STEP-BY-STEP STUDENT GUIDE

AND CHECKLIST

TO THE DEVELOPMENT OF

SCIENCE AND ENGINEERING PROJECTS

Junior Division
5^{th} – 8^{th} Grades

West Central Indiana Regional Science and Engineering Fair
March 13, 2004
Depauw University

CONTENTS

Many thanks to the Tri-Valley Science and Engineering Fair for the permission to allow the SRSEFF to adapt their excellent materials for our use.

SAMPLE TIMELINE

Get an early start on your project (Rules allow research to be conducted over a maximum, continuous 12 month period between January of the year before the fair and up to the date the Fair begins).

1. Deciding on a project— 1 week
2. Background research— 2 weeks
3. Forming a hypothesis/designing procedures— 1 week
4. Submit forms for teacher approval— before starting experimentation
5. Experimentation— 4 - 8 weeks.
6. Results, conclusions, analysis— 1 - 2 weeks
7. Writing the project report— 1 - 2 weeks
8. Building a display board— 1 - 2 weeks

NOTE: There is a deadline for application form submittal to the Fair – Forms must be turned in by February 28, 2004. It is recommended that you submit your application as soon as possible. Your project work can continue and run up until the Fair date.

GETTING THE IDEA

A science project! What'll I do? Do I have to find a cure for cancer? A way to end pollution? An endless supply of inexpensive electricity or water? HELP!

Whoa! Quit biting your fingernails. You're not expected to win a Nobel Prize with your very first project (that can wait a year or two).

What are you expected to do? Well, first of all, you've got to select a topic. And, how, you ask, do you do that? Checklist #1 should help. All you have to do is fill in the blanks. Note: The "Sample Timeline" on the preceding page should give you an idea of how much time you will need to spend on each checklist. Okay, here we go...

CHECKLIST #1 — DECIDING ON A PROJECT

STEP 1

List four things you are interested in

Examples: Playing the piano, football, computers, people-watching, chemistry

Examples: Is black print easier to read than blue?[1] Do brown eggs have more cholesterol than white? Would a helicopter fly better if it had more blades? What care do computer disks really need? Which fishing line is the strongest? (See the Appendix for more ideas)

1. ____
2. ____
3. ____
4. ____
5. ____

If you listed things you like, pick one and ask yourself five questions about it — questions you'd really like to know the answers to. For example, let's say you like football. Your questions might include, "Can I write a computer program to predict the outcome of next year's NFL games?" "Would young players learn faster if the coach used a computer to diagram plays?" "Do Pac-Man whizzes make better passers?" Or, getting away from computers, "Do players with thicker necks suffer fewer injuries?" "Does artificial turf produce more touchdowns?" "Can biorhythms be used to predict player performance?" "What is the relationship between body fat and running speed?"

Get the idea? Okay, your turn.

MY QUESTIONS ARE:

1. ____
2. ____
3. ____
4. ____
5. ____

Use separate pages to do this for each of your topics. Of course, if your first list is of things you've wondered about, you may have already taken this step.

Now, decide which question interests you the most and, after you fill in the next blank, you're on your way.

THE QUESTION MY SCIENCE PROJECT WILL ASK (ALSO CALLED THE "STATEMENT OF THE PROBLEM") IS:

____

[1] Most examples in this publication are adapted from projects previously exhibited in the ***Greater San Diego Science and Engineering Fair.***

NOTE: Remember, your project must involve actual experimentation (i.e., "Effect of Storage Temperature on Battery Life"). It should not be simply a report ("Batteries") or a demonstration ("How Batteries Work").

STEP 2

In choosing your topic be sure to not take on more than you can handle. Narrow it down, take an in-depth look at a single aspect of the problem that interests you. Tackle something that hasn't been done over and over again.

Examples

1. "Effect of Volcanic Ash on Chlorophyll Production in Creeping Charlies" would be better than "Effect of Volcanic Ash on the Growth of Plants."
2. "Effects of Ancient Indian Cacti Remedies on Bacterial Growth" would be more original and interesting than "Effect of Mouth Washes on Oral Bacteria."

Try it. Before you go on to the next section, re-write your QUESTION as a WORKING TITLE, one which simply and accurately describes your research. For example, let's take the five questions listed on the previous page. Good titles for them might be:

1. Blue Vision Decrement and Learning Problems: Study in Perceptual Response
2. Correlation between Shell Color and the Cholesterol Content of Eggs
3. Effects of Blade Number on Helicopter Flight
4. Effects of Care and Environmental Extremes on Floppy Disk Reliability
5. Comparative Strength of Various Fishing Lines

THE WORKING TITLE OF MY PROJECT IN **10 OR FEWER WORDS** WILL BE:

LAYING A FOUNDATION

Okay, you've decided on the TOPIC (the one described by your QUESTION and TITLE) you want to investigate. What next? First you'll need to find out what's already known about the subject.

CHECKLIST #2 — BACKGROUND RESEARCH

If your QUESTION were "Are art talent tests biased against right-handers?" you'd study such things as art tests, right- and left-handedness, the works of famous artists, psychological testing and artistic judgment. Or, if your TOPIC were "Effect of Goggles on Underwater Vision," you'd want to know more about eyesight, lenses, the manufacture of goggles, how depth affects vision, underwater measurements and safety precautions. If, on the other hand, you were interested in how an oil spill would affect sea anemones, you might need to research such things as wave patterns, ocean currents, conditions and substances affecting the growth of anemones, the chemical makeup of oil and what happens when oil and sea water "mix." You'd also collect information on what can be done to prevent and clean up oil spills.

