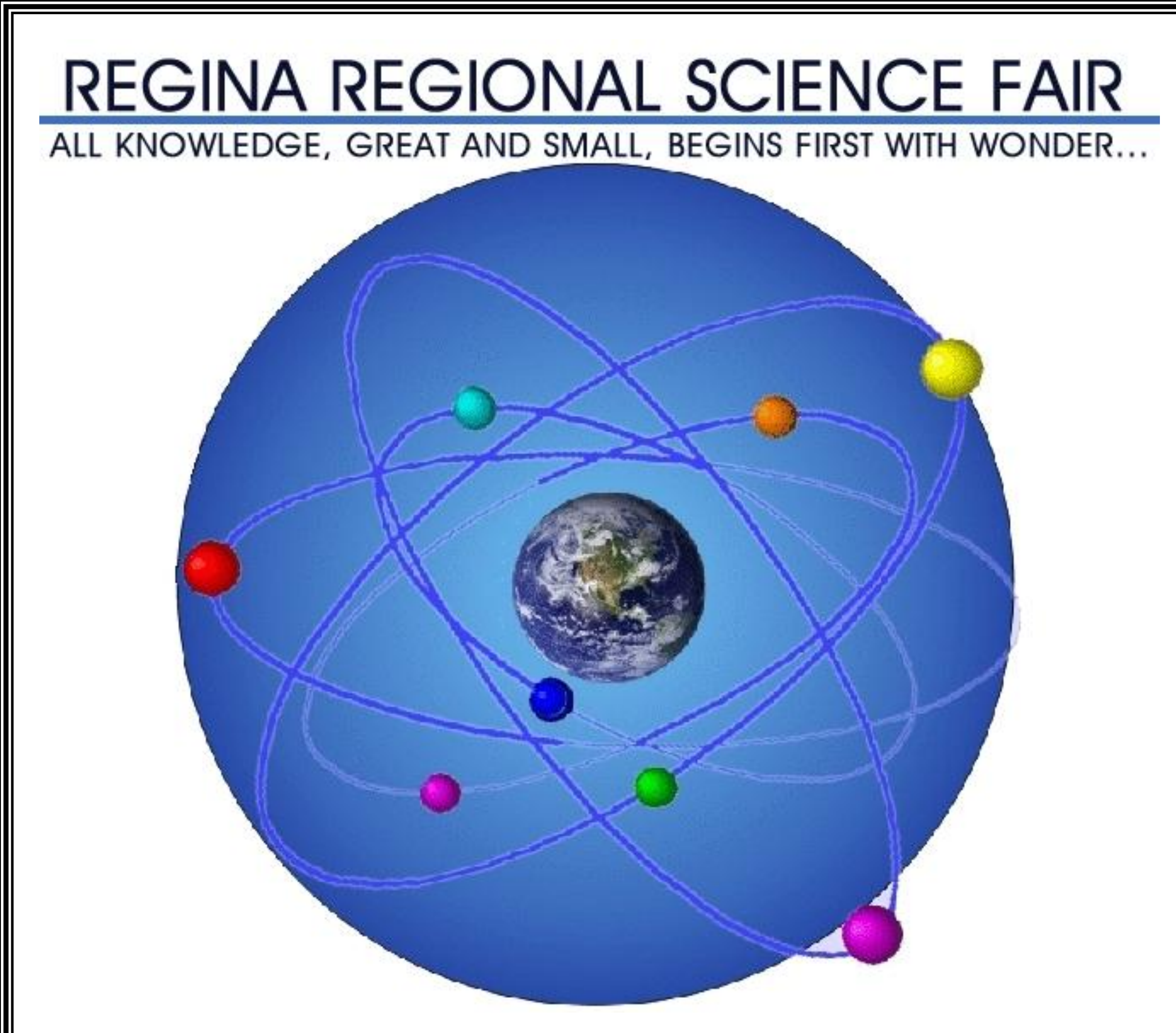
Science Fair Projects for Smarties

A Guide to Effective Design, Execution, and Presentation of a Science Fair Project



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What is a Science Fair Project?

In short, a science fair project is an **independent**, **hands-on**, **inquiry-based** approach to answering a scientific question or addressing a problem. Science fairs involve all the principles of **laboratory investigation**: design and execution, including formulating hypotheses, identifying and controlling variables, taking measurements, interpreting data, and drawing conclusions. Science fair projects often include a **presentation component** that emphasizes clear and organized oral communication skills combined with a **visual display**, usually in the form of a display board, which adheres to principles of attractive and functional design.

Science fair projects are often evaluated by external judges, whose role it is to assess the level of scientific knowledge used in the design and execution of the project. Judges perform this assessment by listening to the oral presentation and formulating questions which will test the student's understanding of the scientific principles that underlie the project. The ability to answer questions "on the spot" correctly and confidently is a major component in assessing understanding.

Characteristics of Science Fair Projects

Independent: *Students decide the topic, how to address the topic, and carry out the techniques required to produce an answer.*

Hands-On: *Science fair projects are intended to have practical components, where students actually do science instead of merely reading and writing about it.*

Inquiry-Based: *Science fair projects are about answering questions and addressing problems. The best projects draw their ideas from gaps in our knowledge about the physical world.*

Skills Used in Science Fairs

Laboratory Skills: *Questioning, Predicting, Inferring, Analyzing, Evaluating*

Oral Presentation Skills: *Speaking, Explaining, Responding*

Visual Presentation Skills: *Organizing, Conveying, Summarizing*

Competitive Science Fairs in Canada

Science fairs occur in schools across the country every year. They may be small, isolated events, occurring in the classroom as a method of alternative learning and holistic evaluation. However, they may also function as a method of selection for the purposes of formal science fair competition.

Many people may not realize that the "Science Fair" as an event is an international undertaking, overseen by a large body of science and science fair specialists. *Youth Science Canada* is the Canadian organization responsible for competitive science fair programming, including the annual Canada Wide Science Fair (CWSF) and selection of Team Canada for the International Science and Engineering Fair (ISEF). National science fairs are overseen by a number of committees, including Host Committees, the National Science Fair Committee (NSFC) and the National Judging Committee (NJC).

Operating under the umbrella of *Youth Science Canada* are the affiliated Regional Science Fairs (RSF), which run competitive events for science students in cities and rural communities across Canada. These RSFs select the top students and projects for the CWSF. The RSFs also advise individual schools on how to run science fairs.

All of these organizations work cooperatively to transmit science programming to youth in schools across Canada. For example, the Chief Judges at NJAC determine the guidelines for safety and ethics that are used for every science fair from the annual Canada Wide Science Fair, to the individual regional science fairs, to the fairs in each school. Therefore, what appears to be a small event, taking place in only your classroom or school is actually an enormous enterprise under the direction of many large national organizations. When you do a science fair project, know that you are part of a much larger undertaking than it may seem.

