-4

Test on Inclined Planes:
Concepts in Science, 1975, numbers I(A), II-III
Concepts and Challenges in Physical Science, 1986, number I(b)
Physics Workshop I, 1988, number IV(a-e)

Activity 3:
Concepts in Science, 1975, numbers 1-3, 5-6
Gateways to Science, 1983, numbers 1-4

Activity 4:
Concepts in Science, 1975, numbers 1-5, 7
HBJ Science, 1985, numbers 1-6

Activity 5:
Concepts in Science, 1975, numbers 1-4
Addison-Wesley Science, 1984, number 1(a-e)

Activity 6:
Concepts in Science, 1975, numbers 6-7
Gateways to Science, 1983, numbers 1-7

Activity 7:
Concepts in Science, 1975, numbers 1, 4-7, 9
Addison-Wesley Science, 1984, numbers 1, 4-6

Activity 8:
Concepts in Science, 1975, material, author developed activity

Test on Levers:
Concepts in Science, 1975, numbers A(1-6), B(1-4)
Gateways to Science, 1983, numbers A(1-3), E, D(2-3)
Concepts and Challenges in Physical Science, 1986, numbers B(5), D(1, 5)

Activity 9:
  Concepts in Science, 1975, numbers 1-4
  Gateways to Science, 1983, number 4(e, g)
  Physics Workshop I, 1988, number 4(g)
  HBJ Science, 1985, numbers 1-3, 4(a-f)

Activity 10:
  Concepts in Science, 1975, material, author developed activity

Activity 11:
  Concepts in Science, 1975, material, author developed activity

Activity 12:
  Concepts in Science, 1975, material, author developed activity

Test on Pulleys:
  Concepts in Science, 1975, numbers A(1), B(1-5)
  Concepts and Challenges in Physical Science, 1986, numbers A(1-4), C(2-4)

Activity 13:
  Concepts in Science, 1975, numbers 1-8

Activity 14:
  Concepts in Science, 1975, material, author developed activity

Activity 15:
  Concepts in Science, 1975, numbers 1(a-h, j), 2(a-d), 3-6
  Gateways to Science, 1983, number 2(a-d)
  Physics Workshop I, 1988, number 1(a-e)
  HBJ Science, 1985, number 1(a-e)

Test on Screws:
  Concepts in Science, 1975, numbers A(1-9, 11), B(1-4)
  Gateways to Science, 1983, number A(7)
  Physics Workshop I, 1988, number B(7-10)

Activity 16:
  Concepts in Science, 1975, numbers 1, 2(a, d-e), 3(a-d)
  Physics Workshop I, 1988, number 2(e, b)
  HBJ Science, 1985, numbers 1(a-g), 2(a-d)

Test on Wedges:
Concepts in Science, 1975, numbers A(1-2, 6), D
Physics Workshop I, 1988, numbers A(3-5), B(1-4), C(1-4)

Activity 17:
Concepts in Science , 1975, numbers 1(a-b), 2(a-d), 3(f)
HBJ Science, 1985, numbers 3(a-f), 4(a-c), 5

Activity 18:
Concepts in Science, 1975, numbers 1(a-g), 2(a-b), 3

Test on Wheel and Axle:
Concepts in Science, 1975, number A(2)
Gateways to Science, 1983, numbers A(1-2), C(1-2, 4)

Activity 19:
Concepts in Science, 1975, numbers 1(a-c), 2(a-b), 3(a-b), 7(a-c), 8(a-b)
HBJ Science, 1985, numbers 1(a), 2(a), 3(a-b), 4, 5

Activity 20:
Concepts in Science, 1975, numbers 1-6

Activity 21:
Concepts in Science, 1975, numbers 1(a-c), 2(a-c)

Activity 22:
Concepts in Science, 1975, numbers 1(a-c, e), 2(a-b, d-e)

Activity 23:
Concepts in Science, 1975, numbers 1(a-b, d-f), 2(a-b, d)

Test on Friction:
Concepts in Science, 1975, numbers A(1-5, 7), B(1-2)
HBJ Science, 1985, numbers A(6, 8-19), B(3-6)

Activity 24:
Concepts in Science, 1975, numbers 1-16, 18-19
HBJ Science, 1985, numbers 9-13, 16, 18-19

Gateways to Science, 1983, numbers 9-13

Test on Work:
Concepts in Science, 1975, numbers A(1-4), B(1-2, 4-6), C
HBJ Science, 1985, numbers A(5-7), B(3)
Concepts and Challenges in Physical Science, 1986, number A(8)

Activity 25:
Concepts in Science, 1975

Test on Compound Machines:
Concepts in Science, 1975

Sources from which material was obtained and activities and ideas for activities were developed for flower parts and their functions came from the following sources:

Guide:
Biology Workshop-3, 1983
Addison-Wesley Science, 1984
Heath Science, 1984

Worksheet 1:
Biology Workshop-3, 1983
Pathways in Science, 1975
The Continuation of Life, 1975
HBJ Science, 1985
Heath Science, 1984

Worksheet 2:
Biology Workshop-3, 1983

Activity 1:
Biology Workshop-3, 1983
Addison-Wesley Science, 1984
Pathways in Science, 1975
The Continuation of Life, 1975
HBJ Science, 1985
Heath Science, 1984

Activity 2:
Biology Workshop-3, 1983
Addison-Wesley Science, 1984

Activity 3:

Biology Workshop-3, 1983
Addison-Wesley Science, 1984
Pathways in Science, 1975
The Continuation of Life, 1975
HBJ Science, 1985
Heath Science, 1984

Activity 4:

Biology Workshop-3, 1983
Addison-Wesley Science, 1984
Pathways in Science, 1975
The Continuation of Life, 1975
HBJ Science, 1985
Heath Science, 1984

Activity 5:

Pathways in Science, 1975
Heath Science, 1984

Activity 6:

Biology Workshop-3, 1983
Addison-Wesley Science, 1984
Pathways in Science, 1975
The Continuation of Life, 1975
HBJ Science, 1985
Heath Science, 1984

Activity 7:

Biology Workshop-3, 1983
Addison-Wesley Science, 1984
Pathways in Science, 1975
The Continuation of Life, 1975
HBJ Science, 1985
Heath Science, 1984

Test on Flower Parts and Their Functions:

Biology Workshop-3, 1983
Addison-Wesley Science, 1984
Pathways in Science, 1975
The Continuation of Life, 1975
HBJ Science, 1984
Heath Science, 1984

Long Range Goals

The student will:

I. appreciate the impact of science and technology in societies.

II. understand that progress in science is a result of cooperative effort.

III. appreciate the importance of individual initiative, curiosity, enthusiasm and creativity in inquiry.

IV. understand and apply skills of observing, classifying, and measuring.

V. understand and apply skills of collecting, organizing, interpreting, and communicating information.

VI. understand and apply skills of hypothesizing, predicting, and inferring.

VII. understand and apply skills in the use of models as powerful tools in explaining phenomena.

VIII. understand and apply skills of identifying and controlling variables.

Intermediate Range Objectives

The student will:

A. use his senses to observe and identify properties, changes, or similarities and differences of an object or event. LRG I, II, III, IV, V, VII.

B. use standards of measurement to make observations, drawings or models, or samplings and estimations. LRG III, IV, V, VII.

C. communicate by defining through actions, describing objects or events, making charts and graphs, recording data, constructing exhibits and models, or drawing diagrams and pictures. LRG II, III, IV, V, VII.

D. infer a conclusion based on reasoning to distinguish between an observation and an inference, interpret recorded data, interpret data received indirectly, or predict events, hypothesize, or draw conclusions from data. LRG I, II, III, IV, V, VI.

E. interpret relationships in data in order to draw conclusions from it. LRG II, III, V, VI.

F. generalize a conclusion based on particular evidence acquired. LRG V, VI.

G. predict from data of future events or conditions that are expected to exist. LRG I, V, VI.

H. find out what makes a difference in an experiemnt by changing or varying that condition alone while other conditions remain constant or controlled. LRG III, IV, VII.

I. be able to experiment by stating a hypothesis or operational question to test, or design a procedure in which variables are controlled. LRG II, V, VI, VIII.

J. describe categories of objects, or object or event properties that are relevant to the situation. LRG V.

K. compare similarities and differences between objects and events. LRG IV, V.

L. classify objects, events, or information representing objects or events in classes accorging to their property, fuction, or value. LRG III, IV, V.

M. formulate hypotheses based on reasoning of what is thought to be true. LRG I, VI.

The Curriculum

SIMPLE AND COMPOUND MACHINES

Objective	Enabling Activity	Evaluation
The student will hypothesize that force may or may not change if the elevation of the plane is changed. IRO A, B, C, D, F, H, K, M.	The student will compare the forces needed to pull an object up an inclined plane at different elevations (see Activity 1, Appendix page 70).	The student will successfully complete a written test over inclined planes (for copy of test see Appendix page 74).

Objective	Enabling Activity	Evaluation
The student will conclude that it takes less force to pull an object up an inclined plane than to lift an object to the same height. IRO A, B, C, D, E, F, H, I, J, L.	The student will compare the force to lift an object to the force to pull an object up an inclined plane (see Activity 2, Appendix page 72).	The student will successfully complete a written test over inclined planes (for copy of test see Appendix page 74).

Objective	Enabliing Activity	Evaluation
The student will understand that an arm may act as a lever. IRO A, C, D, F, I, J, M.	The student will observe his arm to see how it works (see Activity 3, Appendix page 77).	The student will satisfactorily complete a written test over levers (for copy of test see Appendix page 85).

Objective	Enabling Activity	Evaluation
The student will conclude from his data that it takes less force to lift an object using a lever than it does to lift the object. IRO A, B, C, D, E, F, H, K.	The student will compare the amount of force it takes to lift a book with the amount of force it takes to lift the same book with a lever (see Activity 4, Appendix page 78),	The student will satisfactorily complete a test over levers (for copy of test see Appendix page 85).
The student will explore the use of a screwdriver as a lever and wedge. IRO A, C, D, E, F, M.	The student will open a can with a screwdriver and identify the location of the load, fulcrum and effort (see Activity 5, Appendix page 80).	The student will satisfactorily complete a test over levers (for copy of test see Appendix page 85).
The student will observe and classify different classes of levers. IRO A, C, D, E, F, H, I, K, L.	The student will make a lever by laying one pencil across another and and classify levers into three classes (see Activity 6, Appendix page 81).	The student will satisfactorily complete a test over levers (for copy of test see Appendix page 85).

Objective

The student will infer that the greater load can be moved with the least effort when the fulcrum is nearest the load, and that a lever changes the direction of force. IRO A, C, D, E, F, H, I, M.

Enabling Activity

The student will use a small object to lift a large object with the help of a lever (see Activity 7, Appendix page 82).

Evaluation

The student will satisfactorily complete a written test over levers (for copy of test see Appendix page 85).

Objective

The student will understand the relationship between the load and the effort by varying the load without changing the position of the fulcrum and comparing the load with the effort used. IRO A, B, C, D, E, F, G, H, I, K.

Enabling Activity

The student will use a spring scale and lever to investigate the relationship between the load and effort without varying the fulcrum (see Activity 8, Appendix page 83).

Evaluation

The student will satisfactorily complete a written test over levers (for copy of test see Appendix page 85).

Objective	Enabling Activity	Evaluation
The student will conclude that a movable pulley will use less effort than a fixed pulley. IRO A, C, D, E, F, G, I, J, K.	The student will investigate the effort used to lift an object, lift an object with a fixed pulley, and lift an object with a movable pulley (see Activity 9, Appendix page 88).	The student will satisfactorily complete a written test over pulleys (for copy of test see Appendix page 96).
The student will understand that a movable pulley reduces the effort in comparison to a fixed pulley. IRO A, B, C, D, E, F, G, H, K.	The student will demonstrate the use of a fixed and movable pulley to lift a load (see Activity 10, Appendix page 90).	The student will satisfactorily complete a written test over pulleys (for copy of test see Appendix page 96).
The student will conclude that a fixed support holds up half the load when a movable pulley is used. IRO A, B, C, D, E, F, G, H, I, K.	The student will demonstrate that a support holds up half the load when using a movable pulley (see Activity 11, Appendix page 92).	The student will satisfactorily complete a written test over pulleys (for copy of test see Appendix page 96).

Objective	Enabling Activity	Evaluation
The student will conclude that a block and tackle using four ropes to support the load will multiply the effort four times. IRO A, B, C, D, E, F, G, H, I, K, M.	The student will construct a block and tackle and demonstrate that the effort is multiplied by the number of ropes used to support the load (see Activity 12, Appendix page 94).	The student will satisfactorily complete a written test over pulleys (for copy of test see Appendix page 96).

Objective	Enabling Activity	Evaluation
The student will infer that an inclined plane reduces the effort but increases distance. IRO A, D, E, F, G, K, L.	The student will observe inclined planes and compare effort and distance on a steep incline with effort and distance on a gentle slope (see Activity 13, Appendix page 99).	The student will satisfactorily complete a written test over the screw (for copy of test see Appendix page 103).

Objective

The student will conclude that the less the slope of an inclined plane, the less the effort needed to overcome a resistance (move a load). And that one kind of wood offers more resistance than another. IRO A, D, E, F, G, H, I, K, M.

Enabling Activity

The student will compare the difficulty of turning a screw into two different kinds of wood, and investigate which kind of screw will go through wood more easily (see Activity 14, Appendix page 100).

Evaluation

The student will satisfactorily complete a written test over the screw (for copy of test see Appendix page 103).

Objective

The student will learn that the screw with the lowest incline will multiply the effort the most. IRO A, C, D, E, F, G, H, I, J, K, L.

Enabling Activity

The student will construct a winding inclined plane (a screw) and compare what is happening when a load is being drawn up an inclined plane, to what is happening when the screw is being screwed into a block of wood (see Activity 15, Appendix page 101).

Evaluation

The student will satisfactorily complete a written test over screws (for copy of test see Appendix page 103).

Objective	Enabling Activity	Evaluation
The student will conclude that there are various kinds of wedges, each doing a different job but all multiplying effort. IRO A, C, D, E, F, J, K, L.	The student will identify and investigate the work of a variety of wedges (see Activity 16, Appendix page 106).	The student will satisfactorily complete a written test over the wedge (for copy of test see Appendix page 107).