Got it? Okay, list five or more research TOPICS related to your QUESTION.

1. ______________________________
2. ______________________________

3. ____________________
4. ____________________
5. ____________________

Additional TOPICS may be written on a separate page.

Now, head for the library. A search through the card or microfiche catalogs should start you in the right direction — and don't forget the *Reader's Guide to Periodical Literature*, which lists magazine articles by topic.

Take lots of notes (you'll need them later) and be sure you keep a list of your REFERENCES, using standard bibliographical format (see *Science Fair Handbook: A Guide for Teachers and Students*[2] and *Nuts & Bolts: A Matter of Fact Guide to Science Fair Projects*[3]). Note: The use of ten to twenty-five REFERENCES is suggested. Younger students sometimes start with fewer, adding as they go.

Catalog useful material from these REFERENCES, one note to a card, on 3" by 5" index cards. A sample REFERENCE NOTECARD might look like this:[4]

EARTHWORM ANATOMY	--	(what the note is about)
"Oligochaetes lack eyes except for a few aquatic forms. Earthworms do have photoreceptors in their epidermal layer though and thus, are light sensitive."	--	(the note itself, a quote or summary. Use quotation marks if a quote.)
2,56	--	(bibliographic reference refers to a book or article listed in the BIBLIOGRAPHY. 1st number = which reference 2nd number = page number

Your turn. List below, continuing on a separate page, ten or more REFERENCES (books, magazine articles, etc.) you are using in researching your TOPIC.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

Talk to your teacher and to experts on your subject. Write letters. Find out as much as you can <u>before</u>

---

2 Available in most local science classrooms and school libraries

3 Published by The Science Man Press, Harwood Heights, Illinois

4 Adapted from Science Fair Project Guide by Randy Borden, Bell Junior High

starting your experiments. If, for example, you were planning to compare the nutrients in fresh, canned and frozen carrots, you might consult a nutritionist, a chemist, a botanist and a representative of a company where carrots are processed.

Your turn again.

THE EXPERTS I WILL CONSULT ABOUT MY PROJECT ARE:

1. ____
2. ____
3. ____

Additional experts should be listed on a separate page.

Be sure your questions are good ones. Don't say, "I'd like to do a project on fertilizers. Where should I start?" Instead, ask specific questions that show you have already taken the trouble to learn something about your topic.

For example, if you were interested in whether mice learn a maze faster when one of their siblings is at the other end you might ask such questions as "Do you know of any research indicating that mice recognize their brothers and sisters?" "Have you found a particular size or shape maze to be best when working with mice?" "At what temperature should the room where the mice are housed be kept?" "What other factors could influence a mouse's maze-learning ability?" and "Based on your own research, would you recommend using very young mice for this experiment?"

Your turn. Write five questions you might ask about your project:

1. ____
2. ____
3. ____
4. ____
5. ____

Preliminary BACKGROUND RESEARCH done? Okay, it's time to "design your EXPERIMENT." Remember, though, that other questions will arise as you work on your project. These may well require additional library work, the results of which should be added to your BACKGROUND RESEARCH materials.

TAKE A GUESS

"Take a guess!"

Doesn't sound very scientific, does it? Agreed, but, hang in there and let's find out just what "guessing" has to do with developing a science project.

CHECKLIST #3 — FORMING A HYPOTHESIS

You've finished your preliminary BACKGROUND RESEARCH. You've talked to lots of people, spent hours in the library and know a great deal more about your subject than you had thought possible. What next?

Here's where the "guessing" comes in. Based on what you've learned, you're going to make an "educated guess" about the probable outcome of your project.

Let's say you've been researching zippers and everything you've read indicates that metal zippers are more durable than plastic ones. So, your "educated guess" — which scientists call a HYPOTHESIS — is that your experiments will show that metal ones can be zipped more times without snagging or breaking than can plastic ones. That "guess" may be wrong, of course, which is something you'll find out for yourself as your project progresses. You won't be trying to prove your HYPOTHESES right, by the way, merely to test them!

Your HYPOTHESIS is "Metal zippers will last longer than plastic zippers" — a simple, straightforward statement (NOT A QUESTION!) as to what you think the results of your tests will be.

Now, back to your project. Based on your research, what do you think the outcome of your project will be? State it, as a HYPOTHESIS, on the line below.

MY HYPOTHESIS/HYPOTHESES IS/ARE:

____

____

____

TEST TIME

The next job is to decide on a way to test your HYPOTHESIS. The steps you take to do this are your PROCEDURES.

1. If, for example, you compare the effectiveness of six fertilizers on the growth of bean plants, you would:

   a. Decide how many plants (seeds? seedlings? — all should be at the same stage of development) you'll treat with each brand of fertilizer — let's say 20 in each EXPERIMENTAL GROUP (one group for each fertilizer) and 20 in a CONTROL GROUP (no fertilizer). That's 140 bean plants — a minimum SAMPLE SIZE if your results are to mean anything. (Think about it. What happens to one, two, three or so plants could be a fluke. Maybe the neighbor's cat got into the act and added a little extra fertilizer!)

   b. Decide how many TEST RUNS you'll make (how many times you'll do the experiment) — let's say three (again, a minimum number, but if you get similar results on three runs of 140 plants each, you're probably "on to something.")

   c. Make sure the TEST CONDITIONS for each group are the same — identical soil, identical care (water, sun, insecticide, etc.). Decide, too, on the amounts of fertilizers to be used and the frequency of application — basing your decisions on the manufacturers' recommendations. In this way the only VARIABLE (a condition changed by the experimenter) is the brand of fertilizer used.

