Science Fair Instruction Booklet

Roanoke Valley Christian Schools

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The Science Fair at Roanoke Valley Christian Schools (RVCS) has multiple purposes. In summary, students are given the opportunity to follow the scientific method to solve some problem in science and present the project in a fair format.

The science project completed at RVCS provides points for the student's grade. Points are awarded according to the evaluation sheet. The evaluation requirements are summarized latter in this booklet.

PURPOSE
for Science Fair at RVCS

1. To teach the scientific method through experimentation.
2. To teach self discipline by completion of a long term project.
3. To provide contact with professionals (mentors) in science related careers.
4. To provide research in areas of science beyond the scope of the science class.
5. To award academic achievement.
6. To strengthen student interest and motivation in science.
7. To integrate multiple content areas within a single project.

SCIENTIFIC METHOD

The scientific method is not a rigid procedure of a specific number of steps. It is a process that follows a general sequence. The following overview of the scientific method applies specifically to the projects completed for the RVCS Science Fair. Other applications or uses of the scientific method will vary from what is included in this booklet.

RESEARCH

Research is necessary to provide background knowledge for choosing a TOPIC. Once the topic is determined, a PURPOSE can be chosen. The HYPOTHESIS comes from this purpose as explained over the next several pages. The research concludes with the design of an experimental procedure.

TOPIC

The topic is the area of science in which the project experimentation will be preformed. The topic must be an area of science in which experimentation can actually be performed. Below are some categories into which science projects can be divided.

Behavioral/Social	Consumer Products	Medicine/Health
Biochemistry	Earth/Space	Microbiology
Botany	Engineering	Physics
Chemistry	Environmental	Zoology
Computer	Mathematics	

Selecting a Topic

1. Where to find a topic
   - -READ science magazines, newspapers, books
   - -WATCH for ideas around you
   - -ASK a professional, a parent, a teacher
   - -VISIT a library, a laboratory, a museum

2. Which topic to select
   - -one that interests you
   - -one about which you would like to learn
   - -one which you are capable of completing
   - -one which has only two variable
   - -one which is controllable
   - -one which is measureable

PURPOSE

The purpose is the question to be answered. This question is associated with the topic selection and will be answered by experimentation. A well-worded purpose statement makes it possible to easily write a clear hypothesis. Research of the topic selected will allow for a clear purpose statement that is scientifically accurate as well as possible to answer through experimentation.

Good Purposes	Poor Purposes
1. Which antibiotic prohibits bacterial growth on a surface?	1. How do antibiotics kill bacteria?
2. What amount of heat is needed to melt ice?	2. What substance makes ice melt best?
3. What is the gravitational acceleration at locations in the Roanoke Valley?	3. How much gravity is there on the moon?

HYPOTHESIS

The hypothesis is the guiding statement for the whole science project. Sometimes referred to as an "educated guess," the hypothesis should be more education than guessing. Researching the topic allows students to choose a hypothesis that reflects known scientific principles. The guessing comes because the hypothesis is written before the experimentation is performed.

Writing a RESEARCH PAPER introduces the hypothesis. Included in the research paper is the purpose for choosing the hypothesis. Scientific sources should be included to reflect the scientific principles that affect the choice of a hypothesis. All sources used should be documented. This means that a parenthetical reference should follow any information that is borrowed from a source. The bibliographical information from the source is included on the *Works Cited* page.

The hypothesis is the answer to the question asked in the purpose. If the purpose is written well, the hypothesis can be written to answer the question. A poorly written purpose will lead to an incorrect, faulty, or poorly written hypothesis.

Below are good and poor hypotheses written for the good purpose statements earlier in this booklet.

Good Hypothesis	Poor Hypothesis
1. Soaps containing Triclosan prohibit more bacterial growth on surfaces than soaps with alcohol.	1. Bleach is the best.
2. The energy needed to melt ice is related to the mass through this equation: $H=mH_f$.	2. Ice melts fast when hot.
3. The gravitational acceleration at RVCS is 9.80 m/s^2.	3. Gravity is strong.