Objective	Enabling Activity	Evaluation
The student will conclude that the wheel and axle helps to multiply speed and/or effort force. IRO C, D, E, F, J.	The student will investigate the workings of the wheel and axle in the doorknob and eggbeater to see how it helps to multiply speed and/or effort force (see Activity 17, Appendix page 110).	The student will satisfactorily complete a written test over the wheel and axle (for copy of test see Appendix page 113).

Objective	Enabling Activity	Evaluation
The student will learn that the wheel and axle of a bicycle multiplies speed. IRO A, D, E, F,	The student will investigate the workings of a bicycle to discover that the wheel and axle	The student will satisfactorily complete a written test over the wheel and axle (for copy

G, H, I, K, M.	multiply speed and that a speed multiplier can be changed into a force multiplier (see Activity 18, Appendix page 112).	of test see Appendix page 113).

Objective	Enabaling Activity	Evaluation
The student will conclude that material with rough surfaces causes more friction than material with smooth surfaces. IRO A, B, C, D, E, F, G, H, K, M.	The student will compare the force needed to overcome friction on a table top, sandpaper, and wax paper, and compare the differences when extra weight is added (see Activity 19, Appendix page 115).	The student will successfully complete a written test over friction (see copy of test on Appendix page 123).

Objective	Enabling Activity	Evaluation
The student will understand that oil makes sliding friction much easier. IRO A, D, E, F, H, K.	The student will compare the difference between sliding friction on a plane piece of glass and an oiled piece of glass (see Activity 20, Appendix page 117).	The student will successfully complete a written test over friction (for copy of test see Appendix page 123).

Objective	Enabling Activity	Evaluation
The student will conclude that rolling friction has much less resistance than sliding friction. IRO A, D, E, F, G, H, K, M.	The student will observe the differences between rolling and sliding friction by allowing objects to roll and slide down an inclined plane (see Activity 21, Appendix page 118).	The student will successfully complete a written test over friction (for copy of test see Appendix page 123).

Objective	Enabling Activity	Evaluation
The student will infer that rolling friction takes less force than sliding friction. IRO A, B, C, D, E, F, H, K.	The student will investigate the different amounts of force needed for rolling and sliding friction by pulling a block of wood across the table, pulling it across on pencils, and pulling it across with pencils glued to bottom of block (see Activity 22, Appendix page 119).	The student will successfully complete a written test over friction (for copy of test see Appendix page 123).

Objective	Enabling Activity	Evaluation
The student will conclude that friction produces heat energy. IRO A, B, C,	The student will discover that friction produces heat energy by rubbing	The student will successfully complete a written test over friction (for

D, E, F, H.	hands together and by rubbing thermometer bulbs against two different textures of material (see Activity 23, Appendix page 121).	copy of test see Appendix page 123).
<u>Objective</u>	<u>Enabling Activity</u>	<u>Evaluation</u>
The student will understand that work is done when a force moves an object through a distance. IRO A, B, C, D, E, F, H, I, K.	The student will use a formula to discover how much work is being done by lifting an object and by pulling an object up an inclined plane (see Activity 24, Appendix page 127).	The student will successfully complete a written test over friction (for copy of test see Appendix page 129).
<u>Objective</u>	<u>Enabling Activity</u>	
The student will conclude that a compound machine is made of two or more simple machines. IRO A, C, D, E, F, J, K, L.	The student will demonstrate the use of a hand drill and a meat grinder, and identify the simple machines and their function in each compound machine (see Activity 25, Appendix page 132).	The student will successfully complete a written test over friction (for copy of test see Appendix page 133).

FLOWER PARTS AND THEIR FUNCTIONS

Objective	Enabling Activity	Evaluation
The student will become familiar with the parts of a perfect flower and their functions. IRO A, C.	The student will use a study guide and a diagram to complete a worksheet on flower parts and their functions (see Activity 1, Appendix page 148).	The student will satisfactorily complete a written test over flower parts and their functions (for copy of test see Appendix page 158).
Objective	**Enabling Activity**	**Evaluation**
The student will become familiar with the three kinds of flowers and their functions. IRO A, C, K.	The student will use a study guide and diagram to complete a worksheet over the three kinds of flowers and their functions (see Activity 2, Appendix page 149).	The student will satisfactorily complete a written test over flower parts and their functions (for copy of test see Appendix page 158).
Objective	**Enabling Activity**	**Evaluation**
The student will gain an understanding of the parts of a flower and their functions. IRO	The student will use a diagram to dissect a flower, investigate its parts and pollen, mount the	The student will satisfactorily complete a written test over flower parts and their functions (for copy

A, C, K.	parts, and label them (see Activity 3, Appendix page 150).	of test see Appendix page 158).
<u>Objective</u>	<u>Enabling Activity</u>	<u>Evaluation</u>
The student will learn the parts of a flower. IRO A, C.	The student will use a flower and a diagram to draw and label the parts of a flower (see Activity 4, Appendix page 152).	The student will satisfactorily complete a written test over flower parts and their functions (for copy of test see Appendix page 158).
<u>Objective</u>	<u>Enabling Activity</u>	<u>Evaluation</u>
The student will gain a greater awareness of pollen and the three kinds of flowers. IRO A, C, D, E, F, J, K, L.	The student will use a microscope and flowers to investigate the pollen grains and stamen of each, and to classify each as a staminate, pistillate, or perfect flower (see Activity 5, Appendix page 153).	The student will satisfactorily complete a written test over flower parts and their functions (for copy of test see Appendix page 158).

Objective

The student will learn the parts of a flower and their functions, and the three kinds of flowers and their functions. IRO A, C, D, E, F, J, K.

Enabling Activity

The student will help make the cards for a flower concentration game and play the game with a group of classmates (see Activity 6, Appendix page 154).

Evaluation

The student will satisfactorily complete a written test over flower parts and their functions (for copy of test see Appendix page 158).

Objective

The student will learn the parts of a flower and their functions, and the three kinds of flowers and their functions. IRO A, C, D, E, F, J, K.

Enabling Activity

The student will construct a bingo sheet with the flower parts words, help write questions for each of the words and play the bingo game with a group of classmates (see Activity 7, Appendix page 156).

Evaluation

The student will satisfactorily complete a written test over flower parts and their functions (for copy of test see Appendix page 158).

The
Appendix

ACTIVITY 1: The Inclined Plane

MATERIALS:

roller skate (or wheeled toy), rubber bands, board about 1 meter (3 feet) long and 10 centimeters (4 inches) wide, 6 or 7 books, paper, pencils, rulers

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. Hook the rubber band to the front of the skate. Pull the skate (the resistance) horizontally across the table. Measure and record the stretch in the rubber band. #

2. Lift the skate vertically to the top of a pile of 7 books. Measure and record the stretch in the rubber band. Compare the stretch of the rubber band when you lifted the skate vertically to the stretch of the rubber band when you pulled it horizontally across the table. Which one needed the most force (or pull)? *

3. Stack up 7 books.

   a) Place the board so that it slopes to the top of the pile of books. The slope of the board makes an <u>inclined</u> <u>plane</u>. (One type of simple machine) @

   b) Slowly pull the skate (the resistance) up the inclined plane with the rubber band.

   c) Measure and record the stretch of the rubber band.

   d) How much force (effort) did it take?

   e) Compare this force to the force of lifting the skate to the height of the books.

   f) Which takes more force (effort)?

   g) Does the inclined plane make the job of getting the skate to the top of the pile of books easier? Why?

h) Raise the height of the inclined plane.

   1) Does it take less or more force to pull the skate up the inclined plane?

i) Lower the inclined plane.

   1) Does it take less or more force to pull the skate up the inclined plane?

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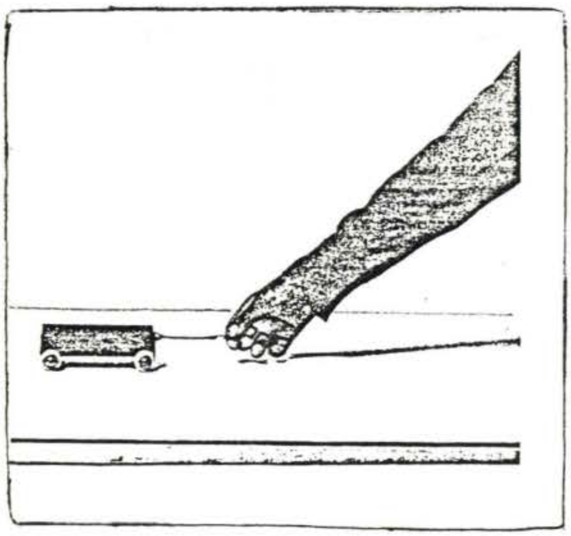

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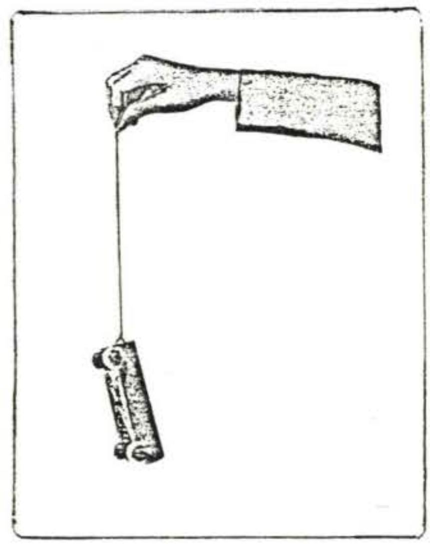

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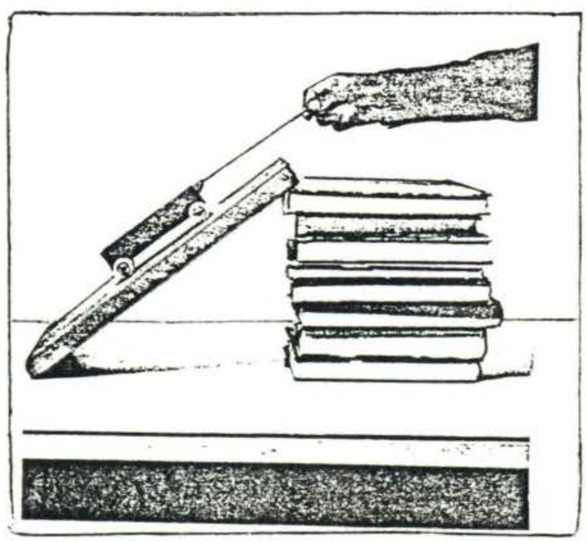


ACTIVITY 2: The Inclined Plane

MATERIALS:

roller skate (or wheeled toy), spring scale, strong cord, books, ruler, board about 1 meter (3 feet) long and 10 centimeters (4 inches) wide

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. Make a stack of 6 or 7 books on your desk. Hook a spring scale onto the front or back of the skate. Use this scale to slowly lift the skate (resistance) to the top of the pile of books. Read the force on the scale as you lift the skate. How much force (or pull) does it take? #

2. Now place a board so that it slopes up to the top of the pile of books. The board makes an <u>inclined plane</u>. (One type of simple machine) Slowly pull the skate up the board with the scale. How much force (effort) does it take now? *

3. How does the force to lift the skate compare with the force to pull it up the inclined plane? Why?

4. Does the inclined plane make the job of getting the skate to the top of the pile of books easier? Are you sure? How do you know?

5. Which is greater - the length of the inclined plane or the height of the books?

6. Does the inclined plane save you work? That is, do you do less work when you pull the skate on the inclined plane?

7. How was the force affected by the inclined plane?

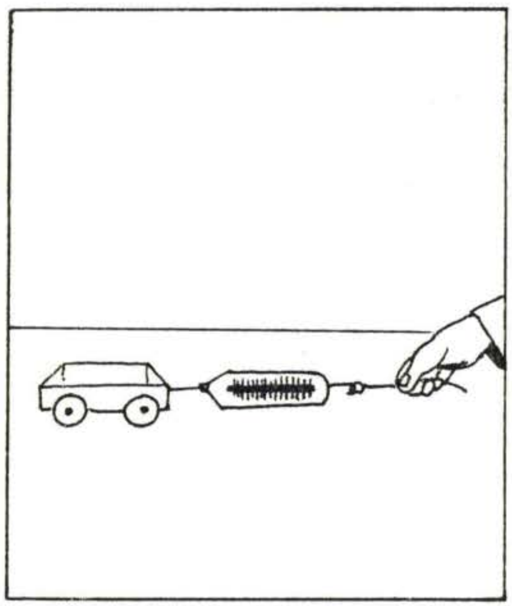
8. How do your measurements compare to those of your classmates?

9. Which do you think is easier, to lift a heavy load up into the back of a truck or to move the load up a ramp (inclined plane)? An inclined plane is one kind of simple machine.

10. Which covers a greater distance - height of a truck bed or the ramp?

11. What can you conclude about a ramp?

12. List all the places you have seen ramps.



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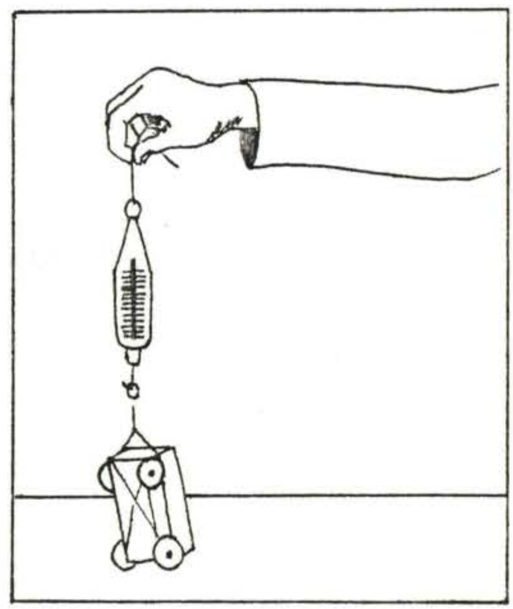

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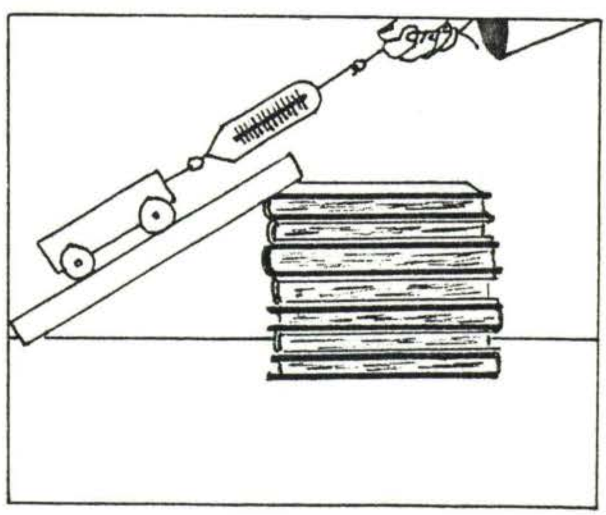

Test for Inclined Planes

I. Circle the best answer.

A. The inclined plane is a simple machine that can
   1) change direction of a force.
   2) multiply force.
   3) increase speed.