CHECKLIST #4 — DESIGNING YOUR PROCEDURES

2. If you test the comparative strength of eight different shape support beams (i.e., triangular, round, rectangular), your project design might look something like this:

a. Decide on the shapes to be used and construct a large number of scale model beams (50, let's say) of each design — making sure they are identical in all other ways (i.e., cross-sectional area, material used, weight, length).

b. Design and build a devise to test the structural strength of the beams.

c. Test each beam under identical conditions. That's 50 test runs — with eight beams used in each run.

Your turn again. On the following lines outline the basic design for your experiments:

THE PROCEDURES I WILL FOLLOW IN TESTING MY HYPOTHESIS ARE:

1. ____
2. ____
3. ____
4. ____
5. ____

NOTE: Either more or fewer steps may be required for your project. Additional steps should be recorded on a separate page.

A MATTER OF TERMS

In the step above you learned the terms "EXPERIMENTAL GROUP," "CONTROL GROUP" and "VARIABLE." Different terms, such as those in the explanation below, are sometimes substituted for these.

> "All experiments (EXPERIMENTAL GROUPS) must have only one MANIPULATED VARIABLE (the part you change/experiment with). All other VARIABLES in the experiment must be CONTROLLED (unchanged). Only one change may be made in each EXPERIMENTAL GROUP, none in the CONTROL GROUP. If, for example, you were testing nutrients which might increase the growth rate of sunflowers, the MANIPULATED VARIABLE would be the nutrients (three different plant foods, for example — one per group) The CONTROLLED VARIABLES would be the amount of water used, the soil mixture, light conditions, temperature, etc. These would be the same for all plants — both in the EXPERIMENTAL GROUPS and the CONTROL GROUP.
>
> "Another term used along with these is RESPONDING VARIABLE (changes occurring as a result of your experiment). In the sunflower experiment these might include plant height, color, leaf size, stem size, number of flowers, size of flowers, etc. In this worksheet you'll include such changes (RESULTS) in your OBSERVATIONS (CHECKLIST #9). Whether you call them RESULTS (to be observed and measured) or RESPONDING VARIABLES (to be observed and measured), however, it will help you to think now about some of the things you should be watching for in doing your project (there'll probably be others)."[55]

Give it a try.

---

[5] Adapted from material submitted by Julia Harlan, Wangenheim Junior High

FIVE CHANGES WHICH MIGHT OCCUR AS A RESULT OF MY EXPERIMENT ARE:

1. ____
2. ____
3. ____
4. ____
5. ____

TEACHER/ADVISOR APPROVAL OF PROJECT PROPOSAL

Before starting work on your project you must have the written approval of your science, math or computer teacher/advisor. Use **Forms 1A and 1B** (*Student Application, Research Plan and Approval Form)* for this purpose. If not already done, PLEASE DO IT NOW! This approval is subject to confirmation by the Scientific Review Committee at screening and/or when application is made to the Fair.

I HAVE COMPLETED **Forms 1A and 1B** and **Checklist for Adult/Sponsor/Safety Assessment Form** and it has been approved by my teacher/advisor.

__________ Check here when **Forms 1A and 1B** and **Checklist for Adult/Sponsor/Safety Assessment** Forms are completed and approved.

SPECIAL CASES

If you plan to use:

1. human subjects/interviewees
2. live vertebrate animals
3.
   A) potentially mutagenic, carcinogenic, teratogenic or infectious agents (including but not limited to microorganisms, i.e., bacteria, fungi, protista, viruses and parasites)

   B) potentially hazardous substances or devices (including chemicals)

in your project, some very important additional considerations are involved. Be sure to carefully read the rules and complete any necessary forms or preapprovals prior to beginning your project.

CHECKLIST #5 — PROCEDURES FOR PROJECTS USING HUMAN SUBJECTS/INTERVIEWEES

Students doing research involving human subjects/interviewees must:

1. Read and complete the "*Human Subjects Form **Form-4A”*** and submit it to your teachers/advisors for approval BEFORE starting your project (approval subject to confirmation by the Scientific Review Committee at screening and/or when application to the WCIRSEF is made). **Form-4B** “Human Informed Consent Form,” must also be approved if subjects are being interviewed or tested.

The approved form **Form 4A (and Form 4B if required) must** be included at the front of the project notebook when the project is exhibited at the Sacramento Regional Science and Engineering Fair.

2. Make sure that

   a. no physical, psychological or social risks are involved

   b. the subjects are not embarrassed

   c. their right to privacy is respected

   d. they (or if they are under 18, their parents or guardians) have given written consent for you to test them. Studies conducted in classrooms with the teachers' consent may be certified by the teachers involved.

   e. no professional psychological (or other) tests are used without written permission of the author(s).

For example, you decide to compare the reactions of middle school students, male vs. female, when asked personal questions. Your procedures might read something like this:

1. Make a list of ten general knowledge (i.e., Who was the 16th president of the United States?) and ten opinion questions (i.e., What is your favorite color?).

2. Review questions with teacher. Are the general knowledge ones appropriate for the age subjects you will use? Are the opinion ones too personal? If they could cause embarrassment or if they pry into areas that are "none of your business," write new ones!

