Mentor/Teacher Ken Mann’s Science Fair Project Curriculum

Presented at the 2014 Minnesota State Science & Engineering Fair

with a few changes for use by TCRSF

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THESE RESOURCES ARE FOUND ON THE CD AT THE BACK OF THE BOOK.

INTRODUCTION

So why do science fair projects? The author had the privilege to work at the Mayo Clinic in Rochester, Minnesota for a number of years as a summer research fellow. This experience encouraged the author to publish two papers in the field of renal physiology (Mann et al., 1991 and 1992). This experience encouraged the author to incorporate the scientific process into the classroom. The author has 15 years of experience in science fair. Students have created very interesting projects that impact their life. Students from the science fair programs are now doctors, engineers, professors and teachers sharing their knowledge of science with others. Students have presented projects all over the United States. Some have even advanced to the European Symposium in London and the Nobel Conference in Sweden. Students have even presented work on the Today Show and CNN News. Student success encourages the author to continue to work to help student's process science. Although some projects may be submitted for publication, it is more important to learn how to do science than to get "good" results.

The trend in science education, through the adoption of state and national standards, is to incorporate more inquiry learning in the classroom (Llewellyn, 2002). A variety of state and national standards will be met or exceeded through the completion of a science fair project. Although a lot of time is required to complete a science fair project, the results will far outweigh the time spent. Students will be able to answer the how and why questions that are frequently seen on standardized tests in science.

So what is inquiry? Many educators think that inquiry is simply hands on activities. Although most inquiry involves hands on work, there are many hands on activities that educators use that do not involve inquiry (Llewellyn, 2002). Inquiry can be defined in many different ways. The Exploratorium in San Francisco identified several statements regarding the definition of inquiry. According to the Exploratorium,

> Inquiry is an approach to teaching that involves a process of exploring the natural or material world, that leads to asking questions and making discoveries in the search of new understandings. Inquiry, as it relates to science education, should mirror as closely as possible the enterprise of doing real science.
>
> The inquiry process is driven by one's own curiosity, wonder, interest or passion to understand an observation or solve a problem.
>
> The process begins by the learner noticing something that intrigues, surprises, or stimulates a question. What is observed often does not make sense in relationship to the learner's previous experience or current understanding.
>
> Action is then taken through continued observing, raising questions, making predictions, testing hypotheses and creating theories and conceptual models.
>
> The learner must find [his or her] own idiosyncratic pathway through this process: it is hardly ever a linear progression, but rather more of a back and forth or cyclical series of events.
>
> As the process unfolds more observations and questions emerge, giving

> occasion for deeper interaction and relationship with the phenomena-and greater potential for further development of understanding.
> Along the way, the inquirer is collecting and recording data, making representations of results and explanations, drawing upon other resources such as books, videos, and colleagues.
> Making meaning from the experience requires intermittent reflection, conversations and comparison of findings with others, interpretation of data and observations, and applying new conceptions to other contexts as one attempts to construct new mental frameworks of the world.
> Teaching science using the inquiry process requires a fundamental Reexamination of the relationship between the teacher and the learner Whereby the teacher becomes a facilitator or guide for the learner's own Process of discovery and creating understanding of the world. (Llewellyn, 2002)

The classroom will provide the student with a wide variety of sources to use throughout this process. A variety of science fair manuals and project idea books can be found in the media center as well as the classroom. These include titles such as Science Fair Manual: An Independent Research Guide (Carnahan and Hartmann, 1988), Students and Research (Cothron et al., 1989), Prentice Hall Science Fair Manual: A Step By Step Approach (Hulse and McMullin, 1991), Students as Scientists (Pellegrini and Olson, 2000), and Giant Book of Science Experiments (Press, 1998). A large selection of teaching textbooks, in all fields of science, are also available. Most libraries will have many sources to help the student as well.

There are twenty assignments broken into 5 steps that the student will complete throughout the process of this project. The teacher will give feedback and suggestions for improvement. The student will have time to make revisions on all assignments. This will be a huge change for the student. Students typically hand in work once and forget about it. This class expects the student will rework assignments until they are excellent. Students who rework assignments will most likely have a higher grade and a higher quality project. The choice is up to each student. Each step will be given a 30 point grade. It is very important that the student keep up with assignments and the student will find that revised work will benefit their grade tremendously. Students will find a list of criteria at the end of each task. The individual assignments will address all of these criteria. The student will be able to rework all steps for two weeks after the step due date. Each student will have flexibility to meet all grades. Each project will be independent however key parts need to be completed on a timely basis to make a high quality project. Procrastination is not an acceptable excuse. There is no substitute for hard work. It is better to make your best attempt at an assignment and allow the teacher or mentor to give you feedback. Revisions will expand the student's knowledge base and allow for a more professional product. When confused, ask for help! Students may work on projects individually or in teams of two or three students. Realize that higher expectations are placed on team projects. For example, if 5 sources are expected for an individual project then ten would be expected for a team of two. More heads can make for more complex projects.