B. A ramp is a simple machine called
   1) a metric newton.
   2) a fulcrum.
   3) an inclined plane.
   4) a pulley.

C. A child is pushing a doll carriage. The carriage is the
   1) work.
   2) resistance.
   3) effort

D. In pushing the doll carriage, the child's force is the
   1) effort.
   2) resistance.
   3) work.

E. A plane is
   1) a simple machine.
   2) curved.
   3) flat.

F. Another word for incline is
   1) plane.
   2) angel.
   3) angle.

G. An incline is
   1) at an angle with the ground.
   2) always steep.
   3) straight with the ground.

II. Think of your environment around you and list five inclined planes.

III. Observe and describe an inclined plane.

IV. Fill in each blank with the correct word or phrase.

sloping flat surface	slant
flat surface	slope
does not	force
simple machine	angle

A) A plane is a __________.
B) An incline is a __________ or a __________.
C) An inclined plane is a __________.
D) An inclined plane lets you do work with less __________.
E) Another word for slope is __________.

Answers to Test on Inclined Planes

I. A. multiply force
   B. an inclined plane
   C. resistance
   D. effort
   E. flat
   F. angle
   G. at an angle with the ground

II. ski slopes, rises in stretches of highways, conveyor belts for loading and unloading, ramps in hospitals, playground slides, etc.

III. tilted, one end higher

IV. A. flat surface
   B. slant or angle
   C. sloping flat surface
   D. force
   E. slant

ACTIVITY 3: Your Body, A Machine (Lever)

MATERIALS:

pencil and paper

ENABLING ACTIVITY:

Write your answers to the following questions on paper.

1. Can a part of your body work as a machine?

2. Observe your arm (to see how it works) when you bend your elbow to lift an object.

3. Is your arm a machine?

4. What kind of machine is it?

5. Did you decide your arm was a lever? If you did, draw a diagram of your arm and label the weight lifted, the load. Label the force used to lift the load, the effort. Label the turning point of the lever, the fulcrum (fool'krəm).

6. Is the lever a machine for multiplying the force of your muscles?

7. Define a lever.

ACTIVITY 4: Can a Lever Make a Job Easier?

MATERIALS:

book, ruler, chair, string, tape, spring scale, pencil, and paper

ENABLING ACTIVITY:

Write answers to all questions on paper.

1. Lift a book with the spring scale. Hold it still. How much force does it take? #

2. Now try lifting the same book using a lever. Tie the book to one end of the ruler. (You may want to tape the string to the ruler so that the string can't slip.) Tie the spring scale to the other end of the ruler by the ring, so that you can pull down on the hook of the scale. *

3. Use the back of a chair for a fulcrum. Have the fulcrum much closer to the book than to the scale. Lift the book by pulling down on the spring scale. *

4. When nothing is moving and the ruler-lever is level, how much force does it take to lift the book with this lever?

5. How does this force compare with the force needed to lift the book without the lever? Do you have any evidence that this lever multiplies force?

6. Why do you think the fulcrum should be closer to the book than to the spring scale?

7. Increase the weight by lifting two books. Keep the fulcrum in just the same place on the ruler. Predict how the force now needed will compare with the weight lifted. Test your prediction and write down the results.

8. Compare your measurements with other groups and write it down.

9. Does the lever make the job of lifting easier?
   If so, how?

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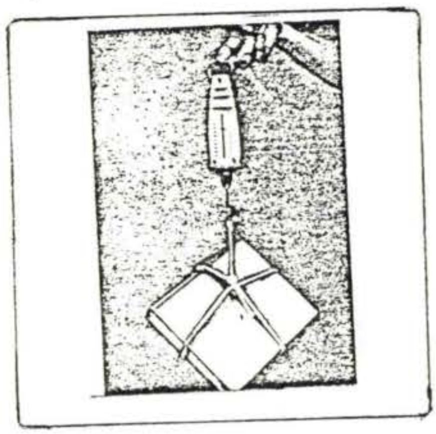

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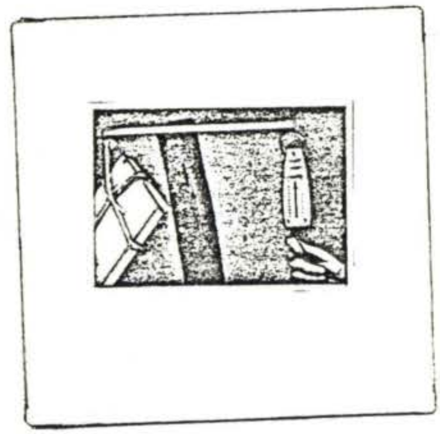

ACTIVITY 5: The Screwdriver as a Lever

MATERIALS:

screwdriver, clean friction-lid type of can like that used to hold paint or varnish, pencil, paper, piece of cardboard, scissors

ENABLING ACTIVITY:

Write answers to all questions on paper.

1. Open the can with the screwdriver.

    a) What simple machine did you use?

    b) Where was the fulcrum?

    c) Where was the load?

    d) Where was the effort?

    e) How did you multiply the effort?

2. In what two ways do you use a screwdriver when you open a paint can?

3. When you tighten a screw, how do you use the screwdriver?

    a) Which is the wheel?

    b) Which is the axle?

4. Hypothesize as to where you would place a piece of cardboard you wanted to cut with shears or scissors. Test your hypothesis.

ACTIVITY 6: Make a Lever

MATERIALS:

2 books, 2 pencils, examples of class A, B, and C levers (bottle opener, nut cracker, ice tongs, tweezers, shears, pliers, fishing pole, wheelbarrow, etc.)

ENABLING ACTIVITY:

Write answers to all questions on paper.

1. Stack two books on the desk.
2. Make a lever by laying one pencil across another.
3. Place one end of the lever under the bottom book (the load).
4. Press (force) on the free end of the top pencil, placing the bottom pencil (fulcrum) in different places under the top pencil.
5. Where was the fulcrum when you needed the least force?
6. List examples of class B levers where the resistance (load) is between the fulcrum and the effort (force).
7. List examples of class C levers where the effort is between the fulcrum and the resistance.

ACTIVITY 7: Can Small Effort Lift Heavy Object? (Lever)

MATERIALS:

one brick, 3 or 4 foot board, two cement blocks, pencil, and paper

ENABLING ACTIVITY:

Write answers to all questions on paper.

1. Hypothesize and write down easiest way to lift cement block with a lever.
2. Use one cement block as the fulcrum.
3. Use the board as the lever.
4. How can you balance the heavy block at one end of the board with the brick at the other?
5. When does the large cement block have the advantage?
6. When does the small brick have the advantage?
7. In which direction did the effort force move?
8. So, a lever changes the direction of _________ _________.
9. In which direction does the load move?
10. What was the easiest way to lift the cement block with a lever?

ACTIVITY 8: Does Changing the Load on the Lever Change the Effort?

MATERIALS:

two 2-cup plastic jars, two cups of sand, ruler or 1 foot by 2 inch board, spring scale, brick, pencil and paper, measuring cup

ENABLING ACTIVITY:

Write your answers on paper.

1. Put a half-cup of sand in a plastic jar. #

   a) Lift the plastic jar with the sand in it with a spring scale.

   b) Record the effort. (This is the weight of your load.)

2. Fasten the spring scale on one end of a ruler.

3. Put the plastic jar with a half-cup of sand on the other end of the ruler.

4. Keep the fulcrum (the brick) in the same location all the time.

5. Use the spring scale. Measure and record the effort needed to lift the jar of sand. Divide the effort by the load (answer to No. 1).

6. Add a second half-cup of sand to the container. Measure and record the effort needed to lift the cup of sand. Divide the effort by the load.

7. Add a third half-cup of sand to the container. Measure and record the effort needed to lift the 1-1/2 cups of sand. Divide the effort by the load.

8. Add a fourth half-cup of sand to the container. Measure and record the effort needed to lift the two cups of sand. Divide the effort by the load.

9. How does the change in the load correspond to the change in effort?

10. Compare the load with the effort used.

11. What pattern do you see?

12. Now lift the jar with the two cups of sand with the spring scale.

13. Is the effort to lift the sand greater or less than the effort to lift it with a lever?

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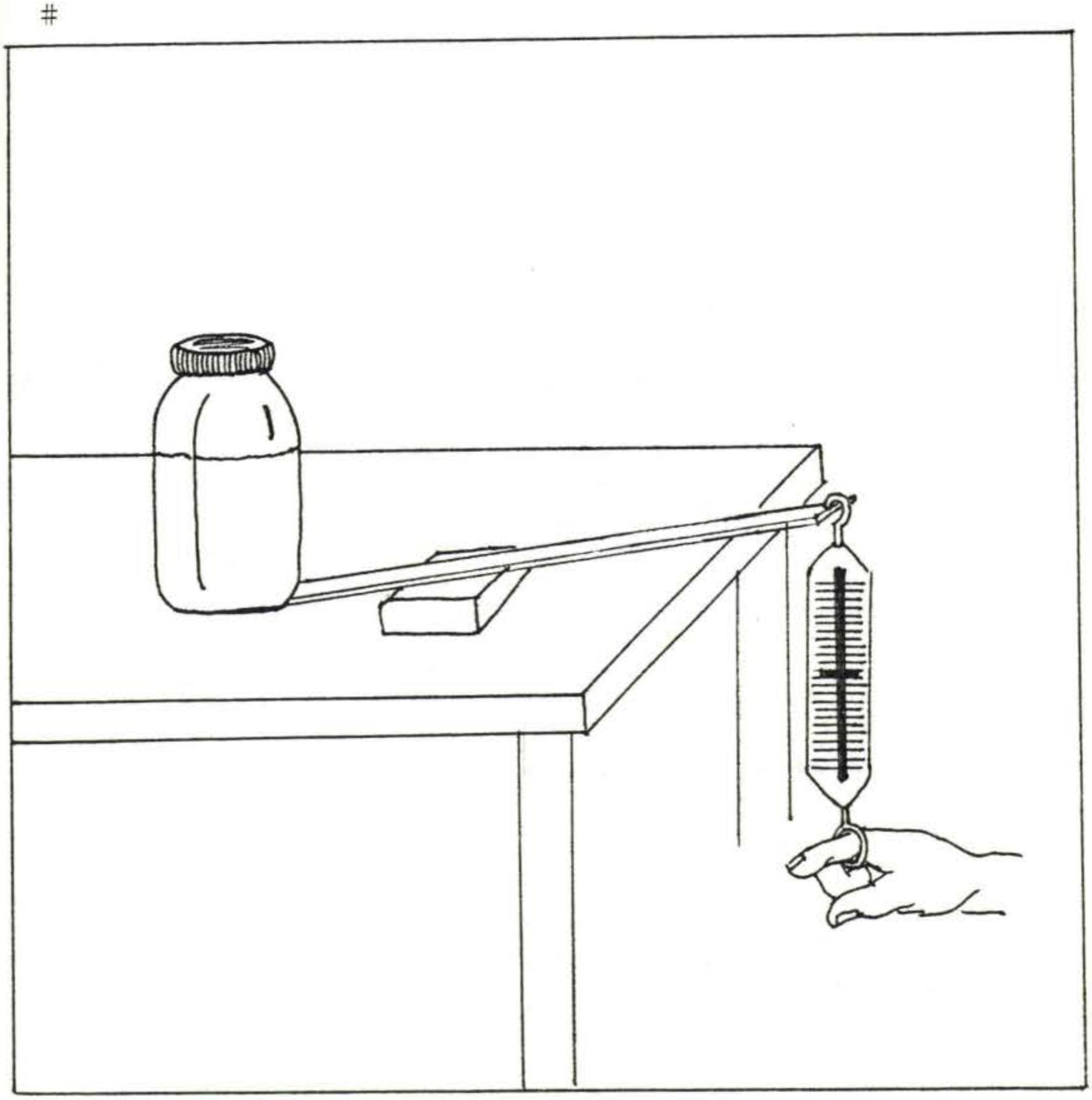

Test Over Levers

A. Write the answer to each question on paper.

1. Name three class A levers with the <u>fulcrum</u> in the middle.

2. Name three class B levers with the <u>load</u> in the middle.

3. Name three class C levers with the <u>effort</u> in the middle.

4. Name five levers that you can find in your environment and identify the effort, load, and fulcrum of each lever. Tell the use of each lever.

5. Why are handles long on tongs, metal shears and pliers?

6. Define a lever.

B. Choose the best answer and write it on your paper.

1. A load can be moved most easily with a lever when the fulcrum is located
   a) nearest to the effort force.
   b) farthest from the effort force.

2. For ease in lifting a load with a lever, place the fulcrum
   a) near the load.
   b) far from the load.

3. A simple machine that is likely to be used as a lever is a
   a) seesaw.
   b) screw.

4. The lever is a simple machine that can
   a) make a force and multiply force.
   b) multiply force and change direction of force.

5. The side of the lever you use force on is
   a) the handle.
   b) the right side.
   c) the effort arm.

C. Fill in the blank with the proper word.

To multiply effort as much as possible with a lever, the __________ should be as near the __________ as possible. And the __________ should be as far from the fulcrum as possible.

D. Choose the items in Column B that best match the terms in Column A.

A	B
1. resistance	a. force used on a lever
2. force	b. distance from effort to fulcrum
3. lever	c. a seesaw
4. effort arm	d. a push or a pull
5. effort	e. balancing point
	f. object moved by a lever

E. Describe the position of the fulcrum, the load, and the effort needed in these two cases: when a person swings a golf club at a ball; when a person fishes with a fishing rod.