3. For example, arrange for 100 boys and 100 girls, ages 12 - 15, to participate — telling them only that they will be asked some questions as part of a science project. Do not explain the purpose of study as this might affect the way they react. Do not press anyone unwilling to participate.

4. Seat subjects one at a time (over a period of several weeks — always at the same time of day) in a quiet room. Ask questions — general first then opinion in half of the cases, reverse the order in the other half. (Changing the sequence will help assure that other factors, i.e., tiredness, don't affect results.)

5. Make notes, identifying subjects by number only (i.e., #22 — male, age 13), recording their body language reactions (i.e., arm folding, hair twisting, pencil tapping) to each question. (Keep separate, <u>confidential</u> list of subjects by name and number but — DO NOT DISPLAY!)

IF <u>your</u> project involves humans re-write your PROCEDURES, showing the precautions you will take to protect your subjects.

1. ____
2. ____
3. ____
4. ____
5. ____

Note: List additional procedures on a separate page.

__________ Check here when your Form 4A (and Form 4B when required) has been completed, submitted to your teacher and approved.

__________ Check here if Form 4B form does not apply to your project.

CHECKLIST #6 — PROCEDURES FOR PROJECTS USING LIVE VERTEBRATE ANIMALS

No experiments involving non-human vertebrate animals will be allowed (except those in which the animals will be observed in a natural environment. Your proposal should specifically describe the environment (such as a zoo).

Back to you. Re-write the PROCEDURES you will follow in doing your project (at least five — include additional steps on a separate page), showing your conformity with the animal rules:

1. ____
2. ____
3. ____
4. ____
5. ____

CHECKLIST #7 — PROCEDURES FOR PROJECTS INVOLVING, A) POTENTIALLY MUTAGENIC, CARCINOGENIC, TERATOGENIC OR INFECTIOUS AGENTS (INCLUDING BUT NOT LIMITED TO MICROORGANISMS, I.E., BACTERIA, FUNGI, PROTISTA, VIRUSES AND PARASITES) AND B) POTENTIALLY HAZARDOUS SUBSTANCES OR DEVICES (INCLUDING CHEMICALS)

See your teacher/advisor before choosing a project because there are specific rules as to what you can and cannot use in your project. Students **must** complete **Form 3** "*Designated Supervisor Form"* and have it approved by their teachers/advisors — **before** starting projects involving these substances (approval subject to confirmation by the Scientific Review Committee at screening and/or when application is made for admission to the Fair).

The approved forms **must** be included at the front of the project notebook when exhibited at the Regional Science and Engineering Fair

________ Check here when your **Form 3** has been completed and approved by your teacher/advisor.

________ Check here if **Form 3** does not apply to your project.

NOW — write the complete PROCEDURES to be used in doing <u>your</u> project (use a separate page for additional steps if necessary), showing your conformity to the rules. Complete information is important to the Scientific Review Committee when considering your project for safety and approval:

1. ____
2. ____
3. ____
4. ____
5. ____

CHECKLIST #8 — PROJECTS INVOLVING HUMAN OR OTHER VERTEBRATE TISSUE (INCLUDING HAIR, TEETH, BLOOD, BLOOD PRODUCTS OR OTHER BODY FLUIDS)

ARE NOT ALLOWED IN THE JUNIOR DIVISION

CHECKLIST #9 — LOGGING IT IN

You've planted your petunias, built a device to measure the effects of humidity on tennis ball bounce or ...... Whatever your project, you're ready to go. Your project design is a good one, with a large SAMPLE SIZE, a single VARIABLE (one MANIPULATED VARIABLE, with all others being CONTROLLED), a CONTROL and plans to make several TEST RUNS.

What now?

Open your eyes. It's time to make notes — OBSERVATIONS — of everything that happens (DATA/RESPONDING VARIABLE MEASUREMENTS) during those TEST RUNS.

When those petunias start growing, for example, you'd note rate of growth, height, number of leaves, size of leaves (precise MEASUREMENTS, i.e., 3.1 cm by 2.3 cm, not "small," "big," etc.), color differences or changes, any problems or unusual developments — always dating your notebook entries and making drawings or taking photographs to illustrate your notations.

The tennis ball project would require such information as the humidity at the times of testing, height from which each ball was dropped, height each ball bounces (exact measurements, not approximates), etc. Drawings or photographs in this case could also be effectively used to illustrate exactly how your device works.

A LOG ENTRY, in this case for a study of whether the distance between a person's eyes affects peripheral vision, might read something like this:

<u>October 12, 2002</u>

1. Tested 3 subjects today — Female #12, age 15; Male #15, age 14 and Female #13, age 14.

2. Administered standard eye chart tests for visual acuity. Results:

    a. Female #12 — left eye, 20/25; right eye, 20/20

    b. Male #15 —— left eye, 20/20; right eye, 20/20

    c. Female #13 — left eye, 20/30; right eye, 20/25

3. Made eye distance measurements. Results:

    a. Female #12 — 5.5 cm

    b. Male #15 —— 5.7 cm

    c. Female #13 — 5.2 cm

4. Measured peripheral vision. Results:

    a. Female #12 — 95^{o}, left; 94^{o}, right

    b. Male #15 —— 97^{o}, left; 97^{o}, right

    c. Female #13 — 85^{o}, left; 84^{o}, right

5. Arranged to re-test these subjects on October 25, November 15 and November 30.

You try it now. Write possible LOG ENTRIES for <u>your</u> project. Remember that ENTRIES should be made for mistakes and hard-to-explain (unexpected) results, too.

