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ABSTRACT

Designed to assist the teacher in introducing a unit on research and experimentation into his/her industrial arts program, this manual provides information for adoption to both classroom instruction and laboratory activities, and a student workbook. The instructor's section includes (1) What is Research? (2) Importance of Research and Experimentation, (3) Types of Research, (4) Kinds of Tests, (5) Methods of Testing Materials (field and laboratory testing), (6) Designing a Laboratory Experiment, (7) Variables, (8) Controlling Variables, (9) Control Groups and Experimental Groups, (10) Apparatus and Special Equipment, (11) Sample Experiment, (12) Analysis of the Experiment, (13) Career Opportunities in Research, (14) Words and Phrases the Students Should Know, and (15) Sources of Additional Information. The student workbook section provides two examples of forms to be used, one for planning the experiment and one for conducting the experiment. (HD)

Research and Experimentation for the Industrial Arts Student

Sponsored by the

Division of Vocational and Technical Education
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HOW TO USE THIS MATERIAL

As an industrial arts teacher you are aware of the importance of research and experimentation in modern industry. Through research and experimentation, our industries have learned to produce more and better products, which have enabled us to enjoy a standard of living unsurpassed in history.

You are also aware that the primary purpose of industrial arts is to provide an appreciation and understanding of industry to the students enrolled in your program. Obviously, as research and experimentation is so important to industry, your program should include some instruction on this topic.

This material has been developed to assist the teacher in introducing a unit of instruction on research and experimentation into his/her industrial arts program. The intent is to provide information on this topic for adoption to both classroom instruction and laboratory activities.

In presenting your instructional program, the objectives should be made clear to the students. The objectives are to:

1. Develop a basic knowledge of the importance of research and experimentation in industry.

2. Develop a basic awareness of the types of experimentation and testing commonly used in industry.

3. Make the student aware of what is involved in setting up and conducting a simple experiment.

4. Make the student a better consumer of research findings.

5. Reinforce industrial arts activities in materials and industrial processes.

Although your students will be primarily interested in and will engage in experimentation that can be performed in the industrial arts laboratory, they should be presented information to make them aware of the broad field of research. They should know, for example, that there are different types of research which are undertaken for various reasons. They should be familiar with the difference between field testing and laboratory testing and the reason for selecting one or the other. Some test methods destroy the material being tested, whereas some do not damage the material. Your students should be informed of these testing methods and their characteristics.

Study the material carefully. Information is provided for you to use in conducting several classes as you introduce and discuss with your students the area of research and experimentation of industrial materials. The examples presented in this manual are built around television commercials with which your students may be familiar. You may wish to conduct an experiment for your class. The sample experiment presented should prove helpful.

The laboratory activities for this unit should center around student experiments. You may wish to divide your class into four- or six-man teams. Each team should be charged with the responsibility of selecting, setting up, and conducting an experiment. After this has been done, it may be of value to have each team explain their experiment, findings, and conclusions to the entire class.

The student material consists of a work booklet for use as the team undertakes their experiment. Ample space is provided for the team to "think through" their experiment. You will want to check their progress before they actually conduct the experiment. Space is also provided on the work sheet for the team to record their findings and present their recommendations.

RESEARCH AND EXPERIMENTATION FOR THE INDUSTRIAL ARTS STUDENT

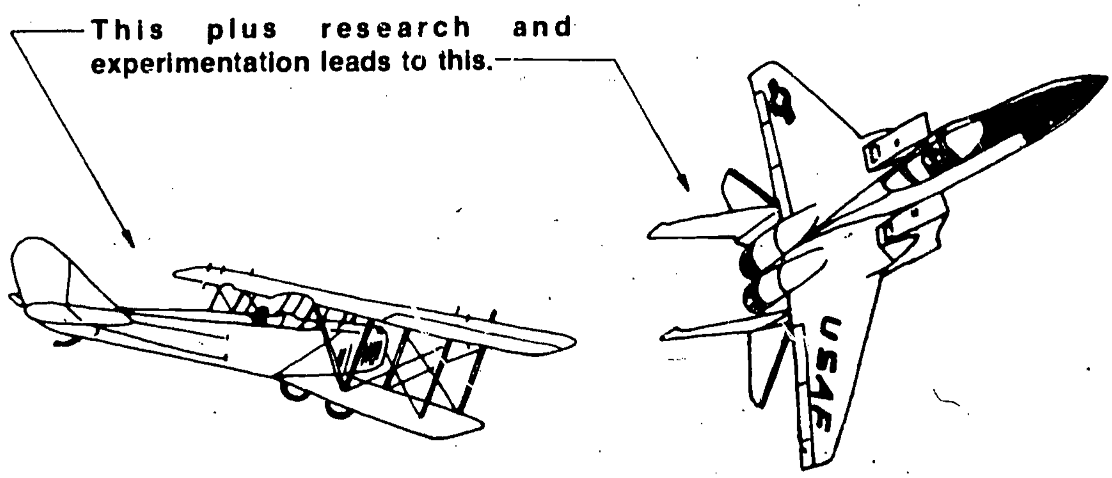
What Is Research?