Answers to Test on Levers

A.
1. crowbar, shears, well pump, tongs, pliers
2. wheelbarrow, oars in a boat, nutcracker, bottle opener
3. fishing rod, ice tongs, shovel, broom, baseball bat, tweezers
4.
5. Long effort arm multiplies effort force.
6. a simple machine consisting of a bar with a support (fulcrum) around which it can be turned

B.
1. b) farthest from effort force
2. a) near the load
3. a) seesaw
4. b) multiply force and change direction of force
5. c) effort arm

C.
load
fulcrum
effort

D.
1. f) object moved by a lever
2. d) a push or a pull
3. c) a seesaw
4. b) distance from effort to fulcrum
5. a) force used on a lever

E.
<u>golf club</u>
fulcrum = opposite end of end used to hit ball (hitter's wrist)
load = ball
effort = force of biceps of arm applied at handle between fulcrum and load

<u>fishing pole</u>
fulcrum = end of pole opposite the fish, the wrist
load = fish
effort = force of biceps of arm applied on the handle or reel between fulcrum and load

ACTIVITY 9: Using a Pulley

MATERIALS:

heavy cord, three bricks, two pulleys, two S-shaped hooks, spring scales, broomstick or heavy board

ENABLING ACTIVITY:

Write your answers to all questions on paper.

1. Tie a piece of heavy cord securely around one of the bricks, so that the brick can be lifted by the cord.

2. Make a simple machine called a fixed pulley by fastening a pulley to a solid support, such as a bar or a doorknob. Tie the second brick with cord and place the cord over the pulley so that the brick can be lifted. #

3. Make another simple machine called a movable pulley by tying the other pulley to the third brick. Then tie one end of the cord to the support. Run the other end of the cord through the pulley so that you can lift this brick. *

4. Now you can compare these three ways of lifting the same load.

   a) Lift the first brick directly by its cord.

   b) Lift the second brick by means of the pulley tied to the support.

   c) Lift the third brick with the pulley attached to the brick.

   d) Which way takes the least effort?

   e) Does either of the pulleys seem to multiply your force?

   f) How do your classmates' findings agree with yours?

   g) Define a pulley, a fixed pulley and a movable pulley.

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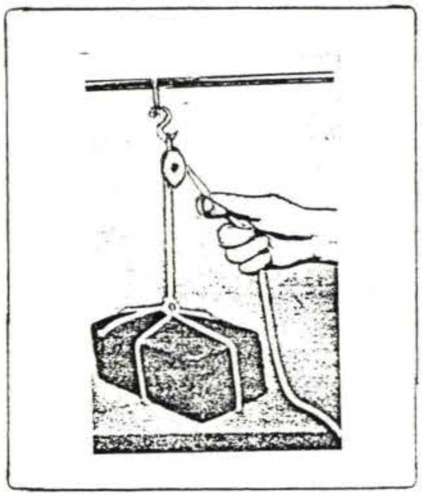

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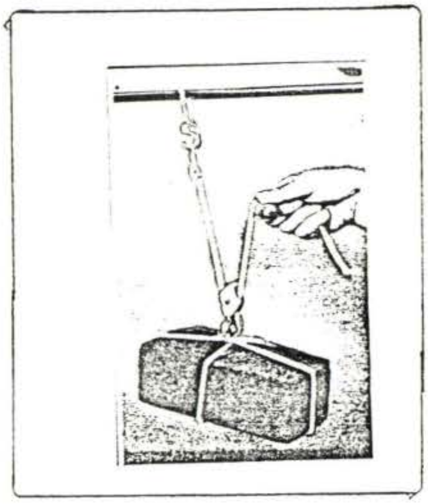

ACTIVITY 10: Work of a Pulley

MATERIALS:

heavy cord, three bricks, two pulleys, two S-shaped hooks, pencil, paper, spring scale, broomstick or heavy board

ENABLING ACTIVITY:

Write your answers to all questions on paper.

1. Tie a piece of heavy cord securely around one of the bricks.

   a) Use the spring scale to lift the brick by the cord.

   b) Record how much effort it took to lift the brick.

2. Make a fixed pulley by fastening a pulley to a solid support, such as a doorknob, or a bar or broomstick over the back of two chairs. #

   a) Tie the second brick with cord and place the cord over the pulley.

   b) Use the spring scale to lift the brick.

   c) How much effort did it take?

   d) Did this take more or less effort than lifting the brick?

3. Make a movable pulley by tying the other pulley to the third brick. *

   a) Tie one end of the cord to the support.

   b) Run the other end of the cord through the pulley so that you can lift this brick.

   c) Use a spring scale to lift the brick.

   d) How much effort did you use?

4. Which way takes the least effort? How much less?

5. Does either of the pulleys seem to multiply your force?

   a) Which one?

   b) How much did it multiply your force?

6. Compare your findings with your classmates' findings.

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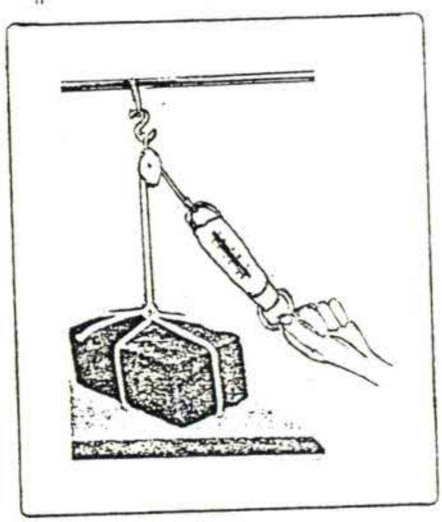

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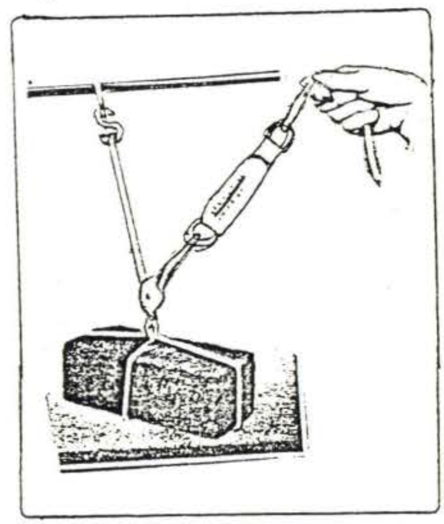


ACTIVITY 11: Does a Fixed Support Help Hold the Load?

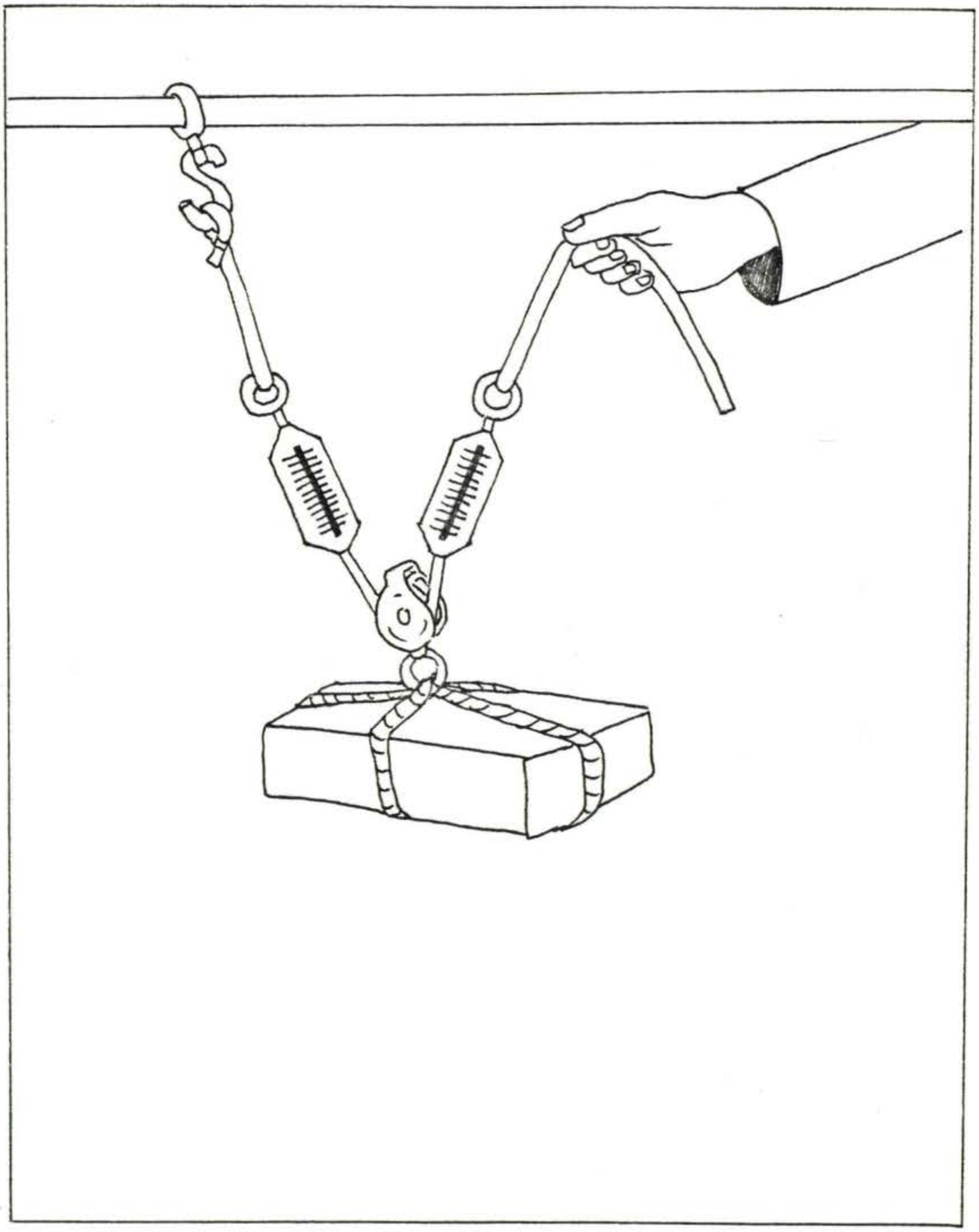
MATERIALS:

2 spring scales, S-shaped hook, 1 brick, cord, paper and pencil, broomstick or heavy board, pulley

ENABLING ACTIVITY:

Write answers to all questions on paper.

1. Predict how much of the load a support will hold up when using a movable pulley. Test your hypothesis. Record your hypothesis.
2. Tie a cord around the brick.
   a) Lift the brick with a spring scale.
   b) Record the effort it took to lift the brick.
3. Attach the pulley to the cord or the brick.
4. Attach a spring scale to the support.
5. Attach one end of a cord to the spring scale on the support.
6. Run this cord through the pulley on the brick.
7. Attach the other end of the cord with the other spring scale. Lift the brick with the spring scale.
8. What does each scale read?
9. How does the total of the two readings compare with the weight of the load when it was lifted by itself with a spring scale?
10. How much of the load does a fixed support hold when a movable pulley is being used?
11. How much does the movable pulley multiply the effort?



ACTIVITY 12: Block and Tackle

MATERIALS:

2 double pulleys, strong cord, 1 brick, broom stick or heavy board, spring scale

ENABLING ACTIVITY:

Write answers to all questions on paper.

1. You can make a machine called a block and tackle with a fixed pulley and a movable pulley connected by one or more ropes.

   a) Make a support by fastening the broomstick across the backs of two chairs with tape or cord.

   b) Fasten one pulley to the support with a piece of cord.

   c) Tie a piece of cord around the brick.

   d) Lift the brick with the spring scale. Record its weight or the effort used to lift the brick.

   e) Hook the other pulley on the brick.

   f) Fasten the end of a long piece of cord to the fixed pulley. Run the cord through the four grooves of the fixed and movable pulleys.

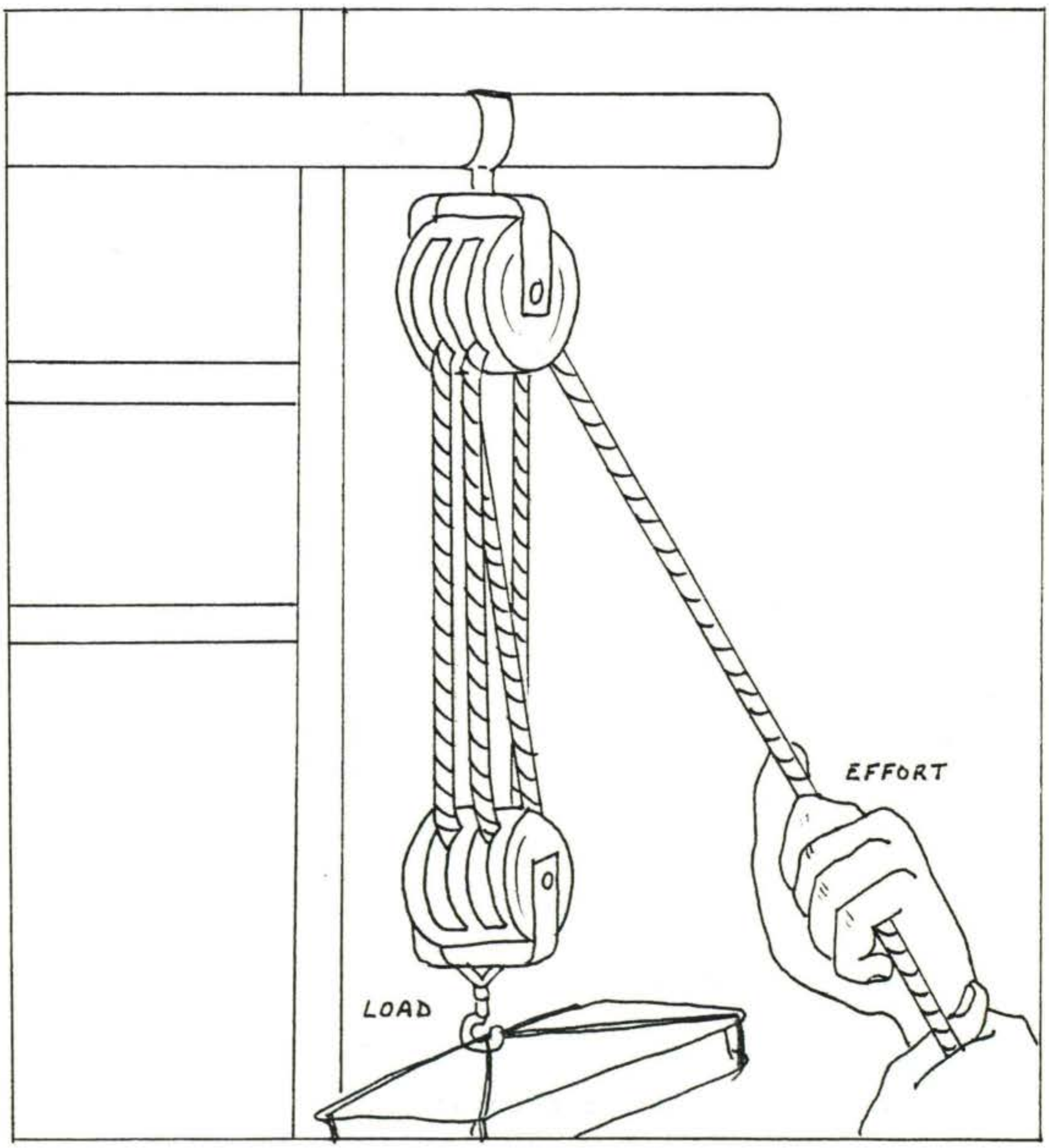
   g) Pull down on the cord with the spring scale to lift the brick. Record the force used to lift the brick.

