STUDENT HANDBOOK

SCIENCE RESEARCH AND SCIENTIFIC METHODS

A science project is an investigation using the scientific method to discover the answer to a scientific problem. Before starting your project, you need to understand the scientific method. The **scientific method** is the "tool" that scientists use to find the answers to questions. It is the process of thinking through the possible solutions to a problem and testing each possibility for the best solution. The scientific method involves the following steps: doing research, identifying the problem, stating a hypothesis, conducting project experimentation, analyzing gathered data, and drawing a conclusion.

1. RESEARCH

Research is the process of collecting information from your own experiences, knowledgeable sources, and data from previous experiments. The research topic should be data driven. It means that you should design a research project that provides quantitative data through experimentation followed by analysis and real life applications of that data.

2. PROBLEM

The problem is the scientific question to be solved. It is best expressed as an "open-ended" question, which is a question that is answered with a statement, not just a yes or a no. You should choose a problem that can be tested experimentally.

3. HYPOTHESIS

A hypothesis is an educated guess about the solution to a problem, based on knowledge and research. While the hypothesis is a single statement, it is the key to a successful project. All of your project experimenting will be performed to test the hypothesis. The hypothesis should make a claim about how two variables relate. In other words, the statement should include independent variable and its expected effect on responding variable. You don't change your hypothesis even if experimentation does not support it. You should repeat or redesign the experiment to confirm your results.

4. CONTROLLED EXPERIMENTATION

Project experimentation is the process of testing a hypothesis. The factors that have an effect on the experiment are called **variables.** There are three kinds of variables that you need to identify in your experiments: independent, dependent, and controls.

The **independent variable** is the variable you purposely manipulate (change). The **dependent variable** is the variable being observed that changes in response to the independent variable. The variables that are not changed are called **controlled variables.**

A **control** is a test in which the independent variable is kept constant in order to measure changes in the dependent variable. In a control, all variables are identical to the experimental setup—your original setup—except for the independent variable. Factors that are identical in both the experimental setup and the control setup are the controlled variables.

You should have only one independent variable in the experiment. Also, you need to repeat the experiments to verify the consistency of your results. During the experimentation, you should keep detailed notes about each single step of the experiments, observations, and measurements. You can use data tables and charts to record your quantitative data.

5. ANALYSIS OF DATA

Summarize what happened in the experiments and organize your data. This can be in the form of a table of processed numerical data, or graphs. It could also be a written statement of what occurred during experiments.

By studying tables and graphs, you need to identify the trends in the charts. You should mention about expected and unexpected trends in your analysis. Also, your analysis should include what variables caused these results. In addition, the researcher should discuss possible experimental errors in data taking, experimental design or observations. Statistical analysis of your data might help you l to understand and explain your findings more clearly.

6. CONCLUSION

Using the trends in your experimental data and your experimental observations, try to answer your original questions. Is your hypothesis correct? Now is the time to pull together what happened, and assess the experiments you did. You can also discuss the followings in your conclusion:

- If your hypothesis is not correct, what could be the answer to your question?
- Summarize any difficulties or problems you had doing the experiment.
- Do you need to change the procedure and repeat your experiment?
- What would you do different next time?
- How would you improve the project in the future?
- How could this project apply to real life?

ELEMENTS OF A SUCCESSFUL PROJECT

1.) Project Journal

As you conduct your experiment, record the results as they are produced. It might be hard to remember some observations and data after experimentation. Take careful notes during data collection. They may be a little 'messy' but try to write every detail of data and observations. Data tables are also helpful .This will help you to organize your data when writing your research paper. Good notes remember everything. So your notes will help you to communicate better with the judges during your presentation. Make sure you date each entry.

2.) Research Paper

The students should prepare a research paper and it should be available along with the project journal and other necessary tools to present your project on their display table. A good research paper has the following sections;

a. Cover Page

This page includes title of the project and name of the researcher.

b. Table of Contents

The second page of your report is the table of contents. It should contain a list of everything in the report that follows the contents page, as shown below.