At the completion of this process the student will have written a scientific paper, completed a project display board, and have a well documented journal. The journal will show the progress of your project from beginning to end. The journal is essential for documenting your progress on your project.

A sample journal sheet may look like the following

SCIENCE FAIR PROJECT JOURNAL

Name:____Date:____________

Please check the type(s) of journal activity(ies) covered in this entry:

_____Proposal/Forms
_____Hypothesis
_____Data Collection
_____Writing Paper
_____Presentation Preparation
_____Literature Search
_____Experimental Plan
_____Data Analysis
_____Display Board
_____Other,___________________________

Please journal below the key things that you accomplished on your project today. Attach all pertinent papers, such as plan sheet, to this entry.

Researcher Signature:_____________________________________

Teacher Signature:____

You are about to embark on one of the biggest challenges, your science fair project. Be inquisitive, be flexible, work hard to learn as much about your project, and most of all have fun!

STEP 1: PROJECT PROPOSAL

The first step that you will be faced with is the project proposal. A well designed project must follow all International Science and Engineering Fair (ISEF) rules. These rules may be found at https://student.societyforscience.org/international-rules-pre-college-science-research. The science fair is guided by rules that protect you from dangers, including safety, as well as protection from legal action. We may think that any project is acceptable. Be very careful to follow all rules, especially if you are completing a project with human subjects, microorganisms, or vertebrate animals. Before you begin your project you must complete all forms and signatures. A well planned project will work smoother in the long run. Take the time to evaluate each step. Enjoy, have fun, and impress yourself with the best project that you have ever completed. See project resources at https://student.societyforscience.org/resources-0 Additional tips on methodologies can be found on TCRSF's Links page at http://www.tcrsf.org/Links.aspx

For many science fair projects, the most difficult task is getting started. As you prepare yourself for this amazing journey; there are a few things that must take place before we begin. To begin, you must have a topic for your project. The research project plan, as described by ISEF, is the development of a scientific research project involving several sets of data and experiments. A good project should contain a controlled experiment with as many trials as can be accomplished. A good statistical test usually requires 30 tests for best results. A MINIMUM OF 3 TRIALS IS MANDATORY FOR ALL PROJECTS. You will find a variety of sources in most libraries that will get you started on possible topics. Remember these are projects that have already been accomplished and you may need to take the idea or procedure and modify it into a new and unique project.

Here are a few suggestions for selecting a topic:

a. Talk with your parents, friends, teachers, or those in the scientific community about your ideas. Discuss time limits (all data should be completed by January 1), budget limits, and possible outcomes of the project.
b. Choose a lab topic that interests you. Look for something you are curious about. You will be spending months on this project, it should be something you consider fun and challenging.
c. Choose a topic which is feasible. Be sure it is at your level. Don't choose a college level project, you will be overwhelmed. Don't choose a very basic project because you think it will be easy to do. These projects end up requiring a lot more time and energy trying to create more things to do to get it up to your level. Work with materials that you have access to utilize. Projects with humans and vertebrate animals will take a considerable amount of time and energy to get everything approved and all forms completed. Choose wisely!
d. Try to narrow your topic without making it too difficult to find sources. You will want to find 10-15 sources to have an effective

project. For example, cancer is a very broad topic which could be narrowed down to treatment of bone cancer.

e. Don't try to design your experiment completely at this time. Allow your topic ideas to develop as you conduct your literature search on your topic. Your sources will help you develop a well designed controlled experiment as you collect notes on your topic. Don't limit yourself at this time.

f. Incorporate your topic ideas into the scientific process: 1) observation, 2) ask questions, 3) form a hypothesis, 4) experiment, 5) gather and record results/data, and 6) conclusion. Will your topic fit into this framework?

g. The following categories represent areas from which you may develop topic ideas:

Animal Sciences
Behavioral/Social Science
Biochemistry
Biomedical & Health Sciences
Cellular and Molecular Biology
Chemistry
Computational Biology & Bioinformatics
Earth & Environmental Sciences
Embedded Systems
Energy: Chemical
Energy: Physical
Engineering Mechanics
Environmental Engineering
Materials Science
Mathematics
Microbiology
Physics & Astronomy
Plant Sciences
Robotics & Intelligent Machines
Systems Software
Translational Medical Sciences

Once you have settled in on a category you need to bring your focus to a specific problem to solve. ISEF also includes subcategories that fit under each of the above categories. These may aid in narrowing your topic. ISEF categories and subcategories are listed at https://student.societyforscience.org/intel-isef-categories-and-subcategories. A well-defined problem will help you to focus your project, define the data to be collected, and speed up the process of implementing your experimental plan.