EXPERIMENTAL DESIGN

The last step in researching is the planning for experimentation to test the hypothesis. The design of an experimental procedure requires identification of the following variables and constants. From a clearly written hypothesis, an experiment can be designed.

From the hypothesis the variables should be identified. VARIABLES are the values that change during the experimentation. A well designed experiment should have two variables.

- The INDEPENDENT variable is changed intentionally during the experimentation. This variable is sometimes referred to as the MANIPULATED variable.
- The DEPENDENT variable changes because of the change in the independent variable. This variable is sometimes referred to as the RESPONDING variable.

The hypothesis could be written according to the following format. If the independent variable is changed in a certain way, the dependent variable will change in a specified way.

Below are the variables for the good hypotheses earlier in this booklet.

Independent variable	Dependent variable
1. Antibiotic in soap	1. Bacterial growth
2. Mass of ice cube	2. Heat needed to melt the ice
3. Locations at which the gravitational acceleration is measured	3. Measured gravitational acceleration

The INDEPENDENT VARIABLE can be changed in a variety of ways. As a part of the experimental design, the EXPERIMENTAL GROUPS are identified. The experimental groups identify the specifics regarding specifically how the independent variable will be changed. Number of trials, time for testing, as well as specific groups are planned. Here are examples that follow the independent variables listed in the previous chart.

1. Three trials of each of the antibiotics tested for one week.
2. Seven trials with one ice cube in each trial. Tested until the cube melts.
3. Three trials at five different locations in Roanoke.

As the experiment is designed, only the two variables should be allowed to change. All other quantities affecting the experiment should be CONTROLLED so that they do not change. Because these quantities do not change, they are sometimes referred to as CONSTANTS. Identifying the quantities that must be controlled is an important step to designing an experiment to test the hypothesis.

An uncontrolled experiment cannot be used to validate or invalidate a hypothesis. Other uncontrolled quantities may be changing the dependent variable. This makes the experimental process useless.

By controlling all quantities and making changes only to the independent variable, the hypothesis can be tested. Any change in the dependent variable is a result of the changes in the independent variable in a well-designed (controlled) experiment.

Every experiment has a different list of quantities which must be controlled. Even though the lists are different, they are vital.

Below are some sample categories of quantities to look at for constants. This is not a complete list since every experiment is different.

Temperature	Volume (size)	Measuring instrument
Color	Mass (amount)	Genetic identity
Location	Method	Age
Distance	Force	Initial conditions

EXPERIMENTAL PROCEDURE

After identifying the variables, controls/constants, and experimental groups, an EXPERIMENTAL PROCEDURE must be written. The procedure is the step by step directions to be followed to test the hypothesis.

The procedure should be detailed and repeatable. The scientific method allows for others to verify one person's work by repeating the procedure and producing the same results. The procedure should be written specifically enough to allow this repetition.

VARIABLES

In the procedure directions should be given for changing the INDEPENDENT VARIABLE. The number and duration of specific trials should be identified.

Directions should be given for measuring the changes in the DEPENDENT VARIABLE. The measuring instrument should be identified. The units that are used should be obvious either in the procedure or data table.

Directions should be given for CONTROLLING the CONSTANTS so that they do not change. The method that will ensure that the constants remain the same should be identified.

MATERIALS

Often as part of the procedure a list of MATERIALS is given. This list of materials allows someone following the procedure to collect the necessary supplies before beginning the experimentation. The materials list can also identify specific pieces of equipment or supplies that may not be ordinary.

DATA COLLECTION

Once your EXPERIMENTAL PROCEDURE is written, DATA COLLECTION can begin. By following the experimental procedure, observations will be made. These observations are called DATA. Data comes in two types.

- QUANTITATIVE DATA is a measurement containing a number with appropriate unit. This data is objective, usually independent of the observer.
- QUALITATIVE DATA is a characteristic observed. This data is subjective, depending on the observer.

Both types of data are important and should be recorded. Every experiment collects data of these two type. The location this data is recorded is called the LABORATORY LOG (or log). Not only should data be recorded in the log, the log should also include all changes in procedure, all constants, results, or other relevant information.