The Science Fair Hierarchy:

Team Canada, ISEF

Canada Wide Science Fair (CWSF)

Regional science fairs

School science fairs

Classroom science fairs

Individual science projects

Purpose of This Document

Producing a high-quality science fair project, whether it is for the small classroom fair or destined to enter the highest levels of competition, is a lot of work. There are many parts to the project; many steps must be carried out before the project can be considered complete. The intent of this document is to outline the different parts of a science fair project and what would be expected of each at a competitive level. Both teachers and students should be able to use this document to gain some insight into the science fair process.

The guidelines presented in this document ultimately are aimed at producing projects that will be judged favourably at a regional science fair or higher. That having been said, not every science fair project is expected to enter formal competition. However, a project fit for competition is certain to have met all the key learning criteria for a science class and will likely also be graded well.

Parts of a Science Fair Project

Science fair projects, from start to finish, have four main parts. The following sections of this document will deal with each of these four parts in turn.

Part 1: The Project

Having a good science fair experience starts with having the right project. The most difficult part of the process is the first step: choosing a topic. How does one find that unique idea that will inspire enthusiasm and perseverance, that will blossom into a positive and worthwhile learning experience, that will drive the search for answers and cause one to question assumptions, and that will be, above all, fun?

Unfortunately, there is no good answer to this question. Every year, students ask this question, and every year, the answer is the same: choose something that is of interest. If the topic chosen is of no interest, it is guaranteed that the project will become a chore instead of a learning experience. Perceiving the project as a chore, a mere hurdle to a report card grade, causes all the problems attendant to this viewpoint to emerge: procrastination, frustration, compromise, and resignation.

> ***Choosing a Topic:***
>
> *What are you interested in?*
>
> *Can it be investigated scientifically or solved with a novel technology?*
>
> *Is there an opportunity for quantitative measurement?*
>
> *Is your idea relevant outside the classroom, to people and society?*

Year after year, the best science fair projects at all levels come about because the students who do them observe something in their world and want to understand it better. They hear or read something that piques their scientific curiosity and are inspired to develop a method to obtain the answer. They identify a problem in the real world and seek a solution, to improve their own lives or the lives of others. There is no good substitute for genuine enthusiasm. Ultimately, the best projects and best topics often come from opportunity and luck.

However this is not to say that because a person is unlucky that he or she will never find that inspirational idea. The following section details some general guidelines to consider when choosing a science fair topic:

- **Is it topic of personal interest?** It may be something that was read in a book or heard in the news, or something that affects a loved one. The greatest motivation to see a project to completion without seeing it as a chore is for it to be personal. Examples from previous fairs include the construction of cheap water filters for impoverished countries, developing a guide robot that can follow environmental cues for the visually impaired, or determining the relationship between a certain environmental pollutant and the decline of a population of animals in a community.

- **Can it be investigated using science or solved using technology?** Science is not a passive thing that is just read about; it is an action that is performed. Science is about constructing knowledge of the physical world. A project about hurricanes is not a good project if all that is being done is reading about hurricanes and gluing pictures of funnel clouds to a board. Remember that the best projects, and the most meaningful projects, are about discovering something that was not previously known.

- **Is there an opportunity to acquire quantitative data?** Science, as a way of knowing, is unique in that its principle tool for understanding is *measurement*. In general, science that does not involve measurements is bad science, or not science at all. When choosing a topic, one should be looking for opportunities to make measurements, whether those measurements are changes in a person's heart rate, the speed of moving objects, or mass of particulate matter recovered from a filter.

- **Does the idea have some relevance to other people and society?** Understanding how the science affects other people is an important indicator of its merits as a science fair project. In the real world, science that is of no real importance does not get noticed. Being able to see the interconnections between the project and the world is an important skill, whether one intends to become a professional scientist or not. Since the best projects typically originate from observation of the physical world, often those very same projects have very real and very meaningful implications for our society.

Types of Projects

In general, there are two types of science fair projects: the experiment and the innovation. The criteria for a successful experiment differ from that of a successful innovation. It is therefore important to have a clear understanding of the differences between these project types. The following section will discuss these two types of projects and what they entail.

1. **The Experiment** – An experiment in science is a practical, hands-on approach to answering a question about the physical world. Ideally, unlike the traditional high school laboratory activity, the answer to the question or the method to be employed is not previously known.

   Typically an experiment is done to determine how one variable affects another. These variables tend to be continuous measureable variables (e.g. length, time, or mass). Oftentimes, data produced is tabulated and can be analyzed by computing summary statistics such as averages and standard deviations. The relationship of continuous measured variables to one another can be analyzed using an X-Y coordinate scatter graph. Examples include the effect of a fertilizer's concentration on plant growth rate, or the effect of temperature on the elasticity of a spring.

   Sometimes, an experiment is done to determine if a variable affects one group (the experimental group) differently than another (the control group). For example, one could test the effect of a specific exercise regimen on weight loss. Typically, each group would contain multiple trials or subjects which would produce averages. These could then be compared to each other to determine if there was a difference in effect. This comparison can be done using simple statistics, such as standard deviation or bar graphs, or may involve more in-depth analyses, such as a t-test.

   Bad experiments – It is easy, when doing an experiment, to fall into the trap of choosing variables that are not continuous and measureable. While this does not automatically invalidate the project, having immeasurable variables almost always reduces the level of scientific rigour required in the data collection and analysis portion of the project.

A common example is *the effect of music genre on the growth of plants*. While the growth of plants can be measured in a variety of ways, including height and dry mass, because there is no *scale* on which genres of music can be measured, an experiment which compares plant growth to rock music and classical music is, really, two separate experiments (assuming there is a *no music* control group). A simple modification is to just pick one song and test how plants grow in response to volume, which can be measured using the dial on the music device or a decibel meter. This makes volume the variable of interest as opposed to the genre of music.

Ideas that make bad projects:

Consumer product testing: *These projects often involve discontinuous (immeasurable) variables (e.g. soap vs. hand sanitizer) and qualitative observations.*

Demonstrations of known scientific phenomena: *These projects ultimately replicate a scientific principle that can be found in any textbook (e.g. baking soda and vinegar volcanoes, batteries made with citrus fruit).*

Replication of existing technology: *These projects involve following an existing plan to build known technology (e.g. maglev trains and hovercrafts).*

Non-practical research projects: *These are projects that are essential book/internet researched essays with no practical, hands-on component (e.g. researching the mechanics of hurricanes without doing any laboratory or field work).*

Projects with ethical issues: *Any project involving animals or humans is subject to ethical review as mandated by the National Judging Advisory Committee (NJAC). Any projects involving ingestion of substances is automatically classified as high risk and must undergo ethical review. In addition, they must be conducted in a formal research laboratory licensed to do such research and must be under the supervision of a licensed researcher.* This is a legal matter. *Projects which contravene ethical guidelines are not eligible for registration or competition at a regional science fair.*

- **Consumer product testing** is another common trap for prospective science fair students, who often end up evaluating the *effectiveness* or *efficiency* of one product versus another. Consider a common example, such as the *effect of common household cleaners on toilet bowl cleanliness*. How is *cleanliness* going to be measured? Often it is by use of subjective (and scientifically speaking, meaningless) terms such as *slightly* clean, *quite* clean, and *very* clean. Additionally, each cleaner used would represent a different experiment (much like the genres of music in the previous example) since the ingredients in each cleaner aren't constant. Again, a simple solution would be to alter the experiment to test different concentrations of a single cleaner (mixing different amounts of detergent in equal amounts of water) so that it is the concentration that is being tested and not the identity of the cleaner.