Research is a systematic process carried on to solve a problem. It is not something new. Man has been conducting research since the dawn of civilization. His efforts at solving problems have been most successful. The abundant life we enjoy today—better foods with higher nutritional value, better products to make our lives easier and more enjoyable, and better ways to prevent and treat disease, thereby creating a greater life expectancy—has come about as a result of research.

Some research is very complicated because the nature of the problem to be solved is extremely complex. Research of this type is carred on by scientists having many years of professional training and experience. A large amount of research, however, is not complicated and is carried on by ordinary people, on ordinary jobs, almost every day of the year. The housewife who is trying to live within the family budget often undertakes research when attempting to get the best food buys for her money. This may consist of little more than reading supermarket ads in the daily newspaper or comparing labels at the grocery store. Most people who are buying an automobile undertake some comparison research before making the purchase. Students at all levels of our educational ladder do research in connection with reports and term papers required in their classes.

Importance of Research and Experimentation

Research and experimentation have played an important role in the technical advances we all enjoy today. Through research and experimentation, man has discovered new and better ways to provide us with a better life. The thousands of industrial products which we use daily had their beginning with research and have been constantly improved through experimentation and testing.



Experimentation is usually done to test something. Every day in industry thousands of decisions must be made concerning products being developed or built. These decisions usually center around the design of a product, materials to be used, or methods of construction. In obtaining data (information) on which to base these necessary decisions, industry must experiment to test the value and feasibility of one design, material, or method over others.

Experimentation is not confined to work being done by scientists and technicians in laboratories. Often the worker on the job site must conduct simple experiments when the need arises to substitute available materials for those not available or to improvise new methods when old methods will not work in a particular situation. As research and experimentation are so important to industry, students engaged in studying about industry should develop a basic understanding of this topic.

Types of Research

There are two main classifications of research. These are: (1) basic research and (2) applied research. Basic research attempts to uncover "mysteries" about the universe and laws of nature that affect our lives. Research of this type is extremely important but is not intended to seek knowledge about, or find solutions to a particular problem. Applied research does attempt to solve particular problems. Such problems may center around how to improve a product, how to create a substitute for it, or how to reduce the time and cost needed in its manufacture.

Because of the cost involved, basic research is limited to a few of the larger corporations, universities, and some branches of the government. Applied research in some form, however, is carried on by practically all companies when seeking solutions to problems affecting their operations.

Kinds of Tests

Two kinds of tests can be used in obtaining data about industrial materials or products. These tests are called: (1) destructive tests and (2) nondestructive tests.

As their names imply, in one kind of test the material or product is destroyed during the test, whereas in the other kind it is not destroyed during testing. The kind of test used is determined by the purpose for which the material or product is being tested. To determine if a television has been correctly assembled, there is no reason to destroy the set in obtaining this information. If the purpose, however, is to determine the amount of impact the protective glass on a television can absorb before breaking, it is necessary to destroy the glass to obtain this information.

Because of the cost sometimes connected with destructive testing, much research and experimentation has been devoted to finding ways and means of obtaining the same information through nondestructive testing. At one time the only means of determining if a weld had been made correctly was to break the weld for examination. This information can now be obtained by means of X-ray, which does not destroy the materials welded together.