CONTENTS

1. Abstract
2. Introduction
3. Materials and Methods
4. Results
5. Discussion
6. Conclusion
7. Acknowledgments
8. References/ Bibliography

c. Abstract

The abstract is a brief overview of the project. It should not be more than 1 page and should include the project title, a statement of the purpose, a hypothesis, a brief description of the procedure, and the results. A copy of the abstract must be submitted to the ISWEEEP officials during registration. See abstract form. Also, it is a good idea to have copies available for judges at your display. This gives judges something to refer to when making final decisions.

d. Introduction

The introduction is a statement of your purpose, along with background information that led you to make this study. It should contain a brief statement of your hypothesis based on your research. In other words, it should state what information or knowledge you had that led you to hypothesize the answer to the project's problem question. Make references to information or experiences that led you to choose the project's purpose.

e. Materials and Methods

You should describe all details of your procedures that you used to collect data, and make observations. Procedures should include a list of the materials used and the amount of each and the procedural steps are in order. Your written methods should be detailed enough so that someone would be able to repeat the experiment from the information in you paper. You can also include detailed photographs or drawings.

f. Results

It should include all measurements and observations that you took during each experiment and analysis of collected data. Graphs, tables, and charts created from your data should be labeled. If there is a large amount of data, you may choose to put most of it in an appendix, which can be placed in a separate binder or notebook. If you do separate the material, a summary of the data should be placed in the data section of the report.

g. Discussion

In this section you will discuss what your data shows; it is not the conclusion. You should compare your results with published data, commonly held beliefs, and/or expected results. Your discussion should include possible errors. Also, discuss what you would do differently to improve this project in the future and what other experiments should be conducted?

h. Conclusion

The conclusion summarizes, in about one page or less, what you discovered based on your experimental results. The conclusion states the hypothesis and indicates whether the data supports it. The conclusion can also include a brief description of plans for exploring ideas for future experiments. Also, it contains practical applications of the project.

i. Acknowledgments

Even though technically your project is to be your work alone, it is OK to have some help. The acknowledgment is not a list of names, but a short paragraph stating the names of the people and institutions and how they helped you.

j. References/Bibliography

A bibliography is a listing of the resources and references used during the research of your project. It should include information about the magazines and books you used. That information is organized so that interested readers could seek out and find the books and articles you refer to.

In the case of a book, you must supply the title of the book, its author, publishing company, the city where the publishing company is located, and the date the book was published.

For a magazine article you must supply the title of the article, the author, the magazine it appeared in, the date of the magazine issue, the volume of the magazine, and the pages the article appeared on. The followings are sample references.

Article

Johnson, Peter H. "Wired For Warmth," (electic soil warmers – plant propagators), *Rodale's Organic Gardening*, Jan. 1987, vol. 34, 68

Book

Math, Irwin. *Wires & Watts*, New York, Scribner, 1981

Encyclopedia

"Gyroscopic Properties," *The World Book Encyclopedia*, 1988, vol. 8, 477

Online website

Planning for College and Academic Planning. The College Board. 7 June 2000, http://www.collegeboard.org/features/parentgd/html/academic.html

3.) Display

Your science fair display represents all the work that you have done. It should be made in such a way that it attracts and holds the interest of the viewer. It has to be thorough, but not too crowded, so keep it simple. Make sure that you follow the ISWEEEP Display and Safety Regulations.

HINTS FOR DISPLAY

1. **Your title** and other headings should be neat and large enough to be read at a distance of about 3 feet (1 m). The title should catch the interest of the observer.
2. **May take pictures** of important phases of the project to use in your display.
3. **Be organized and** make sure that your display follows a sequence.
4. Use neat, colorful headings, charts, and graphs to make your display **eye-catching** but it should look simple not crowded.
5. Be sure to follow display size **limitations and safety rules.**
6. **Don't spend too much time or money** for the display. Your will be judged on the scientific value of your project.

CATEGORIES

In each division, students will compete in 3 different categories: Energy, Engineering, and Environment. These are subcategories in each category;

ENERGY

Renewable Energy

Renewable energy flows involve natural phenomena such as sunlight, wind, tides and geothermal heat. Renewable energy technologies range from solar power, wind power and hydroelectricity through to biomass and biofuels for transportation.