- **Demonstrations of known scientific phenomena** are routinely referred to by officials in the science fair community as *volcanoes*, in reference to the classic baking soda/vinegar/food colouring concoction used to visually approximate a lava flow. The *volcano* is a demonstration of the well known scientific principle, acid-base neutralization. Other examples include the fruit batteries (demonstrating the electrolytic properties of organic acids) and elephant toothpaste (demonstrating the rapid exothermic breakdown of hydrogen peroxide into oxygen and water). Being able to replicate instructions and ideas found in any science textbook and produce an eye-catching effect is not the goal of a science fair. Even if the scientific principles behind the effect were learned, understood, and well-explained, this would still equate to a textbook learning exercise. This is especially true for students in higher grades.

2. **The Innovation** – The term innovation is used in science fairs to describe projects that involve the design and construction of technology used to solve a problem or address a need. In general terms, innovations can be considered as engineering projects. The key to a good innovation is a clear understanding of the scientific and technological principles that underlie the design and construction of the device. One example could be the construction of water filters from silk to address the need for clean water in developing nations. The effectiveness of the filters, how much particulate matter was passing into the filtrate, could be determined using turbidity measurements. Another example might be an autonomous robot that could respond to the stimuli in a manner that could help persons who are visually impaired to negotiate their environments safely.

   Bad innovations – When working on an innovation project, it is easy to resort to repurposing existing technology instead of starting from scratch. Repurposing is not in itself a bad thing; however, oftentimes repurposing means that students will fail to learn the scientific and technological principles that make the device work because they have not undergone the process of deconstructing and/or reconstructing the device. The understanding of how technologies work, or how they work together, to produce the desired outcome is a major component of innovation projects, and this understanding is most commonly present in projects that require *innovation*.

   - **Replication of Existing Technology** – The word *innovation* implies something new. There is nothing new about following well-known scientific principles to build something that already exists. Moreover, since innovation projects are often judged for their ability to address a need or solve a problem, an innovation that duplicates existing technology automatically fails to meet this criterion. Common examples of innovations that fall into this category are the leaf blower hovercraft and the maglev train (both of which, incidentally, always fail to meet project size standards) or the model solar or hydroelectric power generator.

     However, it should be noted that modifications to improve known technology are acceptable, especially if supported by some sort of data collection. For example, an excellent hovercraft project could measure power-to-weight ratios and optimize them such that the hovercraft could carry twice the load using the same amount of power.

Non-Practical Research Projects – In the science fair world, the word “practical” refers to projects that have a hands-on component. In the typical classroom setting, a laboratory experiment is the practical component. Similarly, a science fair is an inquiry-based project with an expected practical component where students are actually doing science rather than just reading about it. At any science fair, there will be projects which are, in reality, research essays that have been pasted to boards. These projects are characterized by an absence of design, experimentation, and analysis. Often, this occurs because the initial topic choice was inappropriate, leading to a project for which no practical component could have been planned. These types of projects should be avoided at a science fair. A research essay has one set of objectives, a science fair project has another, and it is not suitable to overlap the two.

Ethics - Projects Involving Risk to Humans and Animals

Ethical considerations will always be part of science. Any project that involves studies of humans and animals will include a measure of risk. Assessing that level of risk is the job of an ethics committee, a group of science and health professionals that operates as part of the regional science fair structure. If the design of a project poses an ethics question, always consult an ethics committee before undertaking the project. Every regional science fair maintains an ethics committee to vet projects, and students/teachers are encouraged to contact their local RSF representative if ethics questions arise.

Any project involving experimentation on humans and/or animals should be reviewed by an ethics committee before being done. Furthermore, if the project involves vertebrate animals, cephalopods (like octopi), ingestion by humans, or some form of significant risk to humans, there will be some additional requirements that must be met in order to comply with ethics and safety standards. Projects involving humans will always require informed consent from all participants and their parents if the participants are under the age of majority.

It has been decided by the National Judging Committee, which sets the judging and ethics standards for every Youth Science Canada-affiliated science fair, that any project at the national level that contravenes its ethical policies will automatically be disqualified. Projects in regional science fairs that contravene these same ethical policies are automatically rendered ineligible to advance to the national level. Ethics are a serious matter, so please take them seriously.

Low risk projects

Questionnaires, surveys, simple skill tests

Significant risk projects

Everything else

Any project involving ingestion is automatically classified as significant risk and must have prior ethics approval and be carried out in a licensed research facility under the supervision of a qualified researcher.

If you require assistance with ethics rulings and/or procedures, please contact the chair of the Regional Science Fair in your area.

Informed Consent means that human participants in the study must understand fully the nature and purpose of the experiment, any risks it poses, and what will be done with the data once the study is concluded. An informed consent letter typically contains the following information:

- Basic Information: researchers' names; title of the project; purpose of the project; a clear statement that the participant can withdraw at any time for any reason.
- Procedural Information: description of the procedures the participants will undertake; explanation of the duration of the study.
- Risk Information: a clear explanation of the risks present in the study.
- Confidentiality Information: explanation of who will have access to the data, how long the data will be kept, and if/how the participants will be informed of the results.

Experimentation on Animals

In general, ethics requirements for working with animals are more relaxed than for working with humans. There are exceptions to this, however, and this argument only works up to a point. Under no circumstances can any work with vertebrate animals and cephalopods cause the animal stress. Stress is purposefully a general word, as it implies any condition that causes even temporary discomfort to the animal. For example, having mice run a maze for the reward of cheese could be deemed acceptable, but not if they had been starved first. Cephalopods, such as octopi and squid, are included in this category due to relatively recent studies that demonstrate that they have highly developed nervous systems that allow them to learn and remember.

When working with non-vertebrate, non-cephalopod animals, ethics requirements are slightly less stringent, and the idea of stress is not usually a factor. It has been deemed acceptable in the past, for instance, to test the effect of certain aquatic pollutants on the growth and development of *Daphnia*, a microscopic crustacean that lives in freshwater. As organisms increase in complexity, especially with respect to their nervous systems, the rules become increasingly strict. Common sense must be applied: even though earthworms are neither vertebrates nor cephalopods, cutting them in half to test their regenerative capabilities would be considered unethical. Testing the effect of microwaves on cockroaches would also be considered unethical. When in doubt, consult the ethics committee of your local RSF before undertaking the project.

Experimentation on Humans

For simplicity's sake, experiments involving humans are divided into two categories only: low risk and significant risk. Regardless of which category an experiment falls, it must undergo prior review by the ethics committee of your local RSF.

Only three types of tests fall into the low risk category: surveys, questionnaires, and minimal-risk skill tests (such as testing math skills, memory, and non-invasive tests of reaction time and coordination). Anything else shall be classified as significant risk.