Methods of Testing Materials

The two most common types of testing used on industrial materials and products are: (1) field testing and (2) laboratory testing. Each of these two types of testing has advantages and disadvantages. The researcher must be familiar with both types to be able to select the one best suited for the material he wishes to test.

Field testing. In this type of testing the material is subjected to the actual conditions for which it is intended to be used. The durability of house paint could be field tested by painting several houses and observing how they "stand up to the weather" over a period of a year. The wearability of automobile tires, likewise, could be field tested by driving them and observing how they hold up.

The advantage of field testing a product is that the test is conducted using the same condition under which it will later be used by the consumer. The greatest disadvantage of field testing is that it takes too much time. Testing the durability of house paint, mentioned above, might take many years before data can be collected upon which to base findings.

Testing by this method takes too long.

During times of emergence when a product has to be hurriedly developed to meet a particular need, field testing might be out of the question because of the time required. The need for the product may no longer exist by the time the testing has been completed. At other times, considering the nature of the product, field testing may not be desirable because of the danger involved.

Laboratory testing. Laboratory testing is the most common type of testing used to gain information about industrial materials or products. In laboratory testing conditions or factors are simulated to be as close to actual conditions as possible.

In the laboratory variables can be controlled. This makes it easier to determine the effect that one variable plays on materials or products because the other variable can be kept constant. The greatest advantage of laboratory testing over field testing is the time saved in obtaining data (information) on which to base conclusions and recommendations.

Designing a Laboratory Experiment

In designing a laboratory test the researcher must know what the "actual conditions" are so that they can be simulated in the laboratory. Testing the durability of house paint, mentioned before, can be used as an example. In deciding what will affect "durability," the researcher must first identify the various conditions to which paint on a house will be subjected. Blistering heat, freezing cold, rain, sleet, snow, wind and sandstorms, along with pollen, dust and smoke in the air will all have an effect on the paint. These conditions must therefore be simulated in the laboratory test. This can be done with the aid of heat lamps, fans, refrigerators, water hoses, sprinkling devices, and other means.

Using this same example, a comparison of the time required in obtaining data from the two kinds of tests is easy to understand. In field testing, blistering heat and freezing cold suggest a period of one full year waiting for "Mother Nature" to provide a summer and a winter to affect the house paint. In a laboratory test using heat lamps and refrigerators, the heat and cold equal to a full winter and summer could be simulated in only a few days.

Variables

Variables are those "things" or factors which have an effect on the material or product being tested. Suppose a newly designed airplane is to be tested to determine how the design affects air speed. In conducting the test it must be realized that design is only one of the variables affecting the speed of an airplane. Many other variables also have an effect on the speed of an airplane as it moves across the sky. Some of these variables are: weight of the airplane; load carried; wind speed; wind direction, altitude of the airplane; horsepower of the engine; mechanical condition of the engine, octane rating of fuel; amount of fuel; and position of flight—climbing, level or diving. These variables must be known and controlled in order to test what effect the new design has on air speed.

Controlling Variables

How can some variables be controlled to test the one variable under consideration? This is done by carefully designing an experiment which will "cancel out" or control all variables except the one being tested.

For example, suppose an oil company claims its newly developed gasoline will deliver more miles per gallon that the gasoline of its competitors. An experiment can be designed to prove this claim to be either true or false. The experiment must be carefully controlled, however, so the results—either more mileage, the same mileage, or less mileage—can be contributed to the newly developed gasoline and not to some other factor or combination of factors.

Let us look first at an experiment to test the oil company's claim where the variables are not controlled. The gas tanks of two automobiles are filled, one with the newly developed gasoline and the other with the competitor's gasoline. The cars are

This does not prove a thing.

driven until both run out of gasoline. When a comparison is made, it is learned that the automobile using the newly developed gasoline traveled a distance of 75 miles farther than the car using the gasoline of the competitor. Has this experiment proved the oil company's claim of more mileage from its gasoline? Of course not. Many other things, called variables, could have resulted in the increased mileage. This list of variables might include a larger gas tank, smaller engine, better tuned engine, smaller automobile, better tires, better roads traveled, lower driving speed, fewer number of starts and stops, lower speed of starts, mostly highway driving, air conditioner not used, less weight carried in the car, and better driving habits of the driver. Any of these factors or combination of factors could have caused one automobile to travel 75 additional miles on one tankful of gasoline.