2. Which way takes the least effort? How much less?

3. How much did the block and tackle seem to multiply your effort?

4. Compare your findings with your classmates' findings.

5. In this block and tackle, there are four ropes supporting the load. Suppose you were lifting a cement block that weighed 25 pounds. With how much force do you predict you would have to pull to raise the cement block?



Test Over Pulleys

Choose the best answer and write it on your paper.

1. A single fixed pulley is a simple machine that can
   a) change direction of force.
   b) multiply force.

2. To multiply force use a
   a) fixed pulley.
   b) movable pulley.

3. A pulley is
   a) a wheel.
   b) a wheel on an axle.
   c) an axle.

4. Several pulleys used together are
   a) a block and tackle.
   b) less helpful than one.
   c) not helpful at all.

Write your answers to the following questions on paper.

1. Name five pulleys you can find around the house or school.

2. If a fixed pulley does not multiply effort, why do we use it?

3. If you had a helper up in an attic, how could he raise a 50 pound box of toys into the attic with about half the effort?

4. Describe a fixed pulley.

5. What does a movable pulley do?

Fill in the blank with the correct word.

1. A grooved wheel is called a__________.

2. A pulley that turns but does not move is a ____________ _______________.

3. A pulley is one type of __________ machine.

4. A pulley that moves is a __________ __________.

Answers to Test on Pulleys

Multiple Choice

1. a) change direction of force
2. b) movable pulley
3. b) a wheel on an axle
4. a) block and tackle

Questions

1.
2. It is easier or more convenient.
3. Use a movable pulley attached to the box of toys with one end of the rope attached to ceiling of the attic. Put rope through pulley and pull on other end of rope.
4. It is a simple machine that changes the direction of a force.
5. Multiplies the effort by two.

Fill in Blanks

1. pulley
2. fixed pulley
3. simple
4. movable pulley

ACTIVITY 13: Winding Inclined Plane (Screw)

MATERIALS:

a picture of the walkway to the observation platform at the top of Clingman's Dome, a mountain in Tennessee, or any other winding path

Write your answers to the following questions on paper.

1. Look at the picture of the walkway to the observation platform at the top of Clingman's Dome, a mountain in Tennessee.

2. What simple machine does it represent?

3. There is a winding plane you have probably held in your hand. You see it in toys, tables, machines and motors. What is it?

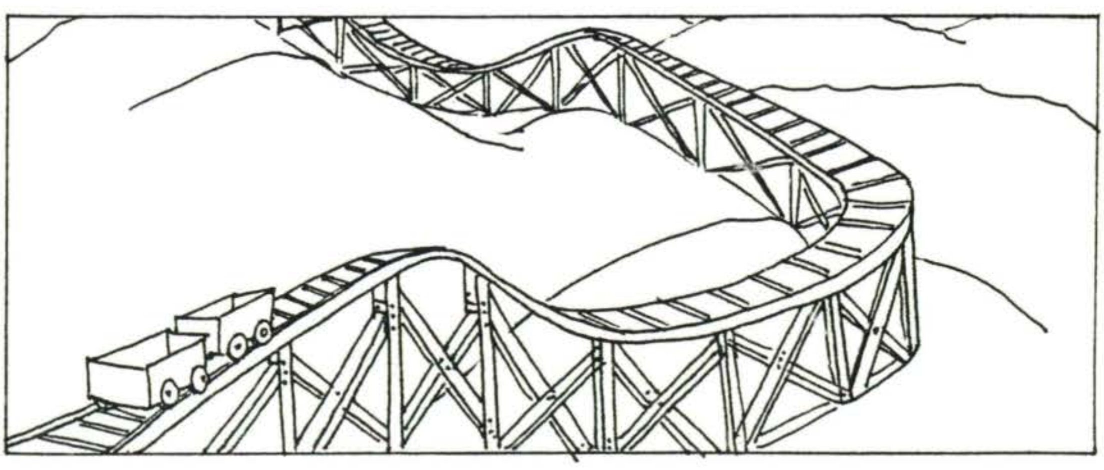
4. What does this machine do?

5. What is added?

6. Think about Clingman's Dome again. Compare effort and distance on a steep incline with effort and distance on a gentle slope.

7. What are some other winding inclined planes, or ramps, for pedestrians?

8. What do all these winding inclined planes do?



ACTIVITY 14: Winding Inclined Plane (Screw)

MATERIALS:

piece of hard wood marked A (such as oak or maple), piece of soft wood marked B (such as pine from an orange crate), two identical screws, several screws each with a different number of threads (pitch) to the inch

ENABLING ACTIVITY:

Write your answers to the following questions on paper.

1. Will it be just as easy to turn a screw in one piece of wood as another, using a screwdriver?

   a) Test your hypothesis.

      1) Screw one screw into wood block A.

      2) Screw the other identical screw into wood block B.

   b) How do you account for any difference?

2. Look at the set of screws having the different number of threads.

   a) Hypothesize which screw is likely to go through the wood more easily?

   b) Test your hypothesis. Screw each screw into the same piece of wood.

   c) Which screw went through the wood the easiest? Why?

ACTIVITY 15: A Winding Inclined Plane

MATERIALS:

sheet of paper, ruler, scissors, pencil and paper, crayon, block of soft wood such as pine, screw, screwdriver to fit groove of screw, thin screw with 10 or 12 threads to the inch.

ENABLING ACTIVITY:

Write your answers to the following questions on paper.

1. Make an inclined plane.

   a) Draw a colored line from the top right-hand corner of your sheet of paper to the bottom left-hand corner.

   b) Cut along the line.

   c) You have made an inclined plane.

   d) Wind it around the pencil.

   e) You have made a winding inclined plane.

   f) Measure and record how far it rises in one turn.

   g) How many turns does it take to get to the top of the plane?

   h) Record the base-height measurement of your inclined plane.

   i) Compare your measurement with the other groups.

   j) Which model screw has an inclined plane with the lowest slope? Why?

   k) Which model screw will multiply the effort the most? Why?

2. Take the screw.

a) Trace the winding plane with your finger around the screw from point to top.

b) Turn the screw about halfway into the block of wood with the screwdriver.

c) Now try to push the screw into the wood with the screwdriver.

d) Is it easier to push the screw into the wood or turn it into the wood? Explain why.

3. Compare what is happening when a load is being drawn up a straight inclined plane with what is happening to the screw being screwed into a block of wood. Explain how the inclined plane works in each instance.

4. Can you pull a screw out of a piece of wood or turn it out with your bare hands? What is the load, or resistance, against which the screw works?

5. What is a screw?

6. Name as many uses of screws as you can.

Test Over Screws

A. Write true or false for each statement.

1. The model screw with the lowest height has the lowest slope.

2. When a screw is used it is the inclined plane that moves.

3. A screw reduces effort but adds distance.

4. When using a winding inclined plane, the greater the incline, the less the effort and the greater the distance.

5. The screw with the least number of threads requires the least effort.

6. A screw is a simple machine that multiplies speed. It consists of an inclined plane wound around a central post.

7. A screw is like a winding inclined plane.

8. A screw does its job by moving.

9. The thread of every screw is longer than its height.

10. Screws only hold things together.

11. A screw is an object that contains a winding inclined plane.

B. Answer the following questions in complete sentences.

1. What is the load or resistance against which the screw works?

2. Name 5 uses of screws.

3. Name 3 winding inclined planes or ramps for pedestrians.

4. Which would bind two pieces of wood together more tightly, a nail or a screw of the same size? Explain your answer.

Answers to Test on Screws

A.
1. true
2. true
3. true
4. false
5. false
6. false
7. true
8. true
9. true
10. false
11. true

B.
1. The wood, the substance the screw is being screwed into.
2. cutter in meat grinder, sharpen pencil in pencil sharpener, to fasten objects together, as a jack to hold up objects, a clamp to clamp things together
3. ramps in automobile garages, ramps for pedestrians in buildings, bobsled runs, ski slopes, circular stairs
4. a screw. The winding inclined plane around a screw offers resistance to a direct pull.

ACTIVITY 16: The Wedge

MATERIALS:

chisel, door stop, stiff cardboard, nail, slender flat-pointed bolt, soft piece of pine

ENABLING ACTIVITY:

Write your answers for the following questions on paper.

1. Demonstrate and explain how a chisel, a simple machine using a wedge, can be forced into wood causing some of it to curl up the inclined plane of the chisel.

2. Look at the door stop, another simple machine.

   a) How does this wedge work?

   b) How does a wedge and an inclined plane differ?

   c) Name other wedges and describe how they work.

   d) Identify and list 4 round wedges.

   e) Define a wedge.

3. Try to push the nail and bolt through the cardboard.

   a) What happens to the fibers of the cardboard as the nail punctures it?

   b) What do you need to drive a nail into wood?

   c) Why can't you usually pull a nail out with your fingers?

   d) Which would go through a piece of wood more easily - a nail or a chisel? Why?

Test Over Wedges

A. Answer the following questions on paper.

1. Name three round wedges and describe how they work.

2. Name three other wedges and describe how they work.

3. The nose of an airplane is shaped like a simple machine. Name this simple machine.

4. Why is the nose of an airplane shaped the way it is?

5. Name some other moving things that are shaped in this general way.

6. Does a wedge act like a pulley, a lever, or an inclined plane?

7. What do you call an inclined plane that moves under or into an object?

B. Match column A with column B. Write the correct letter on the line next to each number.

A	B
____1. to make work easier	a) jobs of a wedge
____2. moves objects and prevents objects from moving	b) does not move
	c) main job of machine
____3. inclined plane	d) helps work by moving
____4. wedge	

C. In each of the following sets of terms, one of the terms does not belong. Circle that term.

1. machines   make work easier   make work more difficult

2. wedge   any number of slopes   only one or

two slopes

3. inclined plane does not move moves

4. wedge does not move moves

D. Which of these have wedges as part of them?

a) gears	d) axe	g) doorknob
b) chisel	e) knife	h) screw
c) pole	f) nail	

Answers to Test Over Wedges

A. 1. nail - A simple machine used for driving into or through wood.
pins - A simple machine for fastening clothes together.
needles - A sharp pointed, slender instrument for sewing or puncturing tissue. It forces the threads of a piece of cloth apart.
nose cone of a rocket - push through the air

2. door stop - A wedge for placing under a door to prevent it from opening.
chisel - A metal tool with a cutting edge at the end of a blade, used in dressing, shaping, or working wood, stone, or metal
axe - A cutting tool with an edged head for felling trees, and chopping, splitting, or hewing wood.
wedge - It splits wood forcing it apart.
hatchet - A short handled axe with a hammer head, to be used with one hand.
knife - An instrument with a thin blade, usually of steel and having a sharp edge for cutting, fastened to a handle. To split materials.

3. round wedge
4. So it can cut through the air more easily.
5. cars, busses, trains, rockets, boats
6. inclined plane
7. a wedge

B. Matching
1. c
2. a
3. b
4. d

C. 1. makes work more difficult
2. only one or two slopes
3. moves
4. does not move

D. b, d, e, f

ACTIVITY 17: Wheel and Axle (Doorknob)

MATERIALS:

doorknob assembled in wood panel, meshed gears (watch, clock), eggbeater

ENABLING ACTIVITY:

Write your answers to the following questions on paper.

1. Dismantle and reassemble the doorknob.

    a) What simple machines are involved?

    b) Describe what you see.

2. Examine and turn the meshed gears.

    a) Describe what you see.

    b) Do any gears multiply force?

    c) Do any gears multiply speed?

    d) Change the direction the force is applied and observe what happens.

3. Examine and turn the handle of the eggbeater.

    a) Observe how the beaters are attached to the axle of the small gears.

    b) What does the handle of the eggbeater turn?

    c) What does the large gear turn?

    d) Do the large gear and small gear turn in the same direction?

    e) What do the small gears turn?

    f) What do the gears on the eggbeater multiply?

4. Put a piece of tape on one blade of the eggbeater.

a) Turn the handle of the eggbeater around one time while watching the piece of tape.

b) How many times does the taped blade go around?

c) How many times is speed multiplied?

5. The term gear ratio means the number of teeth on a large gear compared with the number of teeth on a small gear. What is the gear ratio of the eggbeater?

6. Does the axle multiply force or increase speed?

ACTIVITY 18: Observe Wheel and Axle on Bicycle

MATERIALS:

bicycle, brick, white tape

ENABLING ACTIVITY:

Write your answers to the questions on paper.

1. Observe the bicycle.

   a) Set the bicycle upside down on the handlebars and seat.

   b) Place a piece of white tape on the tire and another near the hub on a spoke in line with the first tape.

   c) Turn the wheel.

   d) Which piece of tape travels faster?

   e) In which direction does the force applied to the axle turn the wheel?

   f) How is this different from the lever?

   g) What uses of the wheel can you think of as a speed multiplier?

2. Turn the pedal of the bicycle.

   a) Observe the force you apply. What happened?

   b) Predict whether a force applied to the rear wheel in order to turn the pedal will be more, less, or the same. Test your hypothesis. A touch of the finger will be enough.

3. Attach a brick to the pedal. Turn the wheel. How does the force applied to the rear wheel to turn the pedal compare now?