Below are examples of the two types of data. The quantitative data requires a measuring instrument which should be listed on the materials list. Notice that the units used in the quantitative data belong to the International System of measurements.

DATA

Quantitative	Qualitative
273 K (0^0 C)	Cold
25.3 m	Long
14.0 s	Quick
3.56 mA	Low current
82.63 L	Big
285 kg	Massive

DATA CHART

Time vs. Distance for Baseball

TRIAL 1		TRIAL 2	
Time (s)	Distance (m)	Time (s)	Distance (m)
0	0	0	0
1	4.9	1	6.1
2	15.2	2	23.4
3	35.9	3	48.9
4	65.3	4	85.7
5	105.2	5	135.8
6	160.4	6	192.7
7	210.3	7	258.4

Notice that the data chart is clearly labeled. This is also a requirement for making graphs. The data chart has a title. The trials are clearly indicated. The independent variable (time) is labeled with the appropriate units (seconds). The dependent variable (distance) is labeled with the unit meters.

Results could also be included into the data chart if it is appropriate. The results should be clearly labeled as such.

RESULTS

After collecting data, the next step is organization of the data. This organization takes the data from raw form in the log, making it easier to read and understand. Organization also includes calculations so that the data relates to scientific principles.

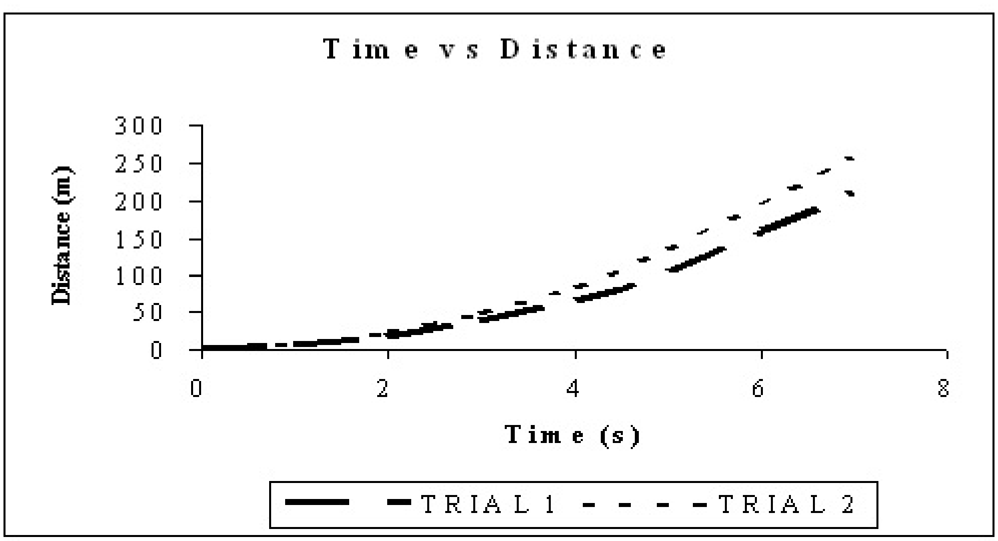
The RESULTS of this organization come in many forms.

- Statistics are one form of results. These can be percentages, averages, standard deviations, or others.
- Charts organize the data in rows and columns.
- Graphs allow the data to be viewed quickly. The graph has many types depending on the type of data.
- Calculations use formulas to find a secondary value for comparison of data.

Whichever organization of the data is preformed, it should be explained clearly and should not be confused with the data that was actually collected. If calculations are preformed on the data, the formulas should be included in the documentation. Labeling of the results should make them clear including units.