Now let us examine how the experiment could be designed to control all the variables except the one being tested—the newly developed gasoline and the competitor's gasoline.

All of the above-mentioned variables can be controlled, or canceled out, by using the same automobile, the same driver, and the same road conditions. The only variable allowed to differ should be the gasolines to be tested. In conducting the experiment, add one measured gallon of the newly developed gasoline into the car's empty tank and drive the automobile until all the gas has been used. Record the mileage driven. Repeat this procedure again, using one measured gallon of the competitor's gasoline. In driving, the same speed should be attained, and the same number of starts and stops should be made. After the automobile has used all of the gasoline, record the mileage driven.

In a comparison test such as this, the experiment should be conducted about six times, three times each with the different kinds of gasoline. The mileage driven using each type of gas should be averaged, and then the averages compared. Under these conditions if a difference in mileage is found, it can be attributed to the difference in the kinds of gasoline. The data obtained from this experiment will prove the oil company's claim to be either true or false.

Why was only one gallon of gasoline used each time instead of a tankful? There are two reasons for this. First, the experiment does not take as long and, therefore, the data is obtained more quickly. The second reason has to do with controlling variables. Remember it was necessary to drive at the same speed and with the same number of starts and stops each time. The longer it takes to conduct the experiment, the more difficult it becomes to keep speed and number of starts and stops equal.

In this sample experiment it is easy to understand why the difference, if any, found between the mileage obtained using the different gasolines can be attributed to the fuel. As all other variables that could affect mileage were controlled, any difference found can be, without question, attributed to the gasoline—the one variable being tested.

Control Groups and Experimental Groups

The terms control group and experimental group identify the things or groups being used in the experiment. In the control group, sometimes referred to as the controlled sample, the variable being tested is not applied. In the experimental group, sometimes referred to as the experimental sample, the variable being tested is applied.

Generally, the control group is treated in the normal method. The experimental group is treated exactly the same, except that the variable being tested is applied. In this way whatever difference is observed can be contributed to that particular variable.

Apparatus and Special Equipment

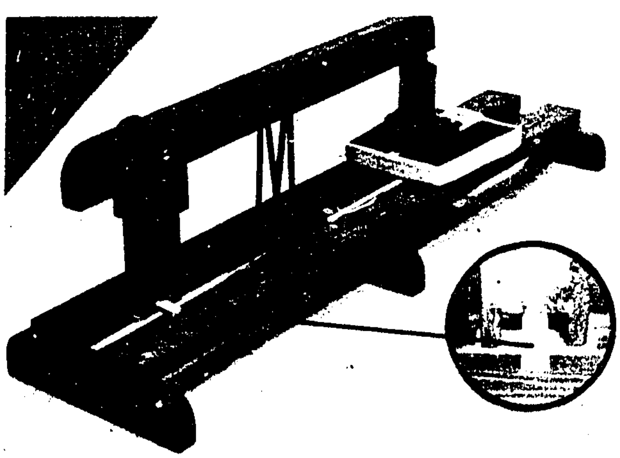
Some experiments your students may want to conduct will require apparatus and special equipment not commonly found in the industrial arts laboratory. In this case efforts should be maae to construct apparatus from material available in the laboratory and equipment borrowed from home. Planning and constructing such apparatus should prove to be a profitable learning experience for your students.

A publication entitled **Experiments with Materials and Products of Industry,** by Arthur W. Earl, will be extremely valuable for ideas concerning apparatus you can construct. If not already in your library, make every effort to obtain a copy.