Test Over Wheel and Axle

A. Write your answers to the following questions in complete sentences.

1. List examples where a big wheel has force applied to it in order to make a smaller shaft turn.

2. Describe a wheel and axle.

B. Match column A with column B. You may use more than one answer.

A	B
1. A wheel and axle	a. multiplies speed.
2. A doorknob	b. multiplies distance.
3. A bicycle	c. multiplies effort force.
4. An eggbeater	d. divides distance.
5. A meat grinder	e. divides force.
6. A pencil sharpener	

C. Fill in the blank with the correct answer.

1. The small wheel is called the __________ in a wheel and axle.

2. Wheels that are connected by teeth are called __________.

3. When a wheel and axle are used __________ is gained and __________ is lost.

4. A wheel and axle is a simple machine that increases __________ and/or __________.

5. The simple machine in a bicycle that helps to move it is a __________.

Answers to Test Over Wheel and Axle

A. 1. doorknob, steering wheels, pencil sharpeners, bicycle gears

2. a simple machine consisting of a wheel attached to a rod passing through its center, to which a force may be applied.

B. 1. a, e
2. e
3. a, e
4. a, e
5. a, e
6. a, e

C. 1. axle
2. gears
3. force, distance
4. force, speed
5. a wheel and axle

ACTIVITY 19: Resisting Force

MATERIALS:

2 blocks of wood, a spring scale, a sheet of coarse sandpaper, hand lotion, wax paper, string, 1 pencil, and 1 piece of paper

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. Pull the block of wood slowly across the table top with the spring scale.

   a) How much force is needed to pull the block? (Take three trials and average them.)

   b) Why does it take force to pull the wooden block over the table top?

   c) What is it that pulls backward when the block is pulled forward?

2. Pull the block across a piece of sandpaper in the same direction and at the same speed that you pullled it across the table top. #

   a) How much force is needed now? (Take three trials and average.)

   b) Why does it take more force to pull the block over sandpaper?

3. Pull the block across a sheet of wax paper. *

   a) How much force is needed now? (Take three trials and average.)

   b) Why does it take less effort to pull the block over the wax paper?

4. Which way takes the most force?

5. Which way takes the least effort?

6. Friction is a force that resists motion. Which material had the most friction? Which material had the least friction?

7. Rub the palms of your hands together.

   a) Now put lotion into the cupped palm of your hands.

   b) Rub your hands together again.

   c) Does this help explain why the force needed to pull the block varied in your investigation? Explain.

8. Place another block of wood on the first block.

   a) Will the force required to pull the two blocks over the various surfaces change?

   b) Test your prediction.

   c) Now pull the two blocks over the three different surfaces. Measure and record your effort force.

   d) What happened to the force required to pull the two blocks instead of the one block? Compare your results.

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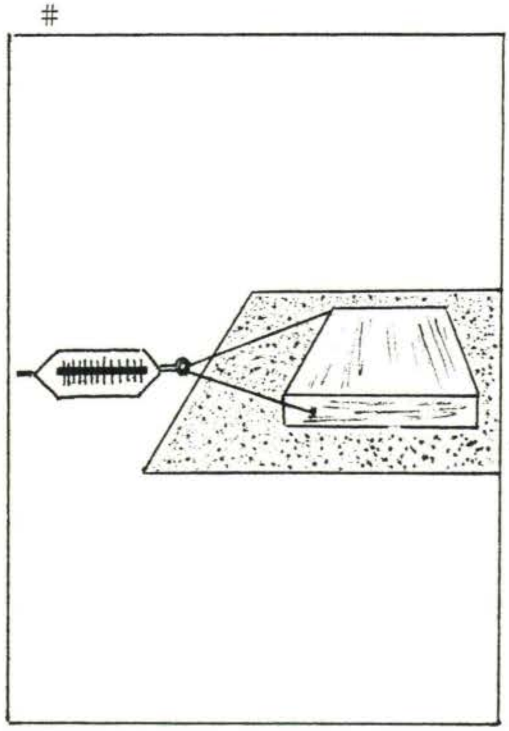

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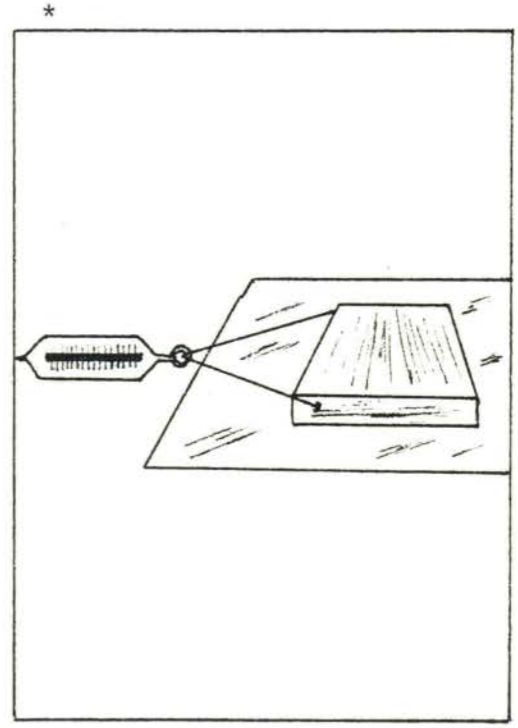


ACTIVITY 20: Sliding Friction

MATERIALS:

2 panes of glass or plastic, oil

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. Place two panes of glass side by side.
2. Put a few drops of oil on one.
3. Rub your finger across the oil and unoiled pane.
4. On which one is rubbing easier? Why?
5. What happens when grease or water is spilled on the floor? Why?
6. Sliding friction is caused when two surfaces rub as one moves over the other, or when two moving surfaces move over one another.

ACTIVITY 21: Rolling and Sliding Friction

MATERIALS:

metal tray, marbles, round and hexagonal pencils, flat plastic or glass objects, small wood block, spoons or forks, 1 pencil, and 1 piece of paper

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. Place marbles, round and hexagonal pencils, flat plastic or glass objects, a small wood block, and spoons or forks at one end of a smooth metal tray.

   a) Which will start sliding first if you tilt the tray slowly? Write down your answer.

   b) Hypothesize and give your reasons as to why you think so.

   c) Test your hypothesis by tilting the tray and observing. Were you right? Why? Write your answer.

2. a) Press the palms of your hands together tightly and rub them.

   b) Put a pencil between the palms of your hands and move your hands again.

   c) What do you observe? Why?

ACTIVITY 22: Rolling and Sliding Friction

MATERIALS:

string, 4 by 4 inch piece of wood, spring scale, 3 pencils, glue, and a piece of paper

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. Sliding friction

   a) Attach one end of a string to a block of wood.

   b) Attach the other end of the string to a spring scale.

   c) Pull the spring scale so the block of wood moves across the table.

   d) How much of the block touches the surface?

   e) What is the force needed to move the block?

2. Rolling friction

   a) Put two round pencils under the block to act as rollers.

   b) Pull the spring scale to move the block of wood across the table.

   c) How much of the block touches the surface, now? How much of the pencils?

   d) What is the force needed to move the block of wood, now?

   e) Why is the force different, now?

   f) Is rolling friction more or less than sliding friction?

3. Sliding friction

   a) Glue the pencils to the block of wood.

b) Draw the block of wood with the glued pencils across the surface again.

c) What kind of friction do you observe now?

d) How much more force does it take than the rolling friction?

e) How does it compare with pulling the block on its flat surface across the table?

ACTIVITY 23: Friction and heat Energy

MATERIALS:

2 thermometers, 2 4 by 4 inch pieces of cloth, a piece of wax paper, a piece of rough paper toweling, a pencil, and a piece of paper

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. Friction

   a) Rub your hands together.

   b) What do you feel?

   c) How would the heating up of the pencils against the surface waste effort?

   d) What would happen if wheels had no friction at all?

   e) How, when, or where can friction be useful?

   f) What would you do if a cabinet door was squeaky? Why?

   g) So, friction wastes effort while being useful.

2. Friction and heat energy

   a) Wrap a thermometer bulb in cloth (to protect it).

   b) Rub the bulb vigorously across wax paper about twelve times.

   c) Read and record the temperature.

   d) Rub another wrapped thermometer bulb across rough toweling about twelve times.

   e) Read and record the temperature.

   f) Which one produced the most friction?

g) Which one produced the most heat energy?

h) What is your conclusion?

Test Over Friction

A. Circle the best ending for the following statements.

1. Compared to running on a dry road, car tires on a wet road have

   a. more friction.
   b. less friction.
   c. same friction.

2. You would produce the most friction when pulling a brick across a

   a. cement floor.
   b. linoleum floor.
   c. waxed floor.

3. You want to reduce friction

   a. sometimes.
   b. all of the time.
   c. none of the time.

4. The friction between a wheel and the road is

   a. sliding friction.
   b. rolling friction.
   c. rough friction.

5. You will find friction in

   a. all simple machines.
   b. most simple machines.
   c. no simple machines.

6. A surface rubbed with oil

   a. changes direction.
   b. multiplies friction.
   c. reduces friction.

7. If there were no friction, the work put into a simple machine and the work gotten out would be

   a. equal.
   b. unequal.

8. Friction in a machine is usually

   a. careful.
   b. helpful.
   c. harmful.

9. A place where friction might come in handy is

   a. on roller skates.
   b. in a car engine.
   c. on a wet highway.

10. Because of friction, some of the force put into a machine is

    a. increased.
    b. multiplied by two.
    c. wasted.

11. When a machine multiplies force, you pay for the advantage by

    a. decreasing energy.
    b. increasing friction.
    c. moving through a greater distance.

12. Machines must overcome

    a. the force and energy.
    b. the friction.
    c. lubriction of surfaces.

13. Friction between objects will

    a. resist motion.
    b. increase motion.
    c. produce motion.

14. Oil and wax is a lubricant that

    a. produces friction.
    b. increases friction.
    c. decreases friction.

15. A machine with wheels

    a. increases friction.
    b. decreases friction.
    c. eliminates friction.

16. The wheels of a machine

    a. slide on the floor.
    b. touch only a small part of the floor at a time.
    c. resist motion.

17. To stop accidents on a slippery road, it is helpful to use sand to

    a. increase friction.
    b. decrease friction.
    c. produce friction.

B. Mark <u>true</u> or <u>false</u> for the following statements.

____1. Friction is a useless force that should be removed.

____2. The amount of friction depends on the kinds of surfaces that are in contact with each other.

____3. Friction is sometimes useful and at other times not useful.

____4. Friction is always useful and should never be removed.

____5. Friction is the resistance to motion caused when two surfaces slide over each other.

____6. A force that resists motion is called friction.

Answers to Test over Friction

A.

1. (b)
2. (a)
3. (a)
4. (b)
5. (a)
6. (c)
7. (a)
8. (c)
9. (c)
10. (c)
11. (c)
12. (b)
13. (a)
14. (c)
15. (b)
16. (b)
17. (a)

B.

1. false
2. true
3. true
4. false
5. true
6. true

ACTIVITY 24: What is Work?

MATERIALS:

8 books, 3 by 4 foot board, wheeled toy, pencil and paper

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. You have observed and studied a number of machines and friction.

2. You have found that you can multiply effort and speed.

3. Did you save work or just make work easier?

4. When you multiplied effort with the block and tackle, how did you have to pay for it?

5. How did you pay for multiplying speed with the wheel and axle?

6. What happened to some of the effort when you pulled against friction?

7. What is work? A scientist says work is done when a force moves an object through a distance.

8. Suppose you lift a four pound sack of dog food a distance of three feet. To find the work done, multiply the force, four pounds, by the distance, three feet. The answer is 12 foot-pounds. You did 12 foot-pounds of work.

9. Stack eight books on a table.

   a) Attach a spring scale to a toy car.

   b) Lift the toy car to the top of the books. Record how much force it took.

   c) Measure and record how far you lifted the car.

   d) How much work did you do lifting the car?

10. Lean the board against the books.

    a) Slowly pull the car up the inclined plane with the spring scale.

    b) Record how much force it took.

    c) Measure and record the distance you pulled the car up the inclined plane.

    d) How much work did you do pulling the car up the inclined plane?

11. Compare the work done pulling the car with the work done lifting it. How does it compare?

12. With the inclined plane, what do you pay for the advantage of multiplying the force?

13. Why did it take more work to pull the skate up the ramp?

14. Suppose you lifted a 10 pound cement block and carried it 12 feet. How much work did you do?

15. Suppose you pushed against a semitruck with 50 pounds of force. How much work did you do?

16. You can never get more work out of a machine than you put into it.

17. Give three examples of doing work.

18. Where do you get the energy to do work?

19. Where do machines get the energy to do work?

Test Over Work

A. Circle the correct ending to each statement.

1. To do work a force must

   a. be multiplied.
   b. make something move.
   c. be decreased.

2. A simple machine cannot multiply

   a. speed
   b. work
   c. force

3. If you use a simple machine to reduce your effort, you must

   a. increase the distance your effort moves.
   b. reduce friction in the machine.

4. If there were no friction, the work put into a simple machine and the work gotten out would be

   a. equal.
   b. unequal.

5. The work you get out of a machine is always

   a. more than the work you put into it.
   b. less than the work you put into it.
   c. less useful than the work you put into it.

6. You cannot produce a force if you have no

   a. energy.
   b. machine.
   c. friction.

7. Work is done when

   a. friction is increased.
   b. no friction is available.
   c. a force moves an object through a distance.

8. We use machines to make work
   a. simpler.

b. hard to do..
c. easier to do.

B. Write <u>true</u> or <u>false</u> for the following statements.

____1. A machine can multiply work.

____2. Work is done only when an object is moved through a distance.

____3. Work is a force moving an object through a distance.

____4. By using machines you can multiply force and save work.

____5. You get no more energy out of a machine than you put into it.

____6. A simple machine can multiply force and thus increase work done.

C. Suppose you pushed your bike 100 feet up the hill. You used a force of ten pounds to push the bike over that distance. How much work would you be doing?

Answers to Test over Work

A. 1. (b)
   2. (b)
   3. (a)
   4. (a)
   5. (b)
   6. (a)
   7. (c)
   8. (c)

B. 1. false
   2. true
   3. true
   4. false
   5. true
   6. false

C. 1000 foot-pounds

ACTIVITY 25: Compound Machines

MATERIALS:

meat grinder, hand drill, block of wood

ENABLING ACTIVITY:

Write your answers to each question on paper.

1. Demonstrate to each other how a drill operates.

   a) Identify three simple machines combined in it.

   b) Tell what each simple machine does.

2. Demonstrate the meat grinder to each other.

   a) Identify two simple machines combined in it.

   b) Tell what each simple machine does.