Bio Energy

Useful, renewable energy produced from organic matter. The conversion of the complex carbohydrates in organic matter to energy. Organic matter may either be used directly as a fuel or processed into liquids and gases. It is also known as Bio Fuels.

Non-renewable Energy-Clean& Green Advancements

Energy derived from depletable fuels (oil, gas, coal) created through lengthy geological processes and existing in limited quantities on the earth. Participants should focus on Clean and Green advancements to minimize the environmental effects of fossil fuels.

Clean Energy Technology

Clean technologies aim to give minimum harm to environment such as Clean Burning Fuels, Electric Vehicles, Fuel Cells, Hybrid Electric, Hydrogen, Zero Emissions, and Pollution Reduction

Energy Efficiency

The more efficient use of energy in order to reduce economic costs and environmental impacts. It aims to use less energy/electricity to perform the same function.

Energy Conservation

Energy conservation is different to energy efficiency in that it involves using less energy to achieve a lesser energy service, and usually requires behavioral change.

Energy Business and Policies

Some issues of energy business development and energy policy development. Proposed actions as an attempt to combat growing energy problems and environmental impacts.

ENGINEERING

Engineering project can be done in the following subcategories. The projects should aim to find practical solutions to globe's problems and should seek the ways of technology that can be used for maintaining global sustainability.

Bioengineering

Biological engineering deals with engineering biological processes in general. It is a broad-based engineering discipline that also may involve product design, sustainability and analysis of biological systems. Generally, bioengineering may deal with either the medical or the agricultural fields.

Civil Engineering &Construction Engineering

Civil engineering is a professional engineering discipline that deals with the construction and design of public and private sector works such as bridges, roads, dams and buildings.

Chemical Engineering

Chemical engineering is the branch of engineering that deals with the application of physical science (e.g. chemistry and physics), with mathematics, to the process of converting raw materials or chemicals into more useful or valuable forms.

Industrial Engineering

Industrial engineering aims to eliminate wastes of time, money, materials, energy and other resources.

Material Science

A multidisciplinary field relating the performance and function of matter in any and all applications to its micro, nano, and atomic structure, and vice versa. It often involves the study of the characteristics and uses of various materials, such as metals, ceramics, and plastics and their potential engineering applications.

Electrical Engineering, Computer Engineering

Electrical engineering is the branch of engineering that deals with the technology of electricity, especially the design and application of circuitry and equipment for power generation and distribution, machine control, and communications. A computer engineer is an electrical engineer with a focus on digital logic systems or a software architect with a focus on the interaction between software programs and the underlying hardware architecture.

Mechanical Engineering

Mechanical engineering is an engineering discipline that involves the application of principles of physics for analysis, design, manufacturing, and maintenance of mechanical systems. Mechanical engineers use these principles and others in the design and analysis of automobiles, aircraft, heating & cooling systems, manufacturing plants, industrial equipment and machinery, medical devices and more.

Robotics

Robotics is the science and technology of robots, their design, manufacture, and application

Thermodynamics

Thermodynamics involves the physics of the relationships and conversions between heat and other forms of energy.

Other

ENVIRONMENT

Land Management

Land management can be defined as the process of managing the use and development (in both urban and suburban settings) of land resources in a sustainable way. Land resources are used for a variety of purposes which interact and may compete with one another; therefore, it is desirable to plan and manage all uses in an integrated manner.

Deforestation

Deforestation is the conversion of forested areas to non-forest land use such as arable land, pasture, urban use, logged area, or wasteland. Generally, the removal or destruction of significant areas of forest cover has resulted in a degraded environment with reduced biodiversity.

Ecosystem Management

Ecosystem management is widely proposed in the popular and professional literature as the modern and preferred way of managing natural resources and ecosystems. Advocates glowingly describe ecosystem management as an approach that will protect the environment, maintain healthy ecosystems, preserve biological diversity, and ensure sustainable development.