Scientific research will deepen your understanding of a subject through problem solving. By applying the processes and procedures of scientific research to your project, not only are you immersed in an interesting project, the results may yield benefits to all humans.

Assignment 1: DEFINE PROBLEM

The most frequent question asked by a judge at a science fair is, “Why did you do this project?”. Before you begin a project you will want to address this question. Why are you doing a project? Why is it important to you, your school, the scientific community, or society?

To define the problem, you begin by asking to whom is the problem a problem. Who owns the problem? Who are the stakeholders that are directly involved with the problem? Who or what is being acted upon? Who or what would benefit from improvement in the problem? How you define the problem will affect what you decide to research. For example, let's say you wanted to test the effects of seed type on growth in your garden. The following is one example for defining this problem:

WHO? The producers (farmer or home gardener)
STAKEHOLDERS? Farmers, gardeners, chemical company that produced the seed, seed company, salespeople, state or federal regulatory agencies, advisors (county extension agent, consultants)
ACTED UPON? Seed Types, Soil Conditions, and Growth Conditions
BENEFITS? Farmer or home gardener, consumers of the products, profits for company, environment

Knowledge of who is involved and why your project is important will help you understand more about why this project is important to society. A judge needs to know that you understand why you did this project and why it is important to you. A project that shows an important application in your life will be more successful than a project assigned as a classroom project. Seek out a project that will hold your interest throughout the six to nine months that you will work with this topic. Don't hesitate to ask your teacher or parents for help if you can't seem to get started.

The following worksheet will help you to define your problem as you begin to explore the importance of this project. A copy of this worksheet can be found on the CD at the back of this book.

DEFINE THE PROBLEM

Name____
Topic of Interest___________________________________
Lab/Class Number _____
Category____

1. Define or explain the potential problem that you want to solve this year.
2. Who or what are the stakeholders that are involved with this project.
3. Why is this project important for you? the community? mankind?
4. List all practical applications of real life for this project.
5. Why do you want to do this project?

ASSIGNMENT 1

1. Complete the Define the Problem Handout.

Assignment 2: FORMS

Forms are probably the most frustrating part of the science fair project. They can be a lot of work, however if they are completed before the project begins, most problems can be avoided. The best place to begin the forms is to use the ISEF Rules Wizard from Society for Science, see: http://apps2.societyforscience.org/wizard/index.asp . This will identify which forms are necessary for your project. These forms help to document your project, which will ensure safety for you and the subjects along the way. Although these seem very tedious to complete, it is essential that they all are on file with proper signatures BEFORE you begin experimentation.

TCRSF recommends that you email your complete research plan to src@tcrsf.org with your name, school, and grade in school in case we require more documentation or proof of supervision than your school requires. This is done by the completion of Assignments 1-5, near the end of Step 1.

All projects must complete forms 1, 1A and 1B and have a typed research plan. The forms are pre-approval forms and all required signatures are before starting your experimental or data collection part of your project. Your teacher will likely be the Adult Sponsor and will complete the Adult Sponsor and Safety Form. Other projects may require additional forms, such as working in another lab or dealing with humans, microorganisms, or vertebrate animals. Your teacher will provide you with current form copies to complete, or you can go on-line to https://student.societyforscience.org/international-rules-pre-college-science-research. These forms can be completed on-line and printed for your teacher. Be sure you are using the current year forms (DO NOT COPY FORMS FROM AN OUTDATED BOOKLET!) - Forms MUST BE SINGLE SIDED ONLY. Do NOT print on both sides. Use only white paper for printing. No colored paper!

Although your teacher does not want to limit your topic choice, previous experience has shown that human projects, microbiology projects, and vertebrate animal projects require a lot of extra effort on your part to get all forms completed. These usually involve prior approval before beginning your experimentation. Although this should not keep you from a project, you must address all other possible projects that could be completed without the use of humans or vertebrate animals. Seriously consider using an invertebrate animal for test subjects.

You probably are already overwhelmed with requirements. The process is very time consuming. You should plan on spending 2-5 hours a week if you plan on completing an excellent project. It will take a lot of hard work and perseverance to complete the project. Stick with it. Stay disciplined and get your work in on time. Your teacher can be an excellent help for you. YOU must, however, get your work turned in on due dates for teacher comments to help you out.