The following examples of apparatus constructed from available and borrowed materials which have proved very satisfactory in conducting experiments should give an indication of the possibilities:

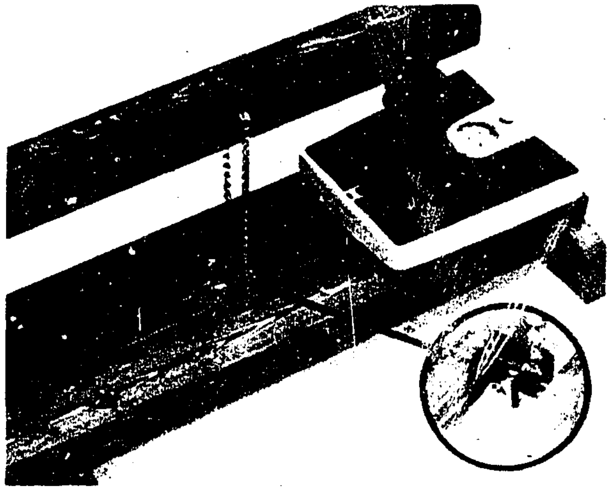
Example No. 1

This apparatus was constructed for conducting experiments requiring a push or pull force, such as testing the holding power of nails, screws, or glues. The force is supplied by the jack, and accurate readings can be observed on the bathroom scale.



A pushing action. Apparatus being used to break a wood joint while testing the holding power of certain glues.

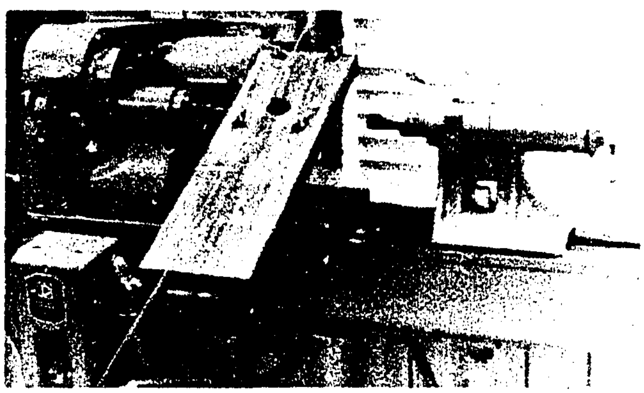
Example No. 1, cont'd.



A pulling action. Apparatus being used to pull a screw from a board while testing the holding power of wood screws.

Example No. 2

This apparatus was constructed for conducting experiments to determine the wearability of various floor coverings.

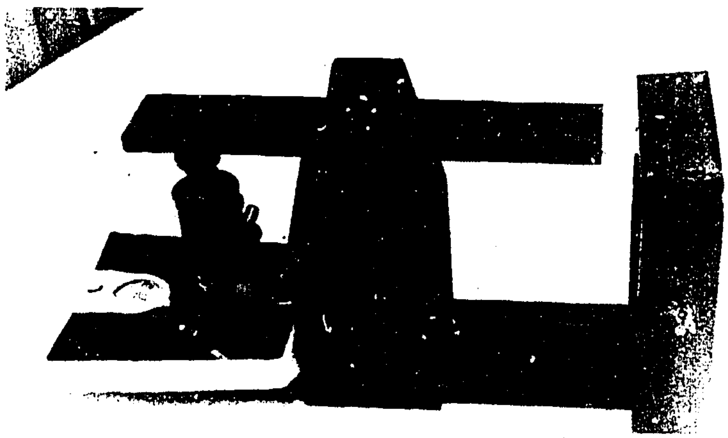


Attached to the bed of the lathe and resting against an abrasive drum, months of normal wear are simulated in only a few minutes.

If a lathe is not available this apparatus can be used with a grinding machine to simulate the same action.