1.____
____
____

2.____
____
____

3. ____
____
____

4. ____
____

5. ____
____

CHECKLIST #10

THE RESULTS ARE IN — ADD THEM UP AND DRAW YOUR OWN CONCLUSIONS

You've run all your TESTS — several times. Your LOG is full of ENTRIES. Now, what do you do with all the information — DATA (RESPONDING VARIABLE MEASUREMENTS)— you've collected?

The first step is to tabulate that DATA — to add it up and see what you have. These figures are your FINDINGS or RESULTS.

In a study made to determine how the academic performance, extracurricular activity participation and social involvement of children with two wage-earning parents compare to that of those with one parent working outside the home, one portion of the results might read something like this:

Of the 300 students studied:

1. 35.2% of those in Group A (two wage-earning parents) and 22.8% of those in Group B (one parent working outside the home) had grade point averages of 3.0 or better.
2. 44.6% of those in Group A and 44.3% of those in Group B had grade point averages better than 2.0 but less than 3.0.
3. 10.9% of those in Group A and 20.4% of those in Group B had averages better than 1.0 but less than 2.0.
4. 9.3% of those in Group A and 12.5% of those in Group B had averages below 1.0.

NOTES:

1. These DATA should also be presented in appropriate easy-to-read forms — i.e., GRAPHS, CHARTS.
2. A number of computer programs that can be used to compile and display your data in chart or graph format are now available.

So, what do all these numbers mean? When you have the answers, when you've ANALYZED the DATA you've collected, you'll be able to draw some CONCLUSIONS.

In other words, RESULTS or FINDINGS (RESPONDING VARIABLE DATA) are what you learn from your TESTS (and bear in mind that negative RESULTS — i.e., test failures — are RESULTS and are to be reported); CONCLUSIONS are your interpretation of those facts and figures.

Which is where the ANALYSIS comes in — the use of STATISTICAL ANALYSIS will provide a solid basis for your CONCLUSIONS — not just "well, it looks as though...." but "analysis of the data indicates that....." You're probably asking, "What in the world is STATISTICAL ANALYSIS?" Mathematicians have developed several ways (averages, means, chi-square test, t-test, etc.) to study RESULTS (RESPONDING VARIABLE DATA) to help decide whether those results happened by chance or were really caused by the MANIPULATED VARIABLE of an experiment (in other words, was the "effect" really caused by the "cause?" Note: A comparison of graphs is NOT statistical analysis.

Therefore, before you draw — or jump to — conclusions, you need to ask yourself, "Are my results meaningful? How do I know they are — or aren't?"

CHECKLIST #11 — WRITING IT UP

Your RESULTS are in, your CONCLUSIONS drawn and it is time to write your PROJECT REPORT. At this point you may want to change your WORKING TITLE. Remember that your final TITLE, the one used in your REPORT and on your DISPLAY BOARD, must contain no more than ten words. The following sample Table of Contents outlines the basic contents of that REPORT. Additional contents which may be needed in some REPORTS.

CONTENTS

And what goes into these?

ABSTRACT — a brief (no more than 250 words) summary of the main points of your project (PROBLEM, PROCEDURES, RESULTS, CONCLUSIONS)

ACKNOWLEDGEMENTS — credits to those providing you with help/advice, i.e., Thanks to your science teacher, the university, and/or professor who offered you use of your lab.

INTRODUCTION — a brief look at the background and goals of your research, with separate entries for the STATEMENT OF THE PROBLEM and your working HYPOTHESIS

REVIEW OF THE LITERATURE — (here's where all that background research comes into play) a report (minimum of 5 pages) on what others have done in your area of research — contains such statements as, "perhaps the most important information is found in John Appleton, et al, (1981), where it was indicated that....." The full name of the publications involved are listed under LITERATURE CITED.

PROCEDURES — a step-by-step description of how you did your project, including your use of MANIPULATED and CONTROLLED VARIABLES

FINDINGS — the DATA you collected, the responses, reactions and RESULTS you observed, the results of your STATISTICAL ANALYSIS

CONCLUSIONS — a simple statement of your interpretation of those results

RECOMMENDATIONS — your ideas on possible uses for your FINDINGS and of additional tests which should be made

LITERATURE CITED — bibliography of works mentioned or quoted in the body of the report

REFERENCES — bibliography of works used in researching project

STATISTICAL ANALYSIS — the actual worksheets on which your DATA was analyzed

PHOTOGRAPHS, GRAPHS, ETC. — those you feel will be most useful in illustrating your project

DAILY LOG and RAW DATA — the day by day records you kept while doing your project (may also be presented in a separate notebook)

When you write the final draft of your REPORT, ask yourself these questions:

1. Is my REPORT neat? __________
2. Is it well organized? _________
3. Does it contain <u>all</u> necessary sections? _________
4. Is the spelling correct? ___________
5. Is the grammar correct? _________
6. Is it written in 3rd person? ________ (ACKNOWLEDGMENTS — 1st person)
7. Is technical language used correctly? _________
8. Is it easy to read? (double-spaced typing is best) ________
9. Is my TITLE short (no more than 10 words)? _________
10. Is it scientific (not "cutesy")? _________
11. Are ALL required SRSEF forms included at the FRONT of my notebook? __________

When done, ask yourself one last question — "Have I made an extra copy?" (A wise precaution after so much work and effort!)