ASSIGNMENT 2

1. Complete Form 1A, 1B, and other forms as needed.

Assignment 3: HYPOTHESIS

BEFORE you begin work on your project, you must create at least one hypothesis. You may find that your project does involve three or more alternative hypotheses. You will need to prioritize these hypotheses to determine your plan of attack for addressing these hypotheses. Scientific knowledge is obtained through the process of developing an idea, hypothesis, experimental plan, and then developing conclusions based on these results. Scientists use deductive reasoning to process an idea. This is based on previous knowledge that the learner has already acquired. You will find an informative chapter of ideas on how we acquire knowledge in Anton E. Lawson's book, Biology: A Critical-Thinking Approach (Lawson, 1996). Although this is written in a biology viewpoint, it can be used across the sciences to understand how scientists solve problems. As you read this, think about how your hypothesis fits with your previous knowledge base and your experimental plan.

The hypothesis is more than simply an educated guess as most books like to address it. The hypothesis is an idea or prediction which you see as the best possible solution to your problem. Keep in mind that the hypothesis must be capable of being tested. When writing the hypothesis, try to limit it to four or five sentences. A clear and concisely written hypothesis will tell the reader what it is you think will be the solution to the problem being tested.

ASSIGNMENT 3

1. Develop a clear hypothesis that is based on all previous knowledge and fits into your experimental plan.

Assignment 4: EXPERIMENTAL DESIGN

Now that you have a preliminary hypothesis, you are ready to begin the process of designing your experiment. The main focus of this chapter will be exploring the basic procedures that you want to accomplish. Remember this is only a plan. It may change as you continue to progress through the project. This plan will be used by the scientific review committee to approve your work before you begin. Be sure to give enough detail so that someone else could repeat your work. Realize that if your plan changes, you will need to have it reevaluated by the review committee. This may lead to a three to four week delay. It is very important to do the planning work up front to avoid changes.

You may find it helpful to look in various books to help you understand the experimental design process. One of the best sources is Students and Research by Julia H. Cothron (Cothron, et al., 1989). You may find many other sources in the teacher's classroom or a local library.

You should include the following ideas in your plan: variables, treatments, controls, experimental procedures and replications, plans for data collection, methods of data analysis, and necessary materials and equipment needed to complete this project. You should also include a brief timeline, which outlines the timeframe for experimentation. Adequate time must be saved for data analysis and presentation preparation. Begin experimentation as soon as you have approval. DO NOT WAIT TO SET UP YOUR EXPERIMENT BECAUSE YOU THINK IT CAN BE DONE IN TWO DAYS! You may encounter many challenges that could delay your project.

You should continue to turn in journal sheets for each day that you work on your project. Judges want to know that this is your work, and the journal verifies each day that you work on your project.

The experimental design plan sheet will ask that you complete the following parts:

1) Title: The title should concisely describe your project. It should catch the reader's attention and show what the project is about. The best project titles are between 8-10 words in length.

2) Independent Variable: This variable is the one which you are using to test your hypothesis. This is what you, as the scientist, are manipulating in the experiment.

3) Dependent Variable: This is the variable that you are measuring as data in your experiment. This variable is dependent upon what the independent variable is causing in the experiment. This is the information that you are going to use to try to analyze the effect that your independent variable had on the experiment.

4) Control: The control is a group of identical constants set up to compare to the independent variable(s). YOU MUST HAVE A CONTROL TO MAKE ANY VALID CONCLUSIONS OR COMPARISONS OF THE DATA COLLECTED!

5) Constants: These are everything that is kept the same in both the experimental and control group settings. The more constants that you control in your experiment the easier it will be to analyze your data and come up with valid conclusions. A common error in science fair projects is when these are not identified.

6) Repeated Trials: Every experimental design requires more than one trial for reducing possible errors in your experimental design. The number of trials will depend upon the availability of subjects, cost of materials, and ease of collecting data. A MINIMUM OF THREE TRIALS MUST BE COMPLETED FOR ALL PROJECTS. Statisticians recommend 30 trials for good statistical evidence when using analysis such as the T-Test.

7) Procedure: The procedure describes what you plan to do with the project. Remember this is only a plan, and things may change. Theoretically, another scientist should be able to duplicate your work by following this procedure.

8) Materials Needed: A detailed list of materials needed will help you to get organized before you begin your research project. It will also allow your teacher to see what equipment the school may have to help you with your project. Be as specific as possible here, as this will save you a lot of time later in the project.