Significant risk projects include anything involving mental or physical stress to the participants, such as exercise or fatigue. It has been noted that even non-invasive tests, such as calculations of Body Mass Index (BMI), could have adverse effects on self-esteem and should be considered significant risk. Projects involving ingestion are a special class of significant risk project that, under all circumstances, must be performed in a licensed research laboratory under the supervision of a qualified researcher. Other significant risk projects may be subject to this requirement on a case-by-case basis, or could be performed locally if the ethics committee of the local RSF deems that this is not necessary.

For any project involving humans, it is essential to check with your local RSF first. All experiments involving human experimentation require prior approval, even if they are low risk.

Part 2: The Report

The report for the science fair is the written component of the entire project. In the scientific world, publishing results is an essential part of communicating findings and conclusions. Publication of results allows other scientists to see what has been discovered, and this in turn is one of the most important criteria in obtaining funding for further research. Competent and professional writing skills are an essential part of establishing scientific credibility; therefore, they are also considered an essential part of the science fair process.

From a competitive perspective, judges at a regional science fair may like to see that a report was written. They may scan the report for specific information that is not on the backboard (such as raw data; see ahead and in Part 3). The requirements for a report at the regional level are specific to the region, and any questions regarding this should be directed to the local RSF. At the Canada-Wide Science Fair, a project report is not only required, but is a graded portion of the judging process. The project report for the CWSF has very specific requirements (both for what should and should not be included), which are outlined in the participant manual each year. At the national level, it is expected that the report will read as a professional document.

Elements of the Introduction

The introduction of the report gives all the information necessary for a reader, often a judge, to understand the intended research goal of the project, as well as the experimental or engineering methodology. A clear and concise introduction is extremely important because this is what a judge will use to determine if the research goal was actually achieved.

Background Information

This section contains the basic scientific information required to understand what was done in the project. This section should be approached from the idea that a writer should never assume the reader's knowledge. This is especially true when writing a report for a competitive science fair where judges, unlike individual classroom teachers, often were not present to witness the work done for the duration of the project. It becomes critical at the competitive level to make sure the background information is complete but not overwhelming.

For example, if a project was done on genetically engineering *Pseudomonas aeruginosa* bacteria to degrade hydrocarbon compounds, one might discuss the growth requirements of *P. aeruginosa*, genetic modification in bacteria, hydrocarbon chemistry, pollution, and biodegradation. If the project dealt with designing a more effective mobility aid for the elderly, one may wish to cover the weaknesses of current mobility aids that the project is designed to address, as well a basic outline of the technologies used to create the new device.

Guiding Questions

Background Information:

What does a reader need to know?

Does the average person reading my report have enough scientific knowledge to understand my work?

Purpose:

What did I want to learn or achieve?

What question was I trying to answer?

What problem was I trying to solve?

Hypothesis:

Based on prior knowledge, what should happen in this experiment?

Have I explained my reasoning?

Variables:

What did I change?

What was the effect of that change?

What factors had to stay the same? Why?

Were there any factors that could not be controlled?

Purpose

Sometimes, a statement of purpose is included in the background information. Other times, one may deem it beneficial to include an outline of research goals in its own dedicated section. Both the writer and the reader must have a clear understanding of the project's purpose in order to later assess whether or not the project achieved that purpose. It instills confidence in judges to know that "this was accomplished," as opposed to being left wondering, "what was the point?"

Hypothesis and Variables

Experimental projects often include a hypothesis, which is a prediction of outcome based on previous knowledge. The common descriptor *educated guess* should be avoided. A hypothesis is anything but a guess; a hypothesis should never be stated without some reasoning. Indeed, it is often beneficial to provide that reasoning in this section. A hypothesis that lacks rationale is a guess and therefore is a poor hypothesis.

When writing a report for experimental projects that deal with relationships between variables, it is advised to include a concise list of the independent (manipulated) variable(s), dependent (responding) variable(s), and controls. These are key properties of many experiments, and listing them outright can indicate understanding of the basic principles of experimental design. If this is done before the project begins, it can also help to identify flaws.

This section is often irrelevant in innovation projects and can be omitted. Students should not be forced to advance a hypothesis if the project type and methodology does not support it. If the process of forming and stating a hypothesis is a learning objective for the individual classroom fair, it should be made clear from the outset that only experimental projects will be permitted. At the regional and national levels, this section is considered based on project type.

Materials and Methods

The materials and methods is a comprehensive listing of all materials and procedures used during the experiment. For many projects, the materials and methods lists will be so long that it will not be practical to list them all on the display board (see Part 3). For this reason, this section of the report should be considered as a supplement to the display board where a full description of materials and methods is available should a judge need more detail than what the display provides.

> ***Guiding Questions***
>
> ***Materials and Methods:***
>
> *Can another scientist, working in the same conditions in which I was working, understand my procedure well enough to repeat my experiment?*
>
> *Will that scientist be able to obtain identical results?*
>
> *Have I assumed any knowledge that I should not have?*

Materials and methods sections, by nature, are not particularly exciting to read. Conveying information clearly and with brevity is extremely important in this part of the report. Employing visual reading cues, such as headings, bullets, and sequential numbers is helpful in keeping methodology easy to follow. Diagrams, blueprints, tables, and charts can further help to organize and clarify information, particularly for judges who may not be inherently familiar with the topic. This is especially true for projects that involve multiple aspects, each with their own materials and methods.

Procedural information needs to be as concise as possible. Simple numbered or bulleted phrases work best, combining clear language and visual cues. The easiest trap to fall into when describing a procedure is assuming reader knowledge. Imagine an experiment which involved measuring heart rate. A procedural step that says, “After exercise, measure the subject’s heart rate,” is insufficient, because there is no description of *how* to measure heart rate. In this example, the writer has assumed the reader knows how to measure a heart rate. Even if the reader does, he or she may not measure it in the same way the writer originally did.

For innovation projects, especially those that require construction and engineering (whether physical, electrical, computational, or otherwise), remember the adage, *a picture is worth a thousand words*. Just like many pieces of furniture one might buy in a store come with illustrated instructions to aid in assembly, having diagrams to accompany engineering or construction procedures will aid judges in understanding how the innovation was designed and built.

Elements of the Main Body

The main body of the report contains the results of the experiment or a description of the final innovation and what it does, including any processed data. Even innovation projects could have data, since it may be necessary to make measurements to show that the innovation does what it is supposed to do. Data is often best displayed in organized tables or charts/graphs. Raw data (initial unprocessed measurements) are typically not shown in this section, but rather presented in an appendix.

Results

Results are an unbiased and objective summary of the outcome of an experiment or the final product of an innovation. Interpretations of data or extrapolations of its significance are left for the conclusion. In some ways, recording results should be approached from the point of view that the reader should be able to draw his or her own conclusions before reading the report. Ideally, if the results have been presented clearly enough, he or she should be able to arrive at the same conclusions.

Results presented in this section should be in their final form. Raw measurements should be averaged. Example calculations can be shown, but the rest of the calculations should be left for the appendix. Any statistics should be given in summary form (such as averages and standard deviations), and raw data should be placed in the appendix. This way, judges can acquire all the essential data quickly without having to sort through pages of numbers and calculations. They can read the appendix if they require more information.