CHECKLIST #12 — DISPLAYING YOUR WORK

The Display Board

The last step in doing your science project is to build your DISPLAY — a three-section board (wide back panel hinged to side panels which angle forward at roughly 45 degrees) constructed of pegboard, masonite, hardboard, foam-core board or wood. It may be painted or covered with burlap or felt. No lights may be attached to the board. (SEE EXAMPLES OF A DISPLAY AT THE END OF THIS CHECKLIST)

Size? No larger than 76 cm (30 inches) deep (front to back), 122 cm (48 inches) wide (side to side) and 274 cm (108 inches) high (floor to top, including height of table). All equipment, notebooks and other display items must also fit into this space.

What goes on it? On the center segment, usually printed on poster board, are the PROJECT TITLE, HYPOTHESIS and STATEMENT OF THE PROBLEM. On the left go the PROCEDURES, on the right the RESULTS and CONCLUSION. Keep these brief and interesting as the idea is to "hook" the judges and other viewers and make them want to read your REPORT. Important photographs, graphs, etc. may also be included, if properly labeled.

REMEMBER — printing must be neat and large enough to be read from three meters away. Be sure spelling and grammar are correct.

To be certain your display is well done, answer the following questions:

1. Does it include all items listed above? _________
2. Is its size correct? _________
3. Is it easy to read from 3 meters away? _________
4. Is it neat? _________
5. Are spelling and grammar correct? _________
6. Is the material on it informative? _________
7. Will it make a judge want to "know more?" ________
8. Have I avoided clashing colors? _________

   — "razzle-dazzle" designs? _________

   — "cutesy/artsy" decorations?_________

   — overcrowding my DISPLAY? _________
9. Is my PROJECT REPORT chained or tied to my BOARD? ________
10. Have I removed expensive or fragile items? ________
    (use photos, drawings, models, etc. instead)

You may find it helpful to make a small mock-up of your DISPLAY BOARD before starting to construct the final project. A large index card, folded into three parts, can be used for this.

Safety Considerations

Be sure you are thoroughly aware of all safety rules and regulations relating to science projects (see *SRSEF 2002-03*). Then, check off the items on the following list:

My DISPLAY contains no:

1. highly flammable materials ________
2. chemicals ________
3. fuels _________
4. flames _________
5. unshielded heat-producing devices ________
6. live or preserved animals or animal parts ________
   (whether vertebrate or invertebrate)
7. microbial cultures _________
8. fungi _________
9. drugs _________
10. wiring/switches that do not meet safety standards _________
11. wet cell batteries _________
12. unshielded vacuum tubes, lasers, etc. ________
13. anything which could be dangerous ________
    (if a two-year-old can't handle it safely, out with it!)
14. liquids (other than plain water) ________
15. dry ice ________
16. sublimating solids ________

Everything okay? Great! It's time to enter your science fair!

SAMPLE PROJECT TITLES

The following project titles were selected from among those featured at a recent Regional *Science and Engineering Fair*. Perhaps they will suggest ideas for your project.

JUNIOR DIVISION (Grades 6, 7 & 8)

A Comparative Study to Determine the Shelf Life of Milk

A Residue Computer

Absorption of Solar Heat: Water vs. Saline Solution

Age Differences in Taste Thresholds

Air Particles in Pet and Non-pet Homes

Allocation of Hospital Resources by Computer Experimentation

Antitranspirants — A New Approach to Agricultural Water Conservation

Audiovisual Aids and a Child's Learning Process

Can Bioluminescence be Regenerated from Dried Plankton?

Can Solar Heat Purify Salt Water and Generate Power?

Can the Color of Unborn Rabbits be Predicted?

Can the Effects of Light on Temperature be Predicted with a Solar Cell?

Cholesterol — Does Egg Color Indicate Amount?

Comparing Windmill Rotors for Use in Pumping Water

Counting Calories with a Computer

Diesel Engine Noise: Will it Affect Your Driving?

Do Bees Select the Sweetest Flowers First?

Do Environmental Changes Affect Paramecium?

Do People Follow Directions When Working Under Pressure?

Does Age Determine Pecking Order?

Does Color Affect a Person's Reading Speed?

Does Dark to Light Stimulation Vary with Age?

Does Height Affect Photosynthesis?

Does Humidity Affect Test Scores?

Does the Tempo of Background Music Affect Problem Solving?

Does Weather Really Affect Radio Transmissions?

Drip Irrigation Vs. Regular Watering: Which Works Best?

Effect of Magnetic Field on Osmosis of a Saline solution

Effect of Temperature on a Simple Pendulum's Period

Effect of Temperature on Viscosity of Fluids

Effect of Tip Removal in Shoot Geotropism

Effect of Water Temperature on Sand Crabs

Effects of Gray Water on Bean Plants

Electronic Games and Eye-Hand Coordination

Energy Efficient Water Purification for Sea Crustaceans

Fatigue and Citizenship Grades

Grade Analysis: A Statistical Approach

Heat Transfer in Earth Materials

Heat-Pump Furnace Filter Effectiveness

How Balls Bounce at Different Temperatures

How do Earthworms Affect Different Types of Soil?

How Does Air Pollution Affect Your Plants?

How Does Alcohol Affect Bacteria?

How Light Affects Bluegill Feeding Habits

How Liquid Crystals are Affected by Varying Degrees of Heat and Energy

How Uniformly Distributed are the Random Numbers on the Apple II+?

Is the Life of a Light Bulb Related to its Burnout Voltage?