Bioremediation

Biological remediation of environmental problems using plants. The use of biological agents, such as bacteria or plants, to remove or neutralize contaminants, as in polluted soil or water. Includes phytoremediation, constructed wetlands for wastewater treatment, biodegradation, etc.

Air Pollution / Quality

Air pollution is the degradation of air quality resulting from unwanted chemicals or other materials in the air. The condition of the air endangers the health, safety, or welfare of persons, interferes with normal enjoyment of life or property, endangers the health of animal life or causes damage to plant life or property.

Soil Pollution / Quality

Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents, which have adverse effects on plant growth and animal health.

Water Pollution / Quality

The introduction of substances that make water impure compared with undisturbed water. Usually this comes from soil erosion, introduction of poisonous chemicals from industries and spills and introduction of domestic sewage or industrial and agricultural wastes.

Noise Pollution / Quality

Noise pollution (or environmental noise in technical venues) is displeasing human or machine created sound that disrupts the environment. The dominant form of noise pollution is from transportation sources, principally motor vehicles.

Reduce-Reuse-Recycle

Waste prevention, or "source reduction," means consuming and throwing away less. For example; purchasing durable, long-lasting goods, seeking products and packaging that are as free of toxics as possible; redesigning products to use less raw material in production, have a longer life, or be used again after its original use.

Reusing items -- by repairing them, donating them to charity and community groups, or selling them -- also reduces waste. Reusing products, when possible, is even better than recycling because the item does not need to be reprocessed before it can be used again.

Recycling turns materials that would otherwise become waste into valuable resources. In addition, it generates a host of environmental, financial, and social benefits. Materials like glass, metal, plastics, and paper are collected, separated and sent to facilities that can process them into new materials or products.

JUDGING

When Judges evaluate your project, they mostly focus on:

1. Were you creative when doing your science fair project?

- Does your research show creativity and originality?
- Did you solve the question in an original way?
- Did you construct or design new equipment?

2. Did you follow the scientific methods and procedures in your science fair project?

- Did you clearly state your problem?
- Did you use scientific literature when you do your initial research?
- Did you clearly state your variables?
- Did you use controls?
- Does your data support your conclusions?
- Do you recognize the limitations of the data / experiment?
  And did you state them in your conclusions?
- Did you make suggestions as to what further research is warranted?

3. Were you thorough in doing your science project?

- Did you carefully think out your science fair project, go about it systematically for simple science fair projects with well thought-out research following the scientific method for kids outline and observations?
- Did you complete all parts of your research experiment?
- Did you keep a project journal?
- Did you keep detailed notes in your journal?

4. What was the quality of your technical skill?

- Did you have the required equipment to obtain your data?

- Was the project performed at home, school, university laboratory?
- Where did the equipment come from? Did you build it? Did you loan it from somewhere? Did you work in a professional laboratory?
- Did you do the project yourself or did you receive help? If you received help the judges are looking for you to give credit to those individuals.

5. Did you have clarity with the details of your science project?

6. How well your project fits in with the theme of being beneficial to society will be taken into account?

JUDGING CRITERIA

CRITERIA	POINT	EXPLANATION
Creativity/Originality	5	Originality of the problem; unique approach to solve a sustainability issue.
Review of Literature	5	Research of scientific literature and use of references.
Scientific Thought	5	Statement of hypothesis; clarity of purpose; identification of all relevant variables.
Scientific Method	5	Evidence of depth of study and effort in employing scientific procedures; proper methods followed for experimentation and investigations.
Data Management	5	Proper recording and display of data in tables, charts, and graphs; proper analysis of data.
Conclusions	5	Drawing logical conclusions, consistency of conclusions with obtained data; recommendations for further research.
Applications	5	Practical applications of the project; benefits for society in certain ways.
Research Skills and Effort	5	Level of skills and effort by (each) researcher to carry out the project; amount of work; high level of understanding of the techniques and equipments used to gather data
Understanding the Project	5	(Each) Student's understanding of each step during the implementation of the project.
Quality of Display	5	Well organized display; project journal.