Guiding Questions

Results:

Have I included enough data to allow others to draw conclusions?

Have I included only the information required to draw conclusions?

Is the rest of the information (raw data and calculations) included in the appendix?

Tables and Graphs:

Have I used the correct presentation method for the data that I have?

Is my numerical data summarized in a table?

Does my table/graph show units and uncertainties?

Have I titled graphs and tables in a meaningful way?

If they had to, can my tables and graphs stand alone and still be understood?

In the body text, have I cued my reader when to look at tables and graphs?

Are my tables and graphs integrated into the text of my report such that a reader can move from one to the other without flipping pages?

Tables and Graphs

The importance of tables and graphs for clear communication cannot be emphasized enough. Primarily numerical data should be tabulated with clear table headings. Units and degrees of uncertainty should always be specified in the table itself.

Graphs should always have clear axis labels that show units and uncertainties. The type of graph used depends on the type of data that is being graphed. Measured data should be graphed. If both the independent and dependent variables are continuous and measurable, an X-Y scatterplot should be used. If the independent variable is discontinuous (for example, males and females) but the dependent variable is still continuous, a bar graph should be used. Other graphs will be required for special cases or different types of variables.

As a general rule, a reader should be able to see a table or graph and understand its meaning and significance without seeing any other information. This means that the title of the table or graph should be an accurate description of what it contains. Some tables or graphs will have very long titles as a result (for example: Table 1. Mean average particle counts in the filtrate of water samples from Wascana Creek in May 2009, from filters of different pore sizes), but this is necessary to ensure that a judge never reads tabulated or graphical data without understanding its context.

Remember that tables and graphs are *supplementary* to the text in the results section; having tables and graphs does not mean writing a detailed analysis of results can be avoided. Indeed, both written and tabular/graphical summaries should be present. Each table and graph should be numbered (Table 1, Table 2; Figure 1, Figure 2; etc.) and titled. Readers should be cued to tables and graphs, which can be done using statements like this: "As shown in Figure 1, as the duration of exercise increases, heart rate increases." Tables or graphs should be integrated into the body of the report so that paging back and forth is minimized. Unless a table or graph contains raw data or other supplementary material, it should never be placed at the back of the report with the appendix.

Elements of the Conclusion

The conclusion is where interpretations of data will be given. It is also where errors and improvements need to be discussed. The importance of the experiment/innovation will be explained here, as well as any commercial or industrial applications, or economic or social importance. More than anywhere else, here is where any interdisciplinary connections should be highlighted.

> ***Guiding Questions***
>
> ***Conclusion:***
>
> *Have I explained what the data means?*
>
> *Have I explained the connection between my project and broader fields of study?*
>
> *Have I given examples of both systematic and random errors?*
>
> *For each error, have I considered possible effects as well as improvements?*
>
> *Have I discussed any problems encountered during the execution of the project and the solutions that were employed?*

Conclusions

In a science fair project, the conclusion section has three specific roles. The first is the same as the typical lab report: it is a place to give interpretations of data, clarifying its meaning with respect to broader science concepts. In the previous example regarding filtrate samples, a discussion of the most effective filter (trapping the most particulate matter while minimizing impacts on flow rate) could be presented. In the example about heart rate, connections to autonomic control of heart rate, cellular respiration, and energy metabolism could be made. This would demonstrate not only an ability to read the data, but also the ability to apply it to related ideas.

The second function of the conclusion is to provide a place where errors and improvements will be listed. All measurements have inherent uncertainty, and therefore all science projects, regardless of type, have some amount of error associated with it. Errors can be divided into two types: systematic, which is caused by equipment limitations, and random, which is caused by people. Not only should examples of both types of errors be listed, but an explanation of possible effects of those errors should be provided. In addition, each identified error should have an associated improvement that would reduce or eliminate the error. In experiments and especially innovations, this could include a description of problems encountered and the solutions used to overcome them. Indeed, this may be the most relevant type of error discussion for innovation projects.

Significance

The part of the conclusion where the importance of the project is explained is arguably the most important part of the project. In the industry of science and scientific research, scientists who cannot demonstrate the importance of their research rarely receive funding. Indeed, many grant applications have a specific portion dedicated to this very topic, and it is often the first thing discussed, not the last.

Projects can be significant in a number of ways, but generally speaking, the importance to the student and society at large should be covered. If the project has commercial or industrial applications, this should be noted. Consider the impacts the research could have on society, technology research and development, the environment, the economy, politics, or people's perceptions. Any or all of these are areas that should be discussed if possible.

> ***Guiding Questions***
>
> ***Significance:***
>
> *Have I explained why this research is important to me?*
>
> *Have I explained why this research is important to you or to specific groups of people or the world?*
>
> *Have I explained any social, economic, political, environmental (or other areas of) significance arising from this work?*
>
> ***Acknowledgements:***
>
> *Have I recognized any individuals, organizations, or institutions that helped me?*

Inside schools, science is often compartmentalized from other subjects; science occurs in one room and no others. This idea must be abandoned, because science outside schools most certainly is not segregated from the rest of the world in this manner. Science, like all other human pursuits, both influences and is influenced by all other systems, human and natural. Scientific research and discovery throughout history, whether deliberate or accidental, has changed, and continues to change, the quality of life for humans and other organisms on the planet for better or for worse. One of the objectives of doing a science fair project is to recognize and embrace the interdisciplinary nature of scientific research so that it can be shared and appreciated by all people, whether they are scientifically trained or not.

Acknowledgements

Most science projects are not always the product of only one or two people. Many others may have had a hand in the success of a project, whether it was parents acquiring supplies, teachers lending their classrooms, or university professors donating their expertise and time. Some projects may have been funded by organizations. Equipment may have been donated. A printing company may have produced the display material. All people, organizations, and/or institutions from which help was received should be acknowledged for their contributions.

Other Elements of the Report

References

The reference list or literature cited is the science equivalent of a bibliography. Whereas the term *bibliography* specifically refers to books, the term *references* is more general and refers to any source of information from primary scientific literature, to videos, interviews with professionals, and even personal communication. The citation style used in science is known as APA (American Psychological Association) and should be employed during the writing of the report.

The reference list, though in the appendix, is not optional. Not documenting references is a form of academic dishonesty, which in the competitive science fair structure can result in disqualification. In post-secondary institutions, the penalties can be far worse. At the Canada Wide Science Fair, the reference list is a required portion of the project report.

Raw Data and Calculations

Raw data and calculations are essential parts of a project, but they are not necessarily essential to understanding the body of work as a whole. This is particularly the case then the raw data is processed before conclusions are drawn. Processing refers to any mathematical or statistical computations that convert the data into a final form. Examples include converting distance and time data to speeds, or computing averages and standard deviations.

In each of these examples, only the processed data is required to be shown in the report. That having been said, having a record of raw data is highly advised, because a judge may ask to see that data, or see examples of the processing that was done. Not having this information readily available would lead a judge to question if the work had actually been performed.