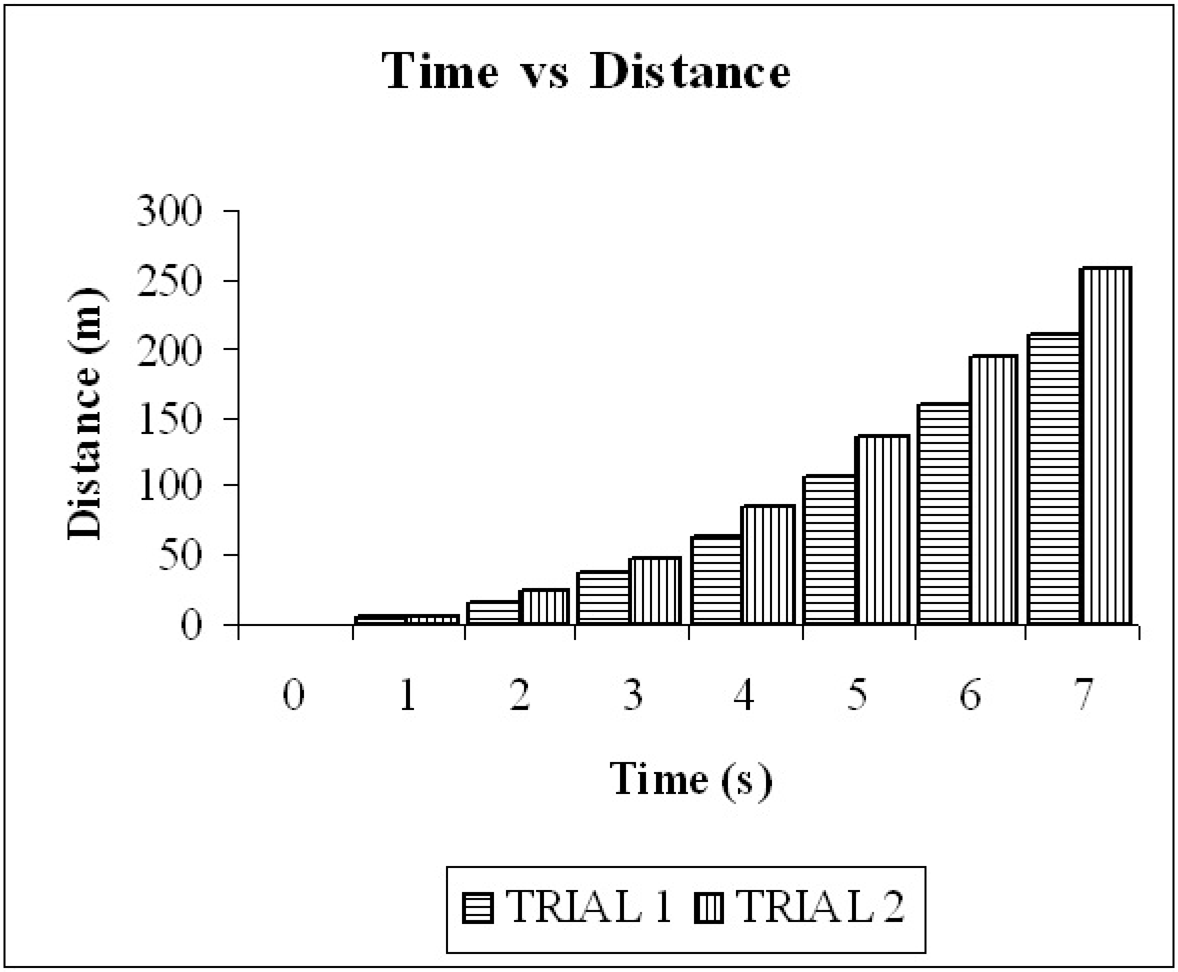
GRAPH

Data can be represented graphically in various ways. This data has two measurements which fit with a coordinate system. Usually the independent variable is represented on the horizontal axis and the dependent variable is represented on the vertical axis. This data could be represented with a bar graph. A bar graph is useful when only the dependent variable is measured. A pie graph would not work well with this data set but would be appropriate for a data set where the percentages equal 100%.



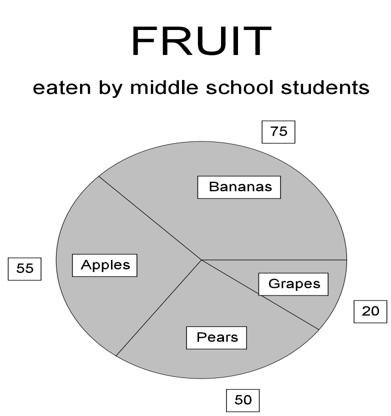
BAR GRAPH

(same data)



PIE GRAPH

(different data)



CONCLUSION

The final step of the scientific method for an RVCS science project is forming a CONCLUSION. This conclusion statement identifies whether the data collected supported or invalidated the hypothesis. The conclusion is specific just for this experiment designed to test the hypothesis.