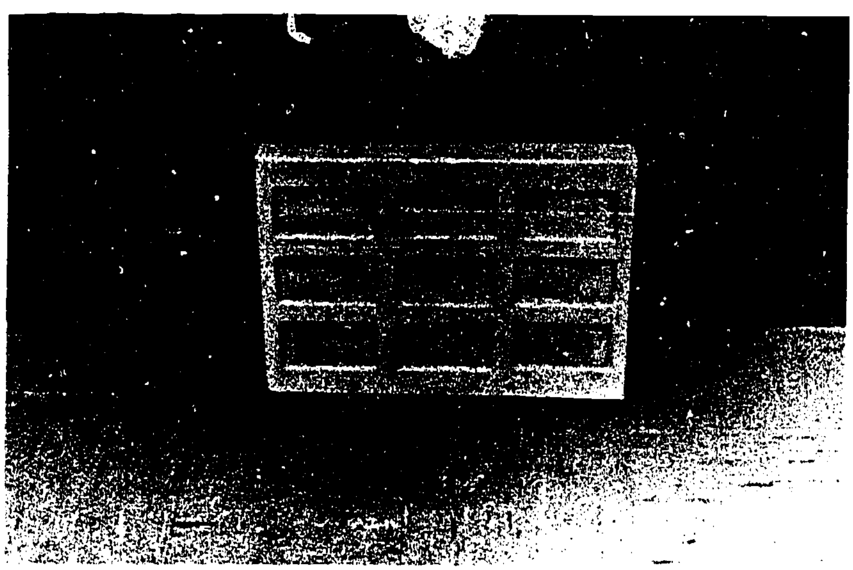
Example No. 3

This apparatus was designed to perform a shear test on different materials. It can also be used to determine the force required to bend certain materials.



Example No. 4

This mold was made to pour samples to test the characteristics of slip. Samples can also be used in other ceramic experiments, such as testing glazes.



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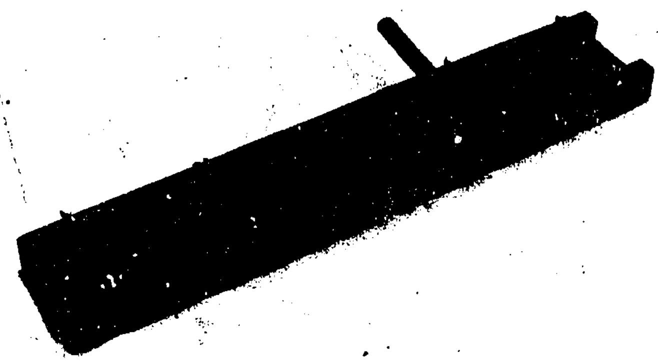
Example No. 5

This apparatus was built to test various abrasive paper. The brick applies a constant weight as it is moved back and forth. Wing nuts allow quick change of the paper.



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A SAMPLE EXPERIMENT

IMPORTANCE OF WOOD PREPARATION FOR FINISHES

INTRODUCTION:

Have you wondered why your instructor is so strict in insisting that projects be properly sanded before applying finishes? A sample experiment can be conducted which will help you decide whether or not this is necessary to produce a beautiful finish.

PROBLEM:

Conduct an experiment to determine the importance of proper wood preparation (sanding) before applying finish. Be careful to control all variables except the one being tested—sanding vs. non-sanding.

MATERIALS AND SUPPLIES NEEDED:

1. One 3/4" x 3" x 18" white pine board free of knots with uniform grain
2. Saw
3. Coarse, medium, and fine sandpaper
4. Sanding block
5. Dark pigmented oil stain (such as walnut)
6. Brush
7. Soft rag

PROCEDURE FOR CONDUCTING EXPERIMENT:

1. Cut six samples 3/4" x 3" x 3" from same board.
2. Number back of samples one through six. (Designate even-numbered samples as the control group and odd-numbered blocks as the experimental group.)
3. Sand surface and one sawed edge of three samples in experimental group with coarse and medium sandpaper.
4. Sponge experimental samples with a damp cloth to raise grain and let dry.
5. Sand experimental samples with fine sandpaper.
6. Apply an even coat of stain to one of the samples and wipe the excess off immediately with soft rag. (Be sure to cover your work area with newspaper.)
7. Repeat Step No. 6 on the remaining 5 samples.

GATHERING DATA:

Have three students from the class rate each of the six samples using the rating scale below. They should rate the samples by numbers and should not be told which ones are designated experimental or control. Their findings should be recorded in the rating box below.

1. Scratches
   3. Excellent—No evidence of scratches
   2. Good—Slight evidence of scratches
   1. Poor—Numerous scratches
2. Smoothness
   3. Excellent—No evidence of roughness
   2. Good—Slight roughness or fuzzy feeling
   1. Poor—Very rough
3. Mill Marks
   3. Excellent—No mill marks
   2. Good—Slight evidence of mill marks
   1. Poor—Numerous mill marks
4. Saw Marks
   3. Excellent—No saw marks
   2. Good—Slight evidence of saw marks
   1. Poor—Numerous saw marks
5. Evenness of Stain
   3. Excellent—Color even over entire area. No streaking or dark spots
   2. Good—Slight evidence of streaks and dark spots
   1. Poor—Variation of color evident

SAMPLE NUMBERS

	1	2	3	4	5	6
Scratches						
Smoothness						
Mill Marks						
Saw Marks						
Evenness of Stain						

Total of E.S. ____ ____ ____ =____

Total of C.S. ____ ____ ____ =____

ANALYSIS OF DATA:

Examine the results in the rating box carefully. Compare the results of the total of the experimental samples with the total of the control samples.