   You will find a variety of sample experimental plans and ideas in the classroom. Once again, don't hesitate to ask for assistance from your teacher or parents. A well-designed experiment will run much smoother in the later steps.

ASSIGNMENT 4: Experimental Plan

1. Complete experimental design sheet.

EXPERIMENTAL DESIGN PLAN SHEET Name_________________________

Project Title:

____

____

Independent Variable:____

Dependent Variable:____

Control(s):____

Constant(s):____

____

Repeated Trials:________________

Procedures:

Materials Needed:

Assignment 5: Key Sources

The final step in the project proposal is to locate at least five key sources that you will use to find background information about your project. These should be primary authoritative sources. This means the source should contain original data or information that is verifiable in a scientific way. These could include books, magazines, scientific journals, interviews, or abstracts. You should avoid internet websites, unless you can verify the credibility of the source. Beware of fake internet sources that look like scientific research. Usually, most internet sources from educational sources (www.???.edu) or government sources (www.???.gov) are credible. A good scientific search engine or database may be a good starting place. When you find a source, be sure to copy all necessary information needed to find the source again or to document in your paper. We will discuss proper format for sources at a later time. Be sure to include the date you accessed the information on a website source since websites can change but your date accessed states that the information you used was available on the date that you accessed the website.

You have now completed all work for step 1. You should turn in all forms and the research plan attachment. This will be your project proposal. Be sure to type this work so that it may be reviewed by other scientists. Their input may save you many hours of frustration at a later time.

Be sure to keep yourself organized. Save all work on your computer as well as a storage device. Keep a backup in case something happens. As you continue to put your project together you will need every step from the process. DO NOT waste your time retyping earlier work. When we get down to "Crunch Time" your organization will be very helpful. Hang in there; put together a great project, and most of all HAVE FUN!

ASSIGNMENT 5

1. Develop a list of at least five key sources to be used in your project.
2. Include one source for care of animals if completing a project with animals.

STEP 1 GRADE CRITERIA

E=Excellent S=Satisfactory N=Needs Work

The following grade criteria will be used to assign points for this assignment:

_____ problem defined

_____ forms completed as needed

_____ forms signed and dated properly

_____ hypothesis is concise, clearly stated, and testable

_____ experimental design plan sheet/procedures

_____ sources are primary authoritative

Format (Grammar, Spelling, Typed, Style) _____

Content (Information, Documented, Reliable, Journal) _____

Creativity/Originality (Ownership of Project, Ingenuity) _____

EXCELLENT WORK: 28-30
SATISFACTORY WORK: 24-27
NEEDS IMPROVEMENT: 21-23

Total Points _____/30 points

Suggestions for Improvement:

STEP 2: LITERATURE SEARCH

One of the most important aspects of the science fair project is for you to become the expert about your topic. The only way that you will be able to make informed decisions about your project is for you to do as much research as possible relating to your topic. I realize that this is not a popular step, but it is crucial to the success of the project. This background information will be the basis for the introduction to your paper. It will also help you to answer the questions that the judges will ask you at the science fair. Remember, you must be the expert in your field of study to be able to successfully discuss your project with others.

A literature search should cover all varieties of sources available to you. Sources may include, but are not limited to, books, newspapers, magazines, scientific journals, brochures, reports, tapes, videos, lectures, interviews, or the Internet. The key is to find as much information as possible. Don't set your goals low. It is better to set a goal to find 15 sources and only find 10, rather than having a goal of 3 and finding 3. Search the media center, the teacher's room, the Internet, or at home. Ask your parents or teacher for ideas. Don't waste time searching. If you can't find something ask someone for help. Materials don't magically appear. It takes a lot of hard work and MANY hours of dedicated research to develop an adequate file of information.

You will want to search for primary authoritative sources. These are sources that have original research results with the original author(s). Journals, magazines, books, and newspapers are your best choices to find original research. Secondary sources are not as good; however; they may provide some good general background information about your topic. Realize that these sources are written about the topic, but are not authoritative regarding factual results or conclusions. A good file will have a good assortment of both of these types of sources.

It is recommended that you explore beyond the Internet. Although the Internet has a vast array of information, it may be difficult to determine the validity of the site. If there is not an author or date published it is probably not a very good source. It is recommended that for every Internet site found, you should find a non-internet site. This will help to balance your sources so you have a variety of viewpoints. There are some excellent search engines that directly connect you to a journal. InfoTrac is an excellent tool to find primary authoritative sources on-line. Proquest is a good search engine for newspaper sources. MINITEX Library Information Network will provide many possible sources. Electronic Library for Minnesota (ELM) is a resource available to all citizens of Minnesota. You can access this through your local library or from home you can visit www.elm4you.org . Internet sources can be fabricated very easily. Some may even look like research, but they are fake. Check out the sample in the classroom showing data on the California Velcro Crop. Reputable cites usually end in .edu or .gov. Be careful with Internet sources!!!!