After the CONCLUSION statement, other relevant information should be included as part of an APPLICATION. The APPLICATION should identify possible problems with the experimental procedure. Possible errors made during data collection should be identified. Related hypotheses that could be tested could also be identified. As part of the APPLICATION, the usefulness of the experimental procedure should be identified.

REPETITION is the next for the scientific method. Although the procedure is repeated to obtain consistent results, this step of the scientific method goes beyond the requirements for the science project at RVCS. The purpose of repetition is to validate related hypotheses to develop broad statements that include many phenomenon. Students may consider this type of repetition as a possibility for future science projects.

CONCLUSION

Below are sample conclusions for the sample hypotheses earlier in this booklet.

1. Soaps containing Triclosan prohibited 50% more bacterial growth on surfaces than soaps with alcohol.

2. The energy needed to melt ice was averaged to be 345 J/g.

3. The gravitational acceleration at RVCS was measured on average to be 9.78 m/s^2.

The conclusion is made by comparing the data with the hypothesis statement. If the data was not consistent or did not match the hypothesis, statements explaining the reason would be included in the application. If experimental error was discovered, proposals for future testing could be included. Ideas for future, related hypotheses could be added to the application as well.

EVALUATION

The grading process for science fair projects at RVCS includes four areas. The projects are also judged by professionals. The judges use some of the same criteria but do not affect the grade given by the science teacher.

DEADLINES

The first part of the grading process gives points to students for meeting DEADLINES. These deadlines are given to check student progress through the scientific method.

DISPLAY

The second part of the grading process gives points for the DISPLAY of the project at the actual fair. The display is required to have the following items: a table, a display board, documentation, an object. The table and display should be sturdy and self supporting. The display board should be attractive, clear, and organized. The data should be graphically represented following the guidelines in this booklet.

SCIENTIFIC THOUGHT

The third part of the grading process evaluates the SCIENTIFIC THOUGHT the student invests in the project. The parts of the scientific method explained in this booklet are checked for correct application: research, purpose, hypothesis, variables, materials, procedure, data, constants, results, conclusion, application. Points will be awarded based on the design of the experiment, the experimentation done, the conclusion, and the difficulty of the project.

DOCUMENTATION

The fourth part evaluated is the DOCUMENTATION. The documentation is a "booklet" which completely explains the science project. The required elements are varied by grade level. The following list includes the required elements for complete documentation at the highest level: title page, outline page, research, hypothesis, complete procedure, data, results, conclusion, application, works cited page.

REQUIREMENTS

The following information is required for the science fair at RVCS. This information is provided to each student on the science fair information and evaluation sheets each year.

New experimentation must be performed as a part of the project. Continued projects must include new experimentation.

Projects should not use tobacco, alcohol, or human subjects without prior approval. Other questionable materials should have approval before the experimentation is planned.

Students working with a mentor need to complete a *Mentor Form*. Help provided must be indicated clearly so the student's work may be evaluated.

The actual display must meet the size requirements. The exhibit size is limited to 76 cm (30 in.) deep, front to back; 122 cm (48 in.) wide, side to side; and 274 cm (108 in.) high, floor to top. Tables are to be about 76 cm high .

Included in the exhibit must be an object not harmful to life or the environment. All containers must be empty or sealed.

The display board should have on it (in logical order) your title, hypothesis, procedure, data/results in graphical form, conclusion, and other important information.

The documentation must include the title page first. An outline page must be second. The following pages must have this information in this order: research, purpose, hypothesis, materials, complete procedure (including variables, controls, material instructions, conditions), data collected, results, conclusion, problems/errors, and applications. The final page should be the works cited page.