3. Will two simple machines combined into a compound machine multilply work?

   a) What can they do?

   b) Can they save work? Why or why not?

4. Collect five pictures of simple and compound machines.

   a) Put them with your classmates pictures.

   b) Divide into one stack of simple machines and one stack of compound machines.

   c) Divide the simple machines into levers, inclined planes, pulleys, screws, wedges, and wheel and axle. Tell what each one does.

5. Take the stack of compound machines and tell what simple machines each one is made of. Tell what each compound machine is used for.

Test Over Compound Machines

A. Answer the following statements on paper.

1. What simple machines make up the bicycle, juice can opener (puncture type), meat grinder, fork, wheelbarrow, and scissors.

2. Name a compound machine that contains all of the following simple machines: lever, wedge, wheel and axle, and screw.

3. Make a list of simple machines and a list of compound machines you can find in your classroom.

4. Sort the selection of different kinds of simple machines into levers, inclined planes, pulleys, screws, wedges, and wheel and axle.

   a. Describe the use of each one.

   b. Make a chart showing which ones multiply effort, multiply speed, or change direction of force.

5. Name three things simple machines can do.

Answers to Test over Compound Machines

A. 1. bicycle (wheel and axle, gears)
juice can opener (lever and wedge)
meat grinder (wheel and axle, screw)
fork (wedges and lever)
wheelbarrow (lever, wheel and axle)
scissors (levers and wedges)

2. pencil sharpener

5. multiply force, multiply speed, change the direction of a force.

ANSWERS TO ACTIVITIES

Activity 1

2. When you lifted the skate vertically.
3(f) lifting the skate
3(g) yes. It takes less effort to pull the skate up an inclined plane than to lift a skate.
3(h) more
3(i) less (The closer the board is to the horizontal, the less force will be required to raise the skate.)

Activity 2

3. more
4. yes. yes. It takes less effort to pull skate than to lift skate.
5. length of inclined plane
6. Don't give answer to this question yet.
7. Force needed is less. Distance traveled is greater.
8. It was less.
9. up a ramp
10. ramp
11. It is easier to move a load up a ramp, but you may have to move the load over a longer distance than if you lift it into the truck.

Activity 3

1. yes
3. yes
4. lever
5. fulcrum = elbow
   load = object moved
   effort or force = biceps
6. yes
7. A simple machine consisting of a bar with a support (fulcrum) around which it can be turned.

Activity 4

5. It is about half the force. Yes, it multiplies by about 2.

6. The longer the arm to which the force is applied, the less force is needed.

8. The lever reduced the amount of force needed to lift the book.

Activity 5

1(a) lever
 (b) edge of can
 (c) lid
 (d) hand
 (e) by having fulcrum near load and far from effort

2. as a wedge to get under the lid and as a lever to pry the lid off
3. as a wheel and axle
 (a) the top of the screwdriver that is turned by the hand
 (b) the blade that fits in the screw head
4. as near the fulcrum as possible

Activity 6

5. close to the load
6. bottle opener, wheelbarrow, nutcracker, etc.
7. fishing pole, ice tongs, tweezers

Activity 7

5. When it is farthest from the fulcrum. (Responses should show observation of the shifted fulcrum.)
6. When it is farthest from the fulcrum. (Response should show observation of the shifted fulcrum.)
7. downward
8. upward

Activity 8

9. The effort will change with the load, but the ratio between them should remain constant.
10. The effort will change with the load, but the ratio between them should remain constant.

13. greater

Activity 9

4(d) with pulley attached to brick (movable pulley)
4(e) yes, third brick with pulley attached to the brick (the movable pulley)
4(g)(1) a grooved wheel around which a rope may be placed
(2) a simple machine consisting of a single grooved wheel attached to a support
(3) a pulley that is free to move

Activity 10

2(d) less
5. movable pulley. The effort with the movable pulley should be about half. The movable pulley multiplies the effort by 2. The ratio will not be exactly 2 because there is friction between the cord and the pulley and between pulley wheel and its axle.
6. yes. movable pulley. by 2.

Activity 11

8. the same
9. the same
10. half of it
11. multiplies effort by two. (The ratio will not be exactly two because there is friction between the cord and the pulley and between pulley wheel and its axle.)

Activity 12

2. the block and tackle. ¼ as much effort.
3. 4 times. (The effort is multiplied by the number of ropes that support the load.)
5. 4 x 5 = 100 pounds

Activity 13

2. screw
3. screw
4. reduces effort
5. distance
6. greater the incline, the greater the effort and the less the distance
7. ramps in automobile garages, ramps for pedestrians in buildings, bobsled runs, ski slopes, circular stairs.
8. reduce effort, increase distance

Activity 14

1(b) Children infer that one piece of wood must have offered more resistance than the other.

2(a) the one with the greater number of threads

(c) the screw with the greater number of threads. The child should infer the rule that the less the slope of an inclined plane the less the effort needed to overcome a resistance (move a load).

Activity 15

1(g) The turns around the pencil will be the same, but the height of the rise (pitch) will differ with the height of the triangle.

(j) the one with the lowest height

(k) the one with the lowest slope or incline, the one with the most turns

2(d) turn it into the wood. Resistance must be at least equal to effort. If the inclined plane multiplies effort, the load (resistance) would need to be greater to offset effort. When screws work loose in an appliance, the resistance (load) has become greater than effort (force), causing the screw (inclined plane) to turn. Friction, the rubbing effect between the inclined plane of the screw and the wood would also need to be considered.

3. In the first example the load is moving up the inclined plane. When a screw is used, it is the inclined plane that moves. A small force travels through a large distance, round and round the screw, to lift a heavy load a small distance.
4. not unless very loose. rubbing of wood against

the inclined plane of the screw.

5. a simple machine that multiplies effort. It consists of an inclined plane wound around a central post.

<u>Activity 16</u>

1. The wedge multiplies effort force.

2(a) Plane stops the door because door is fixed and cannot climb the inclined plane.

(b) The wedge is moved under or into a stationary object. The inclined plane remains stationary while objects are moved up or down it.

(c) door stop, chisel, axe, hatchet, knife

(d) nail, pins, needles, nose cone of rocket

(e) a simple machine, consisting of an inclined plane that can be forced into or between objects to spread them apart.

3(a) the fibers are pushed apart

(b) much force, such as by a hammer, one kind of lever

(c) Fibers of wood resist effort.

(d) nail. All force concentrated at a point.

<u>Activity 17</u>

1(a) wheel and axle

(b) the wheel and axle multiplies your effort.

2(a) When the large gear wheel is turned by the handle, the small gear wheel turns too.

(b) yes

(c) yes

3(b) the large gears

(c) the small gears

(d) no

(e) speed and effort

4(b) about four

(c) Speed is multiplied about four times.

6. Infer that a force on one gear is transferred to another gear, and this froce makes the second gear operate as a wheel and axle. The <u>force is multiplied</u> at the axle of the small gear. The beater blades move through a much larger distance than the axle. So the <u>axle multilplies speed</u> and makes the blades turn faster.

Activity 18

1(d) the one on the tire
(e) the force and wheel turn in the same direction.
(f) Lever changes direction of a force.
(g) most moving wheeled vehicles
2(a) Speed is multiplied a great deal at the rim of the rear wheel.
(b) less
3. still less than to turn the pedal itself. (The child should infer that a speed multiplier can be changed into a force multiplier by reversing the position at which effort is applied, the back wheel.)

Activity 19

1(b) to overcome friction
(c) The backward pull results from friction, the rubbing of two surfaces.
2(b) The rougher surface produces more friction.
3(b) The smooth surface of the waxed paper helps to reduce friction between the block and the surface.
4. sandpaper
5. wax paper
6. sandpaper. waxed paper,
7(c) Layers of oil rub against each other with very little friction. The smoother the surface the less friction.
8(a) yes
(b) Increasing the weight will increase the pressure of one surface on another taking more force to move.

Activity 20

4. the oiled piece of glass. It takes less effort because the oil reduces the force of friction.
5. may slip down. There is very little friction. Oil and water fills and smooths out the tiny pits and hollows.

Activity 21

1(a) the round objects
(b) Objects that roll have less friction than objects that slide.
(c) Rolling friction is less than sliding friction.
2(c) It is easier to move your hands back and forth with a pencil between them than it is to just rub them back and forth. When you rub them back and forth the complete surface of both hands are rubbing causing a lot of rubbing friction. When you use a pencil only one part of the pencil is touching at a time causing less friction. This is rolling friction.

Activity 22

1(d) all of it
2(c) none. one point at a time.
(e) You have rolling friction now causing less friction, therefore, needing less effort to move.
(f) less
3(c) sliding firction
4(b) heat
(c) Heat causes expansion of pencil. It increases friction.
(d) It would not be possible to stop them from rolling by applying breaks, which depend on friction.
(e) special tire and shoe treads, brakes, handle grips, rosin or violin bows
(f) Oil the hinge to give a smooth surface to the working parts.
5(f) the one rubbed on rough paper toweling
(g) the one rubbed on the rough paper toweling
(h) The greater the friction between two surfaces, the greater the heat energy produced.

Activity 23

1(b) heat
(c) Heat causes expansion of pencil. It increases friction.
(d) It would not be possible to stop them from rolling by applying brakes, which depend on friction.
(e) special tire and shoe treads, brakes, handle

grips, rosin on violin bows
2(f) lubricate hinges to cut down on friction.
(g) the one with the toweling
(h) the greater the friction between two surfaces, the greater the heat energy produced.

Activity 24

3. made work easier
4. used more rope
5. large effort at axle
6. wasted as heat
12. the force must be applied through a greater distance.
13. friction is greater.
14. 120 foot-pounds
15. none, because you didn't move anything through a distance.
18. from food
19. fuel, engines

Activity 25

1(a&b) wheel and axle turns and changes the direction of force.
gears turn the bit (an inclined plane or screw)
bit (an inclined plane or screw) when turned in a piece of wood shows that the wood has climbed the inclined plane.

2(a&b) wheel and axle multiplies effort
a screw - a winding inclined plane, multiplies effort force.

3. no
(a) multiply effort more than one simple machine
(b) no, Work out of a machine is never more than work put into it.

Flower Parts and Their Functions

The unit on Flower Parts and Their Functions can be introduced by using an overhead transparency to point out the parts of a flower and their functions. The teacher can then use a real flower to demonstrate how it can be disected, pinned on a piece of cardboard, and its parts labeled while discussing, again, the function of each part.

The students can then use their study guide and the two diagrams to do the learning stations. It works well with no more than five students in a group with one appointed as leader. The activities are set up so that each child has something to do. Since some groups work slower than others, not all groups will finish all seven activities. This is alright since some activities reteach the same material but in a different way. Rotate the groups through the first five activities first, then the last two. It takes two or three days to rotate through the activities. The students can then be called back into a large group to summarize the material and review for a test.

Florists are very willing to save non-usable fresh flowers for school use. Funeral homes are also willing to furnish the school with unwanted flowers.

WHAT IS A FLOWER? (Study Guide)

Let us examine the parts of a flower. Check with Figure A as you read.

The most important parts of a flower are the stamens (Stay minz) and the pistil.

STAMENS

The stamen is the male part of a flower. Most flowers have several stamens.

A single stamen has two parts: A thread-like filament (FIL a mint), and a knob-like anther. The anther is at the top of the filament.

An anther makes a powdery substance called pollen. Pollen is made of a great number of pollen grains. Pollen grains are the sperm cells of a plant. Pollen gets scattered by wind or insects.

PISTIL

The pistil is the female part of a flower. It is located in the center of the flower--inside the circle of stamens. Some flowers have more than one pistil. The stigma may be fuzzy, bumpy, or flat. It is often sticky on top.

The lower part of a pistil bulges. This bulge is the ovary (OH vuh ree). There are hollow spaces inside the ovary that have small round ovules. An ovary contains one or more ovules (OH vyoolz). Each ovule has an egg cell. Fertilization of an egg by a pollen grain takes place in the ovule. Some pollen grains reach the stigma and stick there. They grow tubes down toward the ovary. When a pollen tube reaches an egg cell, the egg is fertilized. Once the egg is fertilized no other tubes will grow into it. A fertilized egg becomes a seed. The fertilized egg that you know as the seed has a tiny plant inside. Together the ovules and ovaries grow and ripen into fruits. What will a seed produce?

Worksheet 1: PARTS OF A FLOWER

Study Figure A, then fill in the blanks.

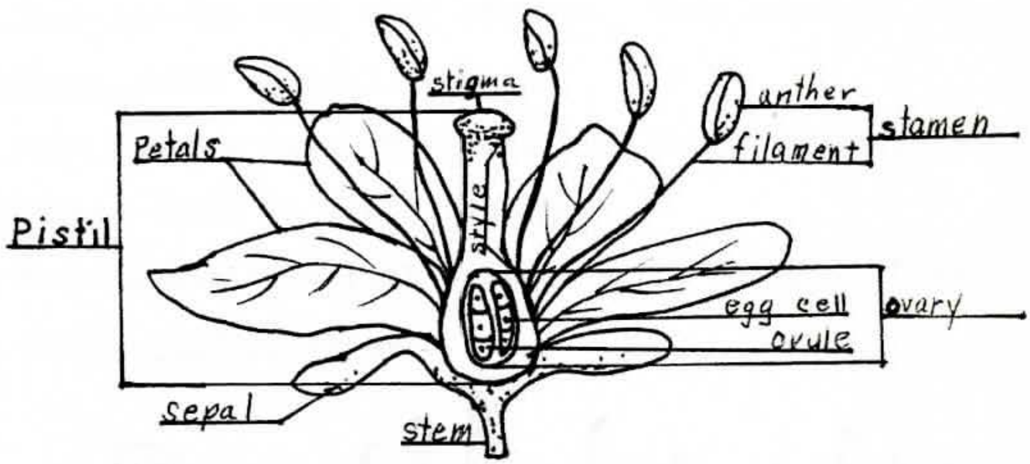


Figure A, a diagram of a flower

1. Name the male part._____________
2. Name the female part.______________
3. Pollen is made by the __________.
4. Eggs are made by the _____________.
5. How many stamens does this flower have? _________
6. a) Name the parts of a stamen.________ __________

   b) Which part of a stamen makes the pollen?________
7. What is the swollen part of a pistil called?________
8. a) How many ovules does this ovary have?__________

   b) How many eggs?________

   c) How many eggs are in each ovule?__________
9. How many seeds may this flower produce?________
10. What do you call a flower's colorful leaf-like parts?____________

Worksheet 2: FEMALE OR MALE--OR BOTH?