There are some occasions where raw data can be included in the body of the report: if the data is already in a form from which conclusions can be drawn and/or if the data required no processing before presentation. Ultimately, what needs to be recorded in the results section and what needs to be shown in the appendix must be evaluated on a case-by-case basis.

Abstract

The abstract is a short (50-200 word) summary of the entire project, usually including a statement of purpose, a very brief description of methodology, and one statement of the findings. The abstract is used so that readers can know what the paper will be about without reading the entire report. In competitive science fairs, the abstract is used to classify the project so that appropriate judges can be assigned. At the Canada Wide Science Fair, the abstract is a required part of the project report.

Part 3: The Display

The display backboard is often what makes a science fair project unique from other science activities. Indeed, the backboard is often the definitive characteristic of the project. That having been said, the display board is often only assembled at the end of the project, prior to its presentation in the classroom or in a competitive fair. The display adds another dimension to the activity; not only do students have to execute the project and write a formal laboratory report, but they must also exercise their skills at graphic design to build an aesthetically appealing and educational presentation board. The following section gives information on constructing an excellent backboard for a science fair project.

Backboard Materials

There are a variety of materials available for making a backboard. The cheapest and most readily available are premade and folded cardboard displays that are available at many office stationary supply stores. Often, these cardboard displays can be purchased in a variety of colours which eliminates the need to paint the board for decorative purposes. These are often suitable for classroom fairs. Other materials that could be used are Coroplast, Sintra, plexiglass, metal, and wood. Recently, printing the display on large poster-sized sheets of paper or vinyl has become another option. While there are different advantages to using these other materials, some may be difficult to acquire or use due to cost, construction requirements, or weight.

At competitive science fairs, local fire and other safety regulations may demand that specific materials are used for backboards. Students and teachers are advised to check with an RSF representative for the backboard material requirements for their local RSF.

At the Canada Wide Science Fair, the backboard material requirements are extremely stringent. Cardboard and Coroplast boards (the two cheapest and lightest display materials) are not permitted. Many of the approved materials are only available from stores specializing in signage. Many require construction, and some may be too heavy to transport easily. *Youth Science Canada* has made wooden boards available to rent at a reasonably low cost. This eliminates the need for complex construction or transportation arrangements, and many students have elected to exercise this option in recent years. Check with your local RSF representative who will be able to list the available options for backboard materials at the CWSF.

Backboard Function

The display is in many ways a visual report which mirrors the written report; therefore, the backboard should contain much of the same information that the written report contains. Background, purpose, materials, methods, results (especially tables and graphs), conclusions, and acknowledgements should all be present. However, remember that the display board serves a different function than the written report, and this function should inform all design decisions during the construction process.

In many science fairs, competitive or otherwise, a judge will probably spend about ten to fifteen minutes looking at a backboard. This means the backboard must convey as much information as quickly as possible. This principle dictates that both the writing style and presentation must differ significantly from the written report.

Elements of a Good Display Board

Clarity of written and visual expression is of crucial importance in the display board. A judge looking at a confusing display could fail to understand the project, which might lead to other issues, like a much more intense and stressful question and answer session. Judges are not only evaluating knowledge but also the ability to express that knowledge. This section details some of the techniques used to enhance the visual display from both aesthetic and functional perspectives.

Characteristics of a Good Backboard

Eye-catching

Attractive

Organized and logical

Not distracting or gaudy

Professional

Conveys a lot of information quickly but clearly

Grab a Reader's Attention

The first thing any kind of display must do is grab the reader's attention. Having an eye-catching display is the first way to positively influence the mood of a judge. An attractive display invites or welcomes judges to read it. A messy display, one with which care and attention was not taken, is usually an indication that the same lack of care and attention was taken during the execution of the science. To this end, a colourful board with a clearly visible creative or witty title often leaves the most lasting impact. Panels are often bordered. Photographs of students actually working on the project are often included. Diagrams are large, clear, and printed in colour. Ultimately, the goal is to present a professional-looking display because a professional display is often associated with professional work.

Don't be Distracting

Always remember that it is just as important that the display is functional as well as pretty. The display is not just an attention grabber; it is also a communication tool. A display that is too flashy is often a deterrent to communication because it distracts the reader. Therefore, functional aesthetics is just as crucial as attractiveness, and finding a balance between both is essential. While boards should be colourful, sometimes it is more useful to choose a colour palette of a few complimenting colours, rather than the entire rainbow. Glitter, fluorescent paper, or other bright and shiny elements should be avoided in areas where a lot of reading will occur. Panels should all be oriented in one direction, typically square to the corners of the board, so that readers do not have to tilt their heads in different directions. Elements in front of the board should not obscure the view of the board itself. Moving parts should be able to be stopped during the presentation. Keep in mind that certain individuals may have colour vision problems of varying degrees and certain combinations (for example, red text on a green background) may be difficult to view. For this reason, text and background colours should be chosen in a combination that produces high contrast.

Don't Strain the Eyes

It is essential to have readable text on a display board. Text that is difficult to read exhausts both the eyes and the mind. Readability is a function of two things, the first of which is text structure. Text should be large enough to be easily read from a distance of 1 to 2 meters without causing eye strain. When printing text panels, consider how far away a judge might be standing, including the space where the presenter(s) will be, and then choose the appropriate sized font. Since it is more difficult to focus on a single line of text as the distance from the board increases, text should be double-spaced. Fonts should be regular non-cursive typeface. They should be largely consistent in style and size across a board, because multiple different fonts can be distracting.

Characteristics of Effective Text

Double-spaced, large-sized, non-cursive font (e.g. Arial or Times New Roman)

Can be read easily at a distance

Numbered or bulleted statements

Accurate language (e.g. each statement's actual meaning matches its intended meaning)

Arranged corresponding to how people read (e.g. left to right, then top to bottom)

Attentive to common visual issues (e.g. colourblindness)

Write Better, Not More

The second determiner of readability is accuracy of language. Since the goal is to convey a lot of information quickly, formal writing, which takes longer to read and process, may actually be detrimental. Therefore, it is often easier to eliminate long, complex sentences and instead utilize short phrases. Students may choose to include both full text and short summaries so that judges can choose which to read. Bulleting or numbering text items cues readers and helps focus them on their location in the text. In addition, panels which can be scanned quickly are easier for *presenters* to use as visual aids and memory tools, often eliminating the need for cue cards. When writing, decide what information each line of text is intended to convey and proofread out loud multiple times to ensure that the intent has been realized without using unnecessary words.

Display What Needs to Be Displayed

The display board is a visual layout of the project report. In theory, all the information that is in the main part of the report should be on the board. That having been said, there are a number of items that can be abbreviated depending on what is needed for the presentation. For example, the materials and methods can usually be minimized. Sometimes, a single labeled diagram or a numbered list outlining the main steps will suffice. Results on the display board should be in summary format, i.e., graphs showing final relationships and tables showing only values relevant to drawing conclusions. Remember, judges can always refer to the project report, which should be in a duo-tang or binder at the display table, for additional information. Material that was included in the appendix of the report does not need to appear on the board, as long as that appendix is accessible to judges.