Student name , teacher name, and class name are NOT to appear on ANY part of the exhibit or in the documentation. The project identity comes from the title card turned in by each student.

SAMPLE EXPERIMENTAL DESIGN

WHAT EFFECT DOES ANTIFREEZE CONCENTRATION HAVE ON WATER'S FREEZING POINT?

Scientific Research: Freezing Point Depression occurs when pure water is mixed with other materials.

Hypothesis: The concentration of antifreeze varies inversely with the freezing point of water up to seventy-five percent, the concentration producing minimum freezing point.

INDEPENDENT VARIABLE:

The concentration of antifreeze in water measured by percent volume.

EXPERIMENTAL GROUPS:

0%	25%	50%	75%	100%
5 trials 10.0 mL	5 trials 10.0 mL	5 trials 10.0 mL	5 trials 10.0 mL	5 trials 10.0 mL

DEPENDENT VARIABLE:

The freezing point of the solutions as measured in degrees Celsius.

CONSTANTS/CONTROLS:

Total volume of solution (to 1/10 th mL)

Initial temperature of environment

Initial temperature of samples

Tap water collected at the same time

One brand antifreeze, from the same container

Calibrated temperature probes

SAMPLE RESEARCH OUTLINE

WHAT EFFECT DOES ANTIFREEZE CONCENTRATION HAVE ON WATER'S FREEZING POINT?

Hypothesis: The concentration of antifreeze varies inversely with the freezing point of water up to seventy five percent, the concentration producing minimum freezing point

I. Water
  A. Physical Properties
    1. Density
    2. Freezing point
    3. Specific heat
    4. Viscosity
    5. Freezing point
    6. Heat of fusion
  B. Chemical Properties
    1. Flammability
    2. Reactivity with materials
    3. Reactivity with the environment
    4. Reactivity with humans

II. Antifreeze/coolants
  A. Types
    1. Organic
    2. Inorganic
      a. Ethylene glycol
      b. Dissolved solids
  B. Physical Properties
    1. Density
    2. Freezing point
    3. Specific heat
    4. Viscosity
    5. Freezing point
    6. Heat of fusion
  C. Chemical Properties
    1. Flammability
    2. Reactivity with materials
    3. Reactivity with the environment
    4. Reactivity with humans

III. Factors affecting freezing point
  A. Concentration of solution
    1. Saturation
    2. Equilibrium
    3. Percent by mass
  B. Pressure
    1. Atmospheric
    2. Internal
      a. Release valves
      b. Systems

SAMPLE DOCUMENTATION OUTLINE

WHAT EFFECT DOES ANTIFREEZE CONCENTRATION HAVE ON WATER'S FREEZING POINT?

Hypothesis: The concentration of antifreeze varies inversely with the freezing point of water up to seventy-five percent, the concentration producing minimum freezing point

I. Research
   A. Water
      1. Physical Properties
      2. Chemical Properties
   B. Antifreeze/coolants
      1. Types
      2. Physical Properties
      3. Chemical Properties
   C. Factors affecting freezing point
      1. Concentration of solution
      2. Pressure

II. Experimentation
   A. Procedure
   B. Data
   C. Graphs
   D. Conclusion
   E. Application

SAMPLE WORKS CITED

Works Cited

Davis, Raymond E., et al. Modern Chemistry. Atlanta, GE: Holt, Rinehart and Winston, 2002.

Department of Public Communication. What's Happening in Chemistry. Washington: American Chemical Society, 1992.

Jones, Kim. Telephone interview. 29 Feb. 2008.

"Sierra: The Safer Antifreeze." Sierra antifreeze/coolant. nd. Online. .http://www.sierraantifreeze.com/benefit.html. 28April, 2008.

Sheehan, James. "Where's the Science?." The Roanoke Times 13 Oct. 1996, 3H.

The Holy Bible, New International Version. Grand Rapids, MI: Zondervan Bible Publishers, 1978.

Udale, Barbara. "A Ternary Phase Diagram for a Less Hazardous System." Journal of Chemical Education. 72 (1995): 1106.

"Water." The New Encyclopaedia Britannica. 1974 ed

Revised in 2008
by John Law

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