Some flowers have only stamens. They are male or staminate (STAM uh nit) flowers.

Some flowers have only pistils. They are female or pistillate (PIST uh late) flowers.

Most plants have both stamens and a pistil. They are called perfect flowers.

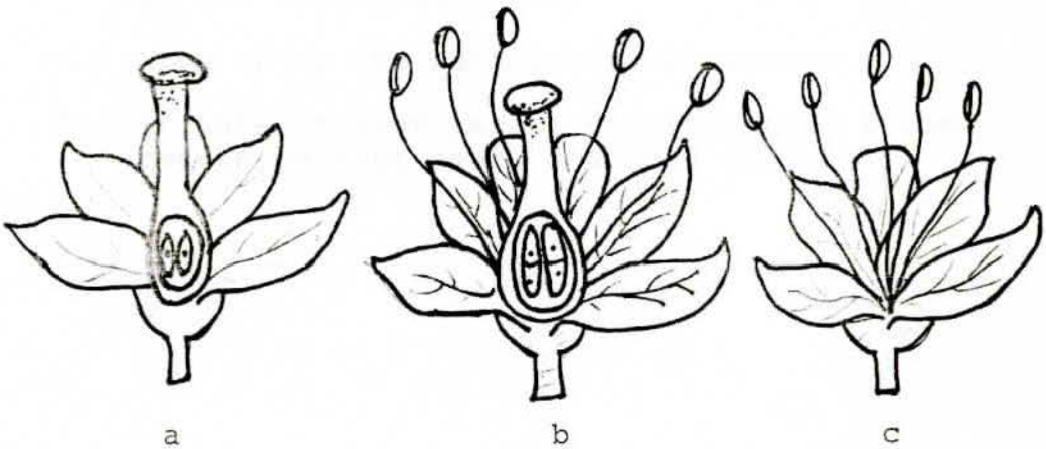


Figure B

Study the flowers in Figure B, then answer the questions by letter.

1. Which is a staminate flower?____

2. Which is a pistillate flower?____

3. Which is a perfect flower?____

4. Which makes only pollen?____

5. Which makes only eggs?____

6. Which makes pollen and eggs?____

7. Which ones can produce seeds?____

8. On the perfect flower is the stamens higher or lower than the pistil?_________

ACTIVITY 1: The Parts of a Flower

MATERIALS:

1 pencil, activity 1 worksheet, 1 study guide

ENABLING ACTIVITY:

1. Use your study guide along with diagram A to work your worksheet.
2. When you are finished put your name on the worksheet.
3. Place your finished worksheet and study guide in the appropriate box.
4. Move on to the next activity center.
5. If this is your last activity choose a book, return to your seat, and read and enjoy.

ACTIVITY 2: Three Kinds of Flowers

MATERIALS:

1 pencil, worksheet 2, 1 study guide

ENABLING ACTIVITY:

1. Use your study guide along with diagram B to work your worksheet.
2. Put your name on the top right hand corner of your worksheet.
3. Place your finished worksheet, study guide, and pencil in the appropriate box.
4. Move on to the next activity center.
5. If this is your last activity choose a book, return to your seat, and read and enjoy.

ACTIVITY 3: Discover the Parts of a Flower

MATERIALS:

1 flower, 1 hand lens, 3 by 4 inch piece of black paper, 8 straight pins, 4 by 5 inch piece of cardboard, 1 piece of paper, 1 pencil, diagram A

ENABLING ACTIVITY:

Write answers to all questions on paper.

1. Choose a partner.
2. Take a flower and carefully remove the petals from one side of the flower.
3. How many stamens does your flower have? How many pistils does it have?
4. Look closely at the stamen to find the thin fillament and the anther.
5. Gently touch each anther.
6. What is now on the tips of your fingers?
7. Dust some pollen grains on the piece of black paper.
8. Look at them carefully with the hand lens.
9. Draw the shape of the grains on your paper and color them. Compare the shape and color with other groups. What did you find out?
10. Study the pistil, the large "stem" in the center of the flower.
11. With the straight pin, carefully cut the ovary and look inside for one or more ovules. How many did you find? How many seeds are in each one?
12. Pin the parts of the flower to the cardboard and label all 12 parts.
13. Put your names on the bottom right hand corner of the cardboard and place it on the cabinet.

14. Put all of the materials back into the appropriate containers.

15. Move on to the next activity center.

16. If this is your last activity choose a book, return to your seat, and read and enjoy.

ACTIVITY 4: Draw the Parts of a Flower

MATERIALS:

1 flower, colored pencils, ½ piece of white construction paper, glue, 1 piece of colored construction paper, diagram A

ENABLING ACTIVITY:

1. Take a piece of white construction paper.
2. Use colored pencils to draw and shade the parts of your flower.
3. Label the 12 parts of the flower. Use diagram A for help. Be as neat as possible.
4. Put your name in the bottom right hand corner of your picture.
5. Use the glue to paste your flower drawing on a piece of colored construction paper, making a frame for your picture.
6. Put your drawing on the cabinet to dry.
7. Put your materials back in the appropriate places.
8. Move on to the next activity center.
9. If this is your last activity choose a book, return to your seat, and read and enjoy.

ACTIVITY 5: Observing Pollen and Stamen

MATERIALS:

3 different varieties of flowers, microscope, three slides, transparency pen, 2 pieces of white paper, colored pencils, tweezers, scissors

ENABLING ACTIVITY:

1. Choose a partner to help you.
2. Collect three different kinds of flowers.
3. Put the names of the flowers, each on a different slide.
4. Dust some grains of pollen from each of the different flowers on the appropriate slide.
5. Take turns observing them under the microscope.
6. Notice the different shapes, sizes, and colors.
7. Each one of you draw the shape, size, and color of the grains of pollen from each flower on a piece of white paper.
8. Put the name of the flower by its appropriate pollen grain drawing.
9. Use the scissors to cut the stamen from each flower. Place the stamen on the appropriate slide and observe through the microscope.
10. Notice the shape, size, and color of each stamen and draw the stamen from each flower on your piece of white paper and label with the name of the flower.
11. Label each flower as a staminate, pistillate, or perfect flower.
12. Put your name on your paper. Clean up and put your materials back in the appropriate places.
13. Move on to the next activity center.
14. If this is your last activity choose a book, return to your seat, and read and enjoy.

ACTIVITY 6: Flower Concentration

MATERIALS:

9 file cards cut in half, 4 pencils, 4 study guides, 4 diagram A, 4 diagram B, rubber band

ENABLING ACTIVITY:

1. Choose three other classmates to play with you.
2. Use the following words to make the game cards: stigma, style, ovary, ovule, egg cell, pistil, stem, petals, anther, filament, stamen, pollen, staminate flower, pistillate flower, perfect flower, fertilization, and sepal.
3. Put the word and the fuction or meaning on one side of the card. Three people do four words. One person do five words.
4. Make two cards for each word.
5. Divide the cards into two stacks. Be sure you keep both cards for each word together.
6. Two students play with half of the cards and the other two students play with the other half.
7. To play concentration shuffel the cards and place them on the table with the word side down.
8. Take turns turning two cards over.
9. If they match read the cards outloud, keep them, and take another turn.
10. If they do not match return the cards face down on the table where they were.
11. The next person takes a turn.
12. The student with the most cards wins.
13. Play at least three games.
14. Then switch cards with the other team.

15. Play three games with the other half of the cards.

16. Put a rubber band around your cards. Put your names on a piece of paper and put it with the cards.

17. Put all materials back in the appropriate places and move on to the next activity center.

18. If this is your last activity choose a book, return to your seat, and read and enjoy.

ACTIVITY 7: Flower Bingo

MATERIALS:

4 bingo sheets, 5 pencils, at least 100 one inch squares of construction paper, 6 pieces of paper, 5 study guides, 5 diagram A, 5 diagram B

ENABLING ACTIVITY:

1. Choose four students to play with you.

2. Choose one of the members to read the questions to the group while the other four play with bingo cards.

3. Each member playing should make a bingo sheet.

4. Put the following words on the bingo sheet: stigma, style, ovary, ovule, egg cell, pistil, stem, petals, anther, filament, stamen, pollen, staminate flower, pistillate flower, perfect flower, fertilization, and sepal.

5. Put a free square in the middle of the sheet.

6. Use some of the words twice so all 25 squares will be filled. Put your name on your bingo sheet.

7. Three members take three words each and two members take four words each. Make a question for each one of your words and write it on paper. Write the answer after the question. Put your name on your questions.

8. Give your questions to the question reader.

9. Bingo players take turns answering.

10. If the student answers correctly on his turn, all four players puts a construction paper square on his bingo sheet.

11. If the student can't answer correctly on his turn, no one puts a construction paper square on his bingo sheet. The questioner will give you the answer and put the question at the bottom of the stack.

12. Play until two people bingo or until all questions have been asked.

13. Write the names of the winners on a piece of paper and place in the appropriate box.

14. Put all materials back in the appropriate places and move on to the next activity center.

15. If this is your last activity choose a book, return to your seat, and read and enjoy.

Test Over Flower Parts and Their Functions

Write the correct names of the flower parts in Figure C on the blank lines. Choose from the following:

pistil	stem	ovary
anther	ovule	stamen
petals	filament	egg
sepal	stigma	style

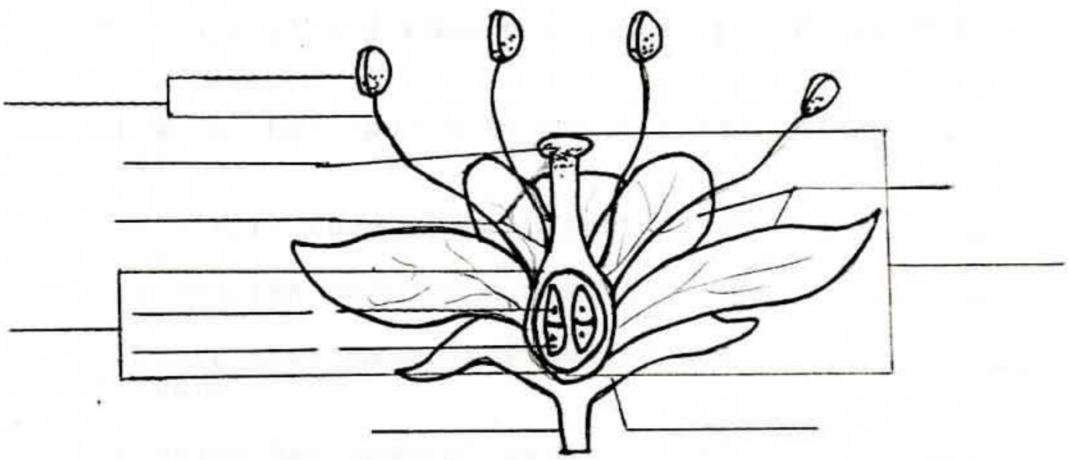


Figure C

Write T on the line next to the number if the sentence is true.

Write F if the sentence is false.

1.____There are male plants and female plants.

2.____Some plants are both male and female.

3.____The most important parts of a flower are the stamens and the pistil.

4.____Stamens are female parts.

5.____Stamens make egg cells.

6.____An ovary has at least one ovule.

7.____One ovule has many eggs.

8.____A fertilized egg becomes a seed.

Complete the sentences with the choices below.

Some of these may be used twice.

stamens	anther	egg cell
staminate	pistillate	ovules
ovary	seed	perfect
fertilization	pistil	pollen

1. The male part of a plant is made up of several ____________.

2. The part of a stamen that makes pollen is the ______________.

3. Flowers that have only pistils are called _________ flowers.

4. The entire female plant part is the ___________.

5. The swollen part of a pistil is the ______________.

6. Flowers that make only pollen are called __________ flowers.

7. An ovary has special parts called _____________.

8. An ovule contains a single ______________.

9. A fertilized plant egg cell becomes a ___________.

10. Flowers which make pollen and eggs are called ____________ flowers.

11. When a pollen tube reaches an egg cell and fertilizes it, that is called _____________.

Flower Parts and Their Functions

Answers to Worksheet 1

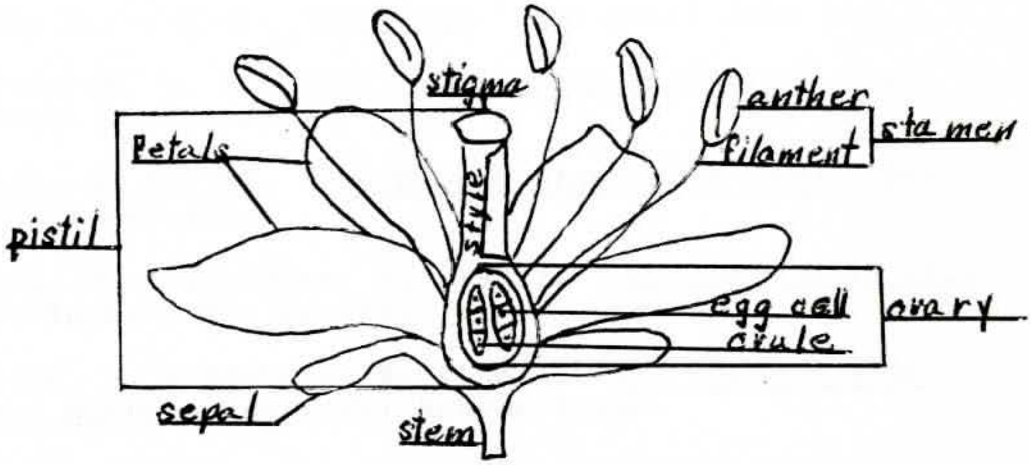
1. stamen
2. pistil
3. stamen
4. ovary
5. 5
6. a) anther, filament
   b) anther
7. ovary
8. a) 6
   b) 6
   c) 1
9. 6
10. petals

Answers to Worksheet 2

1. c
2. a
3. b
4. c
5. a
6. b
7. a & b
8. higher

Answers to Test over
Flower Parts and Their Functions

Flower parts



True and False

1. true
2. true
3. true
4. false
5. false
6. true
7. false
8. true

Sentence completion

1. stamens
2. anther
3. pistillate
4. pistil
5. ovary
6. staminate
7. ovules
8. egg cell
9. seed
10. perfect
11. fertilization

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