CONCLUSIONS:

Based on the analysis of the data above, you should be able to form a conclusion. In the case of this experiment, the conclusion obviously would be one of the following:

1. Proper preparation of wood (sanding) is necessary in order to obtain a nice finish.

2. Proper preparation of wood (sanding) is not necessary in order to obtain a nice finish.

ANALYSIS OF THE EXPERIMENT

This sample experiment, "Importance of Wood Preparation for Finishes," is designed to reinforce the importance of a smooth, well-sanded surface before applying a finish. Although the reason for a properly prepared surface has been taught in industrial arts classes for years, many students fail to realize its importance. This experiment lets the student see for himself why proper preparation is important, and it will be remembered.

Two groups of samples are used in the experiment. and all variables are carefully controlled except the one being tested. To keep the experiment from being "unfair," the following precautions should be taken:

1. All samples are cut using the same saw, from the same uniform-grained board.
2. More than one sample is used in each group, so the results cannot be based on the possibility of a bad sample.
3. Each sample is numbered on the back without selecting samples for certain numbers.
4. Two groups were designated "experimental" or "control" by even or odd numbers, rather than being selected for these groups.
5. All samples are stained at the same time using the same stain and brush, and excess stain is removed at the same time.
6. An unbiased jury of judges (three students in the class not associated with the experiment) rates the samples without knowing which samples are in which group.

The only variable that differs between the control and experimental groups is the preparation of the wood before applying the finish. With these controls, if the results favor one group over the other, the difference must be attributed to the one variable which varied—sanding versus non-sanding.

Career Opportunities In Research

As industry is constantly trying to improve its products and to create new ones, the need for people in the area of research is increasing. Many of the positions in research require advanced college degrees in various fields of science or engineering. Much of the work in some areas of research is carried on, however, by technicians who usually have two years of training past high school. The apparatuses used by researchers in conducting their experiments are built by craftsmen representing all of the trades. These craftsmen get their training through vocational programs in high schools or community colleges, or through apprenticeship programs.

People in the area of research, regardless of the level at which they work, must all have some characteristics in common. They must be able to get along well with other people, because their work is done in groups or teams. They should be able to communicate well, because they must be able to express their ideas to their co-workers. All people in this area of work should have a high degree of curiosity and imagination and must be willing to try new ideas.

As for career opportunities in the area of research in the future, one has only to consider the many problems facing our world. Exhausting supplies of certain types of fuels, overpopulation threatening our ability to produce sufficient food, pollution of the environment, and uncontrollable diseases are only a few of the problems facing researchers. As long as there are problems to solve, there will be a need for research.

Words and Phrases the Student Should Know

- Research
- Basic research
- Applied research
- Experimentation
- Destructive tests
- Nondestructive tests
- Field testing
- Laboratory testing
- Variables
- Control group
- Experimental group

Sources of Additional Information

Listed below are references from which information can be secured concerning properties of materials, testing standards, and suggested experiments.

American Society for Testing and Materials. Annual Book of ASTM Standards. Philadelphia, PA: ASTM, 1969.

Earl, Arthur W. Experiments with Products and Materials of Industry. Bloomington, Illinois: McKnight and McKnight, 1971.

Kazanas, H.C., R.S. Klein, and J.R. Lindbeck. Technology of Industrial Materials. Peoria, Illinois: Charles A. Bennett Co., Inc., 1974.

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MISSISSIPPI
INDUSTRIAL
ARTS

Research and Experimentation for the Industrial Arts Student

RESEARCH TEAM'S
LOG BOOK

Research and Experimentation for the Industrial Arts Student

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SUGGESTIONS FOR ADDITIONAL EXPERIMENTS

Listed below are several suggested experiments that you can set up and conduct. After reviewing several magazines, newspapers, and other references, see if you can list other possible experiments.