Kelp as a Fertilizer

Lateral Line of Fish

Light and Color Responses of the Euglena

Lima Bean Germination After Microwave Treatment

Mathematical Relationships of Line Designs -- String Art to Computer Graphics

Maze of Doom (Adventure Game)

Maze Running Surface and Mouse Speed

Molar Solutions as Gel Cells

Most Effective Tubing for a Solar Heater

Open Star Clusters: Number of Stars, Proximity to Center

Predicting the Phenotype and Genotype of Sex-Linked Lutino Budgerigars

Relation of Eye Dominance to Peripheral Vision

Relationships Among Binary, Octal and Decimal Numbers

Some Conditions that Affect Snail Movement

Testing Color Vision: Symbols vs. Numbers

Testing Reverse Osmosis Membranes

The Optimal Environment for Algae

Water Hardness in Southwestern U.S. Rivers

Weather and TV Reception

What Kind of Reef Slows Cliff Erosion?

Which Carpet Fiber is the Most Energy Efficient?

Which Detergent Depletes Oxygen in Water the Most?

Which Environment do Carassuis Aurtua Prefer?

Which Wood Burns Hottest and Longest?

SENIOR DIVISION (9th - 12th Grade)

A Comparative Analysis of Cassette Tapes

A Relationship Between Sex, Age, Culture and Color Preference

A Study of the Breaking Point of a Falling Column of Water

Adaptive Color Change in Two Species of Tropical Tree Frogs

An Automated Periodic Table

Apple/Pascal Animation

Atmosphere and the Solar Spectrum

Breath Test for Pancreatic Insufficiency

Can a Rubik's Cube be Solved through a Logical Process?

Can Amino Acids Attract Ghost Shrimp?

Can Crickets be Led by Sound?

Can Wheat be Grown Hydroponically in a Dilution of Seawater?

Comparative Analysis of Organically and Inorganically Produced Spinach

Comparing the Purity of Aspirin Brands

Comparisons Between Cross-Dominance and Coordination

Computer Speech in Education

Computerized Carrollian Logic

Correlation Between Geometric Shapes and Stress Patterns

Data Storage Using Linked Lists

Development and Comparison of Computer Spelling Programs

Distribution of Beach Hoppers

Diurnal Movement of Periwinkles

Do Crayfish Rely on Eyes or Statocysts to Determine Body Position?

Do Protein Molecules Aid in the Body's Defense?

Does Age Affect the Way People Interpret an Abstract Painting?

Does Elementary School Integration Reduce Racial Biases?

Does Salt Affect Soybeans? -- Germination Field Analysis

Does Ultra-Violet Radiation Inhibit or Promote the Growth of Molds?

Effect of Cognitive Shifts Between Cerebral Hemispheres

Effect of Contact Lens Wear on Glare Sensitivity

Effect of Shading on the Eating Behavior of Mice

Effect of Sound on Sympathetic Nervous Systems of High School Students

Effect of the Classroom Environment on the Right Brain

Effects of Antibiotics on Zinc Loving and Zinc Hating E. coli

Effects of Anxiety on Memory Process: A Comparative Study

Effects of Environmental Changes on Lactobacillus bulgaricus

Effects of Intra-Stimulus Interval on Evoked Potential Correlates of Selective Attention
Effects of Light Wave Alterations on Photosynthesis

Efficiency in Aquaculture: Cost-Effective Production of Optimal Yields
Energy Conservation Through the Use of Solar Power

Factors Affecting Species Composition of Luminous Bacteria in Seawater

Hormonal Regulation of Peripheral Glial Tumor Growth in von Recklinghausen's Disease
How Closely Does Experimental Evidence Fit the Binomial Theorem?

Hydrodynamics of Fish as Related to Function Within Their Habitat

Mastermind: An Example of Logical Deduction by Computer

Monaural Perception of Sinusoidal Wave

Optical Automation

Players' Reactions to Computer Game Sounds

Post Thaw Storage of Erythrocytes

Relationship of Shoot Gravitropism to Acid and Auxin Responsitivity

Second Sonata -- A Computerized Composition of Music

Society's Knowledge of and Opinions on Nuclear Power

Solutions to 2nd Order Differential Equations Using Continued Fractions
Some Alternative Propeller Designs for Wind Power Development

Subliminal Suggestion: Does It Affect Decision Making?

Synthesis of Sulphur Containing Amino Acids Under Prebiotic Earth Conditions
Territorial Behavior of Land Hermit Crabs

The Physics of Falling Leaves

Thermal Comparison of San Diego County Woods

Thermoregulation Related Color Change: Reptiles vs. Amphibians

Various Cane-Soaking Solutions: Their Effect on Bassoon Reed Cane

Wave Heights and Intervals -- Is There a Relationship?

GUIDELINES/PARAMETERS FOR COMPUTER-ORIENTED SCIENCE PROJECTS

Computer technology may be incorporated into science fair investigations in one or a combination of the following three ways:

I. As a tool to record/statistically analyze data gathered in another experiment

   A. Projects of this type would be entered in the category of the experiment involved.

   B. State whether the student wrote the program used, made a <u>major</u> adaptation of an existing program or used already available software. If the program is the original work of the student, that part of the project should be presented as outlined in III below.

II. Developing/building new computer circuits/hardware items

   A. Project would be entered in the Engineering category.

   B. Software/firmware programs that are original work of the student, they should be presented as shown in III below.

III. Writing a new computer program/software development

   A. A project involving only the writing of an original computer program or a major adaptation of an existing program would be entered in the Computers category.