Some areas that you should be trying to locate include similar scientific studies, current and historical studies, alternative viewpoints about the problem, information about sub problems, or interviews with informed people in the field. Remember your goal is to develop a question to be solved. You need a strong background of information to help you accomplish this goal. The library or media center can help you a lot when searching for scientific information. Don't hesitate to ask for help as you are searching.

As you search for sources, don't eliminate or try to evaluate the source for your project. You might use it after four weeks of testing. You want to keep a research file with copies of as many sources as possible. This research file will be used extensively throughout your project. A box or file system is recommended.

Once you have obtained your sources, you need to document them for future use. It is recommended that you create a bibliography source card for every source that you have found. Be sure to use a common format for bibliography cards. MLA, APA, and Chicago style are all acceptable formats. Pick one and use it consistently throughout your paper. See the following pages for examples. Keep your bibliography cards alphabetized. This will help you when you need to type your cited sources. It is suggested that you begin with a minimum of ten sources. You may add more as your project progresses. If you are using animals in your research, YOU MUST HAVE ONE SOURCE DESCRIBING THE CARE OF THE ANIMAL. This is an ISEF regulation. It does make sense that you should know how to care for an animal BEFORE you begin working with them. Your teacher has a variety of sources that will help you here. You may need to check sources in the classroom that will help you with proper formatting for these bibliographies. (Brooks, 1995; Gibaldi, 1995; Gubanich, 1985; Leahy, 1983: Pechenik, 1997; Turabian, 1987)

SAMPLE BIBLIOGRAPHIC ENTRIES

Traditional Sources

BOOK:

Author (last name first). Book Title. City of Publication: Publisher, copyright date.

Example:
McDougall, Walter. The Heavens and the Earth: A Political History of the Space Age. New York: Basic Books, 1985.

BOOK WITH 2 AUTHORS:

Example:
Kerrighan, Brian W., and Dennis M. Ritchie. The C Programming Language. Englewood Cliffs, NJ: Prentice-Hall, 1978.

BOOK WITH MANY AUTHORS:

Example:
Case, Christina et al. Microbiology. London: Benjamin Cummings Publishing Company, 1982.

PERIODICAL (MAGAZINE/NEWSPAPER):

Author (last name first). "Title of Article." Title of Periodical, Volume/Issue number (or full date of publication), page number.

Other Magazine Examples:

Weber, Bruce. "The Myth Maker." New York Times Magazine, 210(20 Oct. 1986), 23.

Camille, Andre. "Deciding Who Gets Dibs on Health-Care Dollars." Wall Street Journal, (27 March 1984), 30A and 14E.

"Rehearsal for a Space Rescue." Discover, September 1983, pp 24-27.
(NO AUTHOR GIVEN)

REFERENCE BOOKS:

"Title of Entry." Title of Reference Book. Date.

Examples:
"Voluntary Health Agencies." The Medical and Health Encyclopedia. 1987.

"Geochemistry." Webster's Seventh New Collegiate Dictionary. 1988.

INTERVIEW:

Interviewee (last name first), job title, place of work, city, state. Interviewer and date of interview. (Place of interview, if pertinent)

Example:
Morris, Franklyn B., neurologist at Mayo Clinic, Rochester, Minnesota. Interview by author, 27 Sept. 1994. St. Mary's Hospital, Rochester, Minnesota.

FILM:

Title. Director. Names of lead actors or narrator. Distributor, year. Running time if pertinent.

Example:
Much Ado About Nothing. Dir. Kenneth Branagh. With Emma Thompson, Kenneth Branagh, Denzel Washington, Michael Keaton, and Keanu Reeves. Goldwyn, 1993.

VIDEOTAPE:

Title. Videotape. Director. Narrator or actors if pertinent. Distributor. Year. Running time if pertinent.

Example:
Through the Wire. Videotape. Dir. Nina Rosenblum. Narr. Susan Sarandon. Fox/Lorber Home Video, 1990. 77 minutes.

ELECTRONIC SOURCES:

Internet Example:

Author. "Title," complete URL, date.

Yule, James. "The Cold War Revisited: A Splintered Germany," [Online] http://usa.coldwar.server.gov/index/cold.war/countries/former.soviet.block.html , November 5, 1996.