What Should Be Displayed?

Everything that is in the report, excluding the appendix, should be on the board

Diagrams, especially for complicated or tedious sections

The report, including the appendix, present in a binder or duo-tang, accessible if a judge needs it

Keep the Layout Logical

The layout of the board should be logical and fluid, in the way that people intuitively read. Presumably, this will mean left to right and top to bottom. Panels should be arranged in a similar manner on the display board so that a judge or other reader doesn't have to search for information. In general, introductory information starts on the leftmost panel (assuming a three panel board) and reads downward. Results appear on the middle panel and conclusions are displayed on the rightmost panel. This layout can be altered depending on the amount of information in each section, provided the board is labeled well enough so that the layout is not a mystery to a reader. The best test is to observe someone else reading the board. If the reader's head is moving in circles, typically this means information cannot be located and the layout should be altered.

Don't Bring the Lab With You

Many times, students want to have present at the display table actual experimental set-ups, innovations, or materials used during the project. This is almost always excessive and unnecessary. Judges do not volunteer their time to watch a show (see page 5, demonstrations of known scientific phenomena). Nor will judges doubt results if they can't see them. Judges are often scientific professionals and obtain much of their information from reading scientific journals or attending conferences, and in neither case are they able to see experiments or innovations in person. Judges are not there to test trustworthiness; they are there to test scientific understanding.

A good rule of thumb is to ask, "Does displaying x aid a judge in understanding what I did?" If the answer is, "No," then x should not be displayed. Almost all scientific demonstrations will contravene safety rules anyway, which is why projects are carried out in labs and workshops in the first place – <u>they don't belong in the exhibit hall</u>.

In this day of easily accessible electronic media, photographs or even video demonstrations contained on a laptop are much better options for showing experimental set-ups or innovations. Always consult the local RSF rules or with a local RSF representative before bringing experimental materials or innovations to the fair.

Do I Need to Show My Materials?

Ninety-nine percent of the time, the answer is "No". If judges don't need to see a material when reading the report, why do they need to see it when looking at a backboard?

Imagine you have done a project involving liquid soap and bacterial growth. You know the safety rules say you can't bring the bacteria (so you have photographed them), but you are planning on displaying soap pumps containing actual soap. Why? Are you concerned that judges may not know what soap is? Are you concerned that without being able to see soap, the numbers and graphs on your display board will suddenly not make sense?

In this example, there is no reason for the soap to be displayed. Since it does not aid in understanding, it should not be displayed.

Don't bring the lab with you to the fair!

Part 4: The Presentation

The presentation represents the oral communication portion of a science fair project. Scientists in research and industry often attend conferences where they listen to each other speak. Some of these conferences utilize posters to present research in much the same way as science fairs! The ability to communicate clearly and succinctly is an important skill regardless of what field a student eventually chooses as a vocation. Just like executing an experiment, writing a report, or designing a backboard, giving an oral presentation requires a certain set of skills. Remember that the oral presentation for a science fair typically includes a short question and answer session. This section will detail some techniques for giving an effective presentation as well as for effectively answering judges' questions.

Nervousness

Some people find that public speaking comes naturally to them. For others, it is a terrifying experience. Students giving science fair presentations are often concerned with *looking stupid*, whether that means missing information, saying something that is wrong, or not being able to answer judges' questions effectively. Anxiety over these types of things leads to nervousness, which often creates ancillary presentation issues, such as over-reliance on cue cards or inability to make eye contact. Students should remember that they, not the judges, are the experts; after all, they did the projects. In many ways, during the presentation, students *are* the teachers. While a judge may have a better understanding of the scientific principles, only the students know what the project is about.

Don't Be Nervous!

It's your project! You're the expert.

Don't just appear confident. Be confident!

Make eye contact. Smile. Introduce yourself.

Don't be afraid to not know. You're not expected to know everything.

Keep eye contact. Don't read.

Use your board as a guide, for you and for judges.

Speaking Well

Effective oral communication starts with a good speaking voice. Speak slowly and clearly and loudly. Nervousness often leads to an increase in speed, which causes words to run together. Speaking rapidly also causes problems with breathing, whereas a relaxed pace allows one to stop and breathe without interrupting the cadence of speech. Enunciate words, particularly with complex science terms. Learn to use pauses effectively, particularly while showing a diagram, procedure, or object. Remember that judges are seeing the project for the first time and need to process not only what is being said but also what is being shown.

Speaking Tips

Slow. Clear. Loud.

Remember to breathe.

Eye contact. Eye contact. Eye contact.

Give the audience time to process.

Your board is not a decoration; it is a tool. Use it!

Watch your audience for cues on what to do.

Responding to what the audience is doing is but one important non-verbal communication technique. By watching a judge, students can get an idea of when something is unclear and needs to be explained another way or if a concept has been explained well and another topic can be started. In this regard, maintaining eye contact is another key technique that helps keep everyone engaged in the discussion.

Gesticulation can be useful for emphasis or for directing a judge's attention to something in particular, such as a graph on a board or a particular line of data. However, wild and random gesticulation should be avoided because it can be distracting. That having been said, the board should be used actively. Assume that judges are seeing the display for the first time, which means they should be directed at what to look at. Point to the materials list, or a line on a graph, or a photograph of the experiment; don't make judges search for information while they are trying to listen, process, and formulate ideas and questions. The board is a tool; the more it is used, the less the presenter has to learn by rote.

What to Speak About

Like the report and the display board, the presentation is supposed to be an overview of the entire project. However, in much the same way that the display board is an abbreviated version of the project report, the oral presentation is an abbreviated version of the display board. The goal is to give a judge an overview of the entire project, from background to conclusion, in just five to ten minutes, so making deliberate and discriminating choices as to what needs to be said is crucial. More than likely, most of the details will have to be omitted. This is why diagrams, figures, and summary tables are so important to the backboard design; there is simply no time to give lengthy descriptions during which large volumes of text must be read. In fact, it is probably advantageous to omit all but the most significant details anyway; overwhelming a judge with a huge volume of information will probably not be beneficial.

Generally speaking, a minute or two will be spent giving background information, including the initial inspiration, purpose, and background. Methodology should be extremely limited in most cases, and no time should be spent on reading out a materials list. It would be appropriate to tell a judge to ask for more information on materials, methods, or procedure if he/she needs more information. The bulk of the presentation should be spent on results and their interpretation, looking at tables and graphs, making scientific conclusions, and explaining probable errors and potential improvements. By the time the results and conclusion are finished, most talks will have already reached ten minutes in length.

By being proactive in crafting the presentation, some control over the question and answer session to follow can often be exercised. Rather than trying to be as complete as possible during the initial presentation, sometimes it can be useful to build in areas with obvious gaps in information. For example, one might leave out discussion of a fairly obvious error. Doing this could (but not always) lead judges to ask questions to fill in these gaps, but since the omission was intentional, the answer could be prepared. There is a risk to this technique, however, since it could lead a judge to assume that the reason the omission occurred was an actual lack of knowledge.