   B. A project of this type should include:

      1. A statement of the student's OBJECTIVE This should include a description (the configuration) of the computer system that will be used to achieve that objective and of the system's capabilities.

      2. A summary of the research done by the student before writing the program. What else has been written/programmed about this topic? State why this new program will be different/better/more useful.

      3. A chronological description of the development of the program. It should describe the various approaches tried and explain why they were accepted/rejected.

      4. A concise block diagram or similar presentation to show the structure of the program design (maximum of two pages) and that it is cross-referenced to the program listing (#5 below).

      5. A program listing that includes explanatory "remark statements" and is cross-referenced to the block diagram (#4 above).

      6. Sample run(s) to show the product(s) of the program.

A critique of the completed program showing how well the objective was achieved and/or how the program is qualitatively different/better than other similar programs.

SCIENCE FAIR PROJECTS TO AVOID
PROJECTS WHICH WILL NOT BE ACCEPTED

1. Survey projects (opinion sampling, product use, etc. However, an in-depth questionnaire which probes into factors affecting opinions may be used as a preliminary step in behavioral studies.)
2. Models, i.e. volcanos
3. Demos, i.e. how a battery works
4. Anything in violation of animal regulations
5. Projects with small sample size
6. Projects with limited number of test runs
7. Illogical tests -- i.e., effect of rum on plant growth
8. Projects in which the results are common knowledge
9. Kit building, i.e., Radio Shack or Heathkit
10. Projects which duplicate standard class/text experiments
11. Collections, i.e., minerals
12. Anything with purely subjective measurements
13. Child-resistant caps tested on kids (arthritics, maybe)

PROJECTS UNLIKELY TO BE ACCEPTED -- AVOID!

(Although frequently done, an original twist, combined with exceptional thoroughness and solid scientific method could provide the depth needed for acceptance.)

1. Effect of colored light on plants (or anything else)
2. Effect of music on plants (ditto)
3. Effect of talking on plants (ditto)
4. Effect of cigarette smoke on plants (ditto)
5. Mold growth
6. Crystal growth
7. Effect of Coke, coffee, etc. on teeth
8. Effect of running, etc. on blood pressure
9. Effect of music on blood pressure
10. Effect of video games on blood pressure
11. Effect of almost anything on blood pressure
12. Do we eat balanced diets? (data usually unreliable)
13. Strength/absorbancy of paper towels (and other products)
14. Most consumer product testing ("Which is best?" approach generally without scientific merit)
15. Graphology
16. Astrology

17. ESP, especially standard card test
18. Basic maze running
19. Any project which boils down to simple preference
20. Effect of color on memory, emotion, mood, etc
21. Effect of color on taste
22. Effect of color on strength
23. Optical Illusions
24. Reaction Times
25. Many male/female comparisons (especially if bias shows)
26. Basic planaria regrowth
27. Detergents vs. stains
28. Basic solar collectors
29. Acid rain projects (Important: to be considered, thorough research into the composition of acid rain and a scientifically accurate simulation of it would be necessary.)
30. Flight tests, i.e, planes, rockets
31. Battery life (plug in and run down type)
32. Basic popcorn volume tests
33. Stills
34. Pyramid power
35. Basic flower preservations techniques
36. Taste comparisons, i.e., Coke vs. Pepsi
37. Smelling vanilla, etc. to improve test scores
38. Sleep learning
39. Taste or paw-preferences of cats, dogs, etc.
40. Color choices of goldfish, etc.
41. Basic chromatography
42. Wing, fin shape comparison with mass not considered
43. Ball bounce tests with poor measurement techniques

APPENDIX

LIBRARY RESEARCH

Almost all research projects start with a literature search -- a careful look at what has already been done. As it is generally safe to assume the authors have "done their homework" and that their bibliographies are pertinent and up-to-date, you'll save time by starting with recent publications.

Library research is a lot like detective work and, fortunately, you're more likely to be swamped with clues than hampered by their lack. Find a good basic reference, check its bibliography and you're on your way. For starters, try these:

1. A recent encyclopedia (general)
2. *McGraw Hill Encyclopedia of Science and Technology*
3. *Van Nostrand's Scientific Encyclopedia*
4. *Kirk-Othmer Encyclopedia of Chemical Technology*
5. *The Harper Encyclopedia of Science*
6. Textbooks (college, comprehensive)
7. *Applied Science and Technology Index*
8. *The Education Index*
9. *Reader's Guide to Periodical Literature*
10. Periodicals, i.e.
    Journal of Applied Physics
    Quarterly Review of Biology
    Science
    Science World
    The American Biology Teacher
    The Journal of Nutrition
    The Science Teacher
    The Scientific American

(Many of these contain reviews of recent books — another handy reference source.)

From here you'll be branching out into more specialized works. Your teacher or advisor can help you choose the most useful and authoritative references but, basically, you're on your own. READ, READ and READ some more. Learn as much as you can about the work others have done. And make notes -- on 3" by 5" cards or in a notebook, always including a full bibliographical listing. An extensive bibliography, properly referenced and cited, adds greatly to the authenticity and completeness of your work.

Although you'll probably spend most of this research time at a school, city or county library, remember that many universities (UC Davis, Sacramento State) are open to you and that it is also possible -- by making an appointment -- to work at many of the libraries maintained by businesses, societies, medical facilities, museums, etc. and that interlibrary loans of materials not readily available to you can often be arranged by your school's librarian. It may also be possible to borrow technical publications from professional scientists.