When you have a bibliography card for each source, you will begin taking notes on each source. A note card is a record of one piece of information that you may use in writing your paper. This note card should include the source and a keyword reference. These keyword references will be used as key ideas when writing the introduction to your paper. Be sure to use a keyword on each note card and cross-reference the source so you can use this in documentation later in writing your paper. A good source for note taking is Students and Research which can be found in the classroom (Cothron, et al. 1989). Use of direct and indirect quotations will provide documentation needed in your written paper. Direct quotations are taken word for word from the source. You should include the page number with the quote, as this will be needed later when writing your paper. Indirect quotes involve taking a passage and stating it in your own words without changing the meaning of the original passage. A suggestion is that you do not use more than two consecutive words from the original passage.   Be sure to use quotes on all materials that you copy from the source. YOU MUST DOCUMENT ALL QUOTED MATERIAL. You will have approximately 8 weeks to get notes on all of your sources. It is recommended that you begin by taking notes on books or borrowed items that need to be returned. Copied materials will always be in your file for later reference.

Some key ideas that the note cards should include are definitions, facts, previous data or studies conducted on your topic, procedural information, safety guidelines, etc. If you think you may use the information as background information in your paper it must be recorded on the note cards. These will save you a lot of time when writing your paper. A sample note card is shown below.

Author, Date	Keyword

"Direct Quotation" (page number)

An indirect quote allows you to include information
Which is not taken word for word from the text.

Don’t underestimate the importance of this step. You must be the expert if you are going to convince a judge that you are responsible for this work. Good luck in your search.

This step involves the preliminary stages of taking notes. Remember you will continue this process for many weeks. It is important that your notes are complete and organized by keywords. This will help you as you begin to write the introduction of your paper. You will save yourself A LOT of time if you take good notes.

Remember that each note card should focus only on one key idea. It is better to separate all ideas on many different cards. Be sure to include the keyword on each card. Some students have found that highlighting the keywords with a color code is very helpful in putting the same ideas together. Each card should reference the source, either by number or code (if you don’t use the complete entry).

The note cards need to reflect adequate knowledge base for the complexity of your project. A general project will have many more note cards than a specific topic, which is narrowed down. It is expected that numerous hours will be needed to prepare you for understanding your project. This is not a step to take lightly. You will save many hours later if you do a good job here. As the saying goes, “you can pay me now, or you can pay me later!” Put in the time NOW!!

An alternative to notecards is to collect sources and keep a copy of each journal. Using a highlighter you can highlight the key ideas in that source. This approach saves you time initially but it will take you longer when you are assembling your paper.

The research file is a compilation of all information that you have collected through your searches. This file will probably have a number of copied sources, note card files, interview responses, notes from experts in the field, and copies of journal articles. It is important that you know everything that is available so you can relate to your topic. This file will continue to grow as you find even more information through future searches. This file will document all of the hours of searching that you have completed on your project. Once again, don’t eliminate potential sources. Keep them in your file until you are 100% sure that you won’t need them later in the project. The more you search, read, and understand the project, the easier it will be to explain your project to the judges.

Assignment 6: OUTLINE FOR PAPER

Now that you have a good foundation for your project, we need to turn our attention to the early stages of writing a scientific paper. The first section of the paper is the introduction, which summarizes the key background ideas that you have been collecting in your literature search. The author finds it very helpful to establish an outline for writing your paper. You have been accumulating note cards using different keywords. You should be able to take these keywords and organize your paper in the order that you wish to write your introduction. You will want to look at each keyword to identify how you may subdivide the keyword into smaller groups. A sample outline is shown below. Note that you always find two subdivisions below each heading. If you only have one subdivision, then it should be included in the heading. It is recommended that the introduction include a purpose statement and the last paragraph of the introduction focus on the hypothesis of your study.

As you plan your outline, plan so that the ideas flow from one into another. Avoid jumping from topic to topic and then back to the original topic. Keep your ideas together by subject or keywords and you should have no problem. Remember that you will end with the hypothesis for your project. Build up to this with the most important aspect of your background being discussed before the purpose statement and hypothesis.

SAMPLE OUTLINE

I. Main Heading 1

   A. Subheading 1
   B. Subheading 2
   C. Subheading 3

II. Main Heading 2
   A. Subheading 1
      1. Idea 1
      2. Idea 2
   B. Subheading 2
      1. Idea 1
         a. example 1
         b. example 2
         c. example 3
      2. Idea 2

III. Main Heading 3
IV. Purpose Statement
V. Hypothesis

ASSIGNMENT 6

1. Create an outline using all keyword ideas for your project.

Assignment 7: INTRODUCTION

The introduction is a very important part of your final paper. It provides an adequate review of the literature and it defines key facts and ideas that are central to solving your problem. The introduction is typically one to four pages in length depending on the complexity of your project. Remember the total length of the written paper, including graphs and tables, should not exceed twenty pages. A historical review and any previous studies relating to your problem should be documented in the introduction.