1. Glues are commonly used to join a number of materials together. If the joints are properly bonded, they are often stronger than the base materials. However, for maximum strength, the glue surface must be cleaned of all grease, dirt, and other foreign materials. Otherwise, the glues will adhere to these materials and weaken the joint. The importance of a properly cleaned surface can be determined by setting up and conducting an experiment.

2. The dyeing of leather is very important in industry, as well as in the craft laboratory. For leather work to look finished and professional, the dyed surface color must be even and free of spots. Although these conditions have been perfected by leather manufacturers, the craftsman must take extreme care in cleaning the leather to obtain the desired smooth color finish. An experiment can be developed to test the importance of cleaning the leather surface before applying dye.

3. Teachers commonly emphasize selecting a hacksaw blade that has the correct pitch when sawing thin-gauged metal. It is recommended that at least three teeth should be in contact with the base metal, but the reason for this is usually not given. Set up an experiment and see if the conclusion is not obvious.

4. There is no one type of wood glue that is better in all respects than other types. Each type has its own purpose and characteristics. Conduct an experiment to test adhesives used in bonding woods under various conditions to determine which adhesives are suited for specific jobs.

5. There are a number of different brands of drawing pencils on the market that vary in price from 10¢ to 50¢ each. An experiment can be conducted to determine if the quality of the more expensive pencil actually justifies the additional price.

6. Television commercials advertise that certain products are superior to others. Conduct a controlled experiment, compare, and draw your own conclusions. Products commonly advertised are as follows:

   1. Floor wax
   2. Flashlight batteries
   3. Detergents
   4. Paper towels
   5. Dishwashing soaps
   6. Floor cleaner
   7. Furniture polish
   8. Antifreeze
   9. Car wax

PLANNING YOUR EXPERIMENT

Date Started: __________ Date Completed: __________

Research Team Members' Names:

1. ____________________ 4. ____________________

2. ____________________ 5. ____________________

3. ____________________ 6. ____________________

TITLE OF EXPERIMENT: ____

INTRODUCTION: (State reasons for and background information about the experiment.)

PROBLEM: (Make a specific statement about what is to be done and what your team is trying to prove, disprove, or find out.)

MATERIALS AND SUPPLIES NEEDED: (List all materials and supplies needed to conduct the experiment.)

TOOLS AND/OR EQUIPMENT NEEDED: (List all tools and equipment needed to conduct the experiment.)

DRAWING: (On the last page of this log book, make a drawing of any specific equipment or apparatus which must be constructed to conduct this experiment.)

PROCEDURE FOR CONDUCTING EXPERIMENT: (Describe how your team plans to conduct this experiment. Tell what you will do and how you will do it.)

GATHERING DATA: (Make a statement explaining how data are to be gathered.)

REFERENCES: (List any references used in planning the experiment.)

Submit to instructor before conducting experiment.

Instructor's Approval: ______________________________
Date: ______________________________

CONDUCTING YOUR EXPERIMENT

Date Started: ______________

FINAL CHECK BEFORE CONDUCTING EXPERIMENT:

1. Has your instructor approved your team's plan? Yes ____ No ____
2. Are all tools and equipment needed to conduct the experiment available in the laboratory? Yes ____ No ____
3. Has your team collected all materials and supplies required to conduct the experiment? Yes ____ No ____
4. Are all samples required for the experiment prepared? Yes ____ No ____
5. Is each team member familiar with the procedures to be used in conducting the experiment? Yes ____ No ____
6. Does each team member know exactly what he/she is to do while conducting the experiment? Yes ____ No ____

PROCEDURES USED IN CONDUCTING EXPERIMENT: (List the step-by-step procedure your team follows in conducting the experiment.)

1.

2.

3.

4.

5.

6.

7.

FINDINGS: (Record date on the data sheet and make all mathematical calculations in space provided below.)

Data Sheet:

Adapt the table below to your experiment and record the results.

CONCLUSIONS: (Now that your team has done the experiment, what conclusions can be drawn from the data obtained?)

RECOMMENDATIONS: (Write any recommendations that can be made based on the conclusions drawn from the experiment.)

DATE COMPLETED: ____________________

TOTAL TIME SPENT ON EXPERIMENT: ____