How to Answer Questions

After the ten minute presentation, a short (usually five minute) question and answer session will occur. During this time, a judge will ask questions to ascertain that the science that has just been presented is actually understood. This is to separate exemplars of actual learning from those who blindly followed the instructions in a book or who received an inappropriate level of mentorship.

Questioning by science fair judges is supposed to occur according to a fairly specific model (though it cannot be guaranteed that every science fair or judge follows this model). The judge chooses an area in which to question a student and begins with a basic inquiry for which the answer should be known. If the answer given is correct, the judge moves to a more difficult question in the same area. This pattern continues until the student fails to answer a question correctly. At this point, the judge should have a good idea of the student's level of knowledge on the topic. Further questioning in the same area should not occur, because the student's limit has been reached. The judge should then proceed to a new area of questioning, again beginning with a basic question. After several rounds of increasingly difficult questions in a variety of areas, the judge should have developed a reasonable picture of the student's understanding of the science.

Question and Answer Techniques

Listen. Answer the question that was asked, and avoid saying more than you need to.

You're the expert. Prove you understand.

When possible, show the judge your answer by using the board or the report.

Ask for a question to be repeated or reworded if needed.

Be honest. If you don't know, say "I don't know."

"I don't know" can often be followed by other statements such as, "but that would be a good thing to test," which can make the knowledge gap seem narrower.

Phrase hypotheses appropriately. Don't make hypotheses sound like guesses.

In the typical science fair questioning model, you are not expected to be able to answer every question.

Answers to questions should be clear and succinct. Answering without hesitation usually indicates better understanding. Stalling for time is as simple as asking the judge to repeat the question. If the question is not understood, be honest and say so. Ask the judge to state the question another way. If the answer is on the board or in the report, show the answer to the judge while giving it. Pay attention to the question that was asked and answer it. Don't fall into the trap of getting into a protracted digression on a related topic and then losing sight of the goal or answering a question that was not asked. Remember, the more that is said, the greater the number of opportunities to make a mistake.

It is not expected that students know the answer to every question. In fact, according to the questioning model described above, there are supposed to be several questions the student cannot answer. In an oral presentation, there is only one correct answer to a question for which the answer is not known: "I don't know." However, gaps in knowledge can be partially filled through the use of supplementary phrases such as, "that would be an interesting thing to try and this is how I would do it…" or, "I never thought of it from that perspective; that might influence my conclusion in this way…" This simple technique can transform a gap in knowledge into an opportunity to demonstrate critical, creative, and quick thinking.

While it might be daunting to be honest and say "I don't know," lying to a judge is not a good technique. In a written examination, taking a wild guess is often encouraged as opposed to providing no answer, because there are really no negative consequences for doing so. Either the answer is wrong, or it is serendipitously correct. In an oral presentation, taking wild guesses is risky. Some judges will not indicate that an answer was wrong, but rather continue asking questions based on the initial incorrect answer to see how far a student will carry that guess before admitting the mistake.

Keep in mind that not all guesses are wild. It is completely valid to ask a question related to, but not part of, the project to see if sound scientific principles can be applied from one situation to another. In this case the answer may seem like a guess, but with effective phrasing, such as by saying, "based on X and Y, I would predict Z," the guess is, in fact, transformed into an intelligent hypothesis.

On the Use of Cue Cards

Cue cards are both a blessing and a curse. Some students prefer to use them as a confidence booster. Many defer to them so completely that they forget to make eye contact for the duration of the entire presentation. Sometimes, even though a student is using cue cards appropriately (to cue memory at specific instances), the cards themselves are so poorly designed that attempting to read them becomes more of a distraction than anything else.

Cue cards are memory aids. The word *aid* implies that memory is really the important factor and that the card is only there to help should the memory fail. Students should not treat cue cards like scripts because this results in reading. Reading a presentation is one of the key indications that the student doesn't know his/her science. If a student truly spent weeks or months working on a science project, it is not unreasonable to expect that the student be able to speak candidly about the experience without having to pre-script the presentation. Reading a presentation prevents eye contact, reduces engagement, eliminates the ability to watch and respond to the judges' behavior, and leads to other irritating behaviours such as ignoring the display board or having to search for position in the script after each time the backboard is used.

> ***An Example Cue Card:***
>
> **Conclusion**
>
> **Fig 1:** **positive correlation**
>
> **emphasize 55-100 mL**
>
> **Errors:** **no temp control**
>
> **humidity effect**
>
> **Uncertainty!**

If cue cards are used, they should be unobvious and non-distracting. Each card should have only a few key words written in large text to reestablish position in a presentation. At no time should the card need to be lifted to eye level to see. Full text should be avoided to remove the temptation to read. In fact, the best cue card for a science fair project is sitting on the table: the display backboard already has all the required information. When using the display board as a cue card, take care not to spend too much time facing it. Glance at the board and then quickly reestablish eye contact.

Final Thoughts

Being involved in a science fair is a huge undertaking. Thousands of volunteer hours are committed each year to run regional, national, and international level competitions. Even in individual schools or classrooms, participating in science fairs can be a daunting task for students and teachers. Nevertheless, the traditional science fair project as an assessment tool represents the model for authentic teaching and learning of science at the elementary and secondary levels. It involves multiple types of evaluation that target different strengths and aptitudes. It is meant to engage students, regardless of their learning preferences or styles. Done properly, it reflects scientific research being carried out in universities and other institutions worldwide.

I hope that this guide makes science fair more accessible to everyone, whether you are a student designing a project, a teacher planning a classroom event, or a school coordinator hosting a school or regional competition. A better understanding of the scientific process in the individual classroom leads to a better caliber of science being performed in both competitive science fairs and in the world of research and development. Inquiry doesn't have to be elaborate or intimidating. Start simple; even the smallest question may reveal hundreds of surprising answers. The sheer magnitude of all our scientific and technological achievements makes it easy to forget one fact – indeed a poignant reminder would be a good thing, now and then – *that all knowledge, no matter how great or small, began once as wonder*.

~J Jo, 2010

For more information on running science fairs, including judging rubrics and guidelines, please see the *How to Run a Science Fair Manual*, available for viewing on the Regina Regional Science Fair website, www.ReginaRSF.com.

About the Author

Jim Jo has been a classroom teacher for six years, teaching high school physics and biology, in the regular and International Baccalaureate programs. Prior to teaching, he spent seven years in university, studying biochemistry and microbiology, including three years doing Masters research on the mechanism of antibiotic resistance in *Pseudomonas aeruginosa*, a common respiratory bacterium which is the major cause of fatal secondary lung infections in persons with cystic fibrosis.

Jim started volunteering with science fairs in 1999 with the Greater Vancouver Regional Science Fair where he performed various roles ranging from multimedia development to deputy chief judge. In 2003, he joined the Regina Regional Science Fair committee and became Chair and President of the Regina Science Fair Council in 2004. To-date, he has attended eight Canada-Wide Science Fairs. In 2008, Jim was elected by representatives from Saskatchewan, Manitoba, Northwest Territories, and Nunavut to represent them on the National Science Fair Committee for a three year term.