The introduction tells your readers about the topic by briefly describing what you intend to do and what others have already done. Describe any facts that helped you formulate your hypothesis. You must give a clear picture of the work already done in the area you are studying. Be sure to read about the work of other scientists. Avoid the temptation to include all facts that you read about during your note taking experience. You may have discovered many interesting facts during your literature search, but only include material that is important to your project.

It is recommended that you end the introduction with your hypothesis. Some suggestions for your introduction include:

1. Begin with an opening sentence that gets the readers attention. Avoid starting your introduction with "My project is about . . ."
2. Define key background terms used in your study. These are probably your keywords from your note cards.
3. Organize your paragraphs by keywords from your research.
4. Include related studies.
5. DOCUMENT all borrowed information by quoting, by giving reference to the source, or by citing the source.
6. End your introduction with the hypothesis of your study.
7. Avoid using First Person writing style. Don't use personal pronouns such as I, we, and they unless absolutely necessary.
8. Write the introduction as if it could be published and written by anyone.

When referring to examples, remember each one has good and bad parts. These are not necessarily perfect examples to follow word for word. You will also find some common problems with introductions based on the article entitled, Guidelines for Preparation and Presentation of Student Research (Martin and Brenstein, 1998). You may also find the guidelines from the Minnesota Academy of Science to be very useful. These are located in the classroom.

What is the purpose for doing this work? If it is simply to get a grade for school, stop now. Get out. You're doing this for the wrong reason. Remember, you should be trying to impress yourself with solving a problem. Don't try to impress your teacher or the judge with your brilliant intelligence. Show a genuine look at a unique problem that you are attempting to solve.

Why is this research important to the world? Why is it important to you? How does this problem fit into everyday living? These are some of the questions that your purpose statement should address. Your purpose should address an ethical project showing a reason that this work is important. It is important to show how this project applies to your life. Refer back to assignment 1 which addresses these ideas.

The purpose statement should be clear and concise. Get to the point. Don't put a lot of fluff in the purpose statement. A good purpose statement should be three to six sentences in length. Give some explanation but keep it brief. Keep all explanations in the body of the introduction section.

ASSIGNMENT 7

1. To develop a sound theoretical/methodological framework for your project.
2. To adequately review the literature available to you regarding your project.
3. To develop a clear purpose statement and hypothesis for use in the paper and on the display board.

ASSIGNMENT 8

1. Revise assignment 7

Assignment 9: BIBLIOGRAPHY

The bibliography is a record of all sources that were cited somewhere in the paper. Most of these will be from the literature search, however some may be procedural or from the discussion section. The bibliography of cited sources will change throughout the process of writing your paper. If you have kept accurate bibliography cards you should be able to copy the entry from the cards.

This is one section that you definitely want to save on your computer and a storage device. It is very important to have a backup. It is tedious to get everything formatted so you don't want to type this part more than one time. If you need to add a source it will be easy to insert as necessary.

You will want to follow the format from the beginning of this step. Remember to alphabetize your sources. Typically the author's last name is first. You can find samples in the back of this book on the CD provided. You may also find samples in the classroom or you can find other examples in writing books (Brooks, 1995; Gibaldi, 1995; Gubanich, 1985; Leahy, 1983; Pechenik, 1997; Turabian, 1987). Ask your teacher, parent, or librarian for help if you are having trouble with formatting. You may also use many different bibliography generators from the internet. We typically use MLA format, although other formats are also acceptable. Refer to the ISEF Student Manual for other formats.

The following guidelines should be followed when word processing a bibliography:

1. single space your bibliography
2. do not number your entries in the bibliography
3. alphabetize your bibliography by author; if there is no author use the title for alphabetizing
4. the author's last name always goes first
5. first line of bibliography is not indented; the second line is indented
6. double space between entries
7. pay attention to punctuation within each entry; be consistent using same style throughout bibliography
8. remember to end each entry with a period
9. underline book, encyclopedia, magazine, and journal titles

10. use quotes around the titles of articles from encyclopedia or journals (Martin and Brenstein, 1998)

ASSIGNMENT 9

To develop a bibliography of cited sources used in the body of the paper.

STEP 2 GRADE CRITERIA

E=Excellent S=Satisfactory N=Needs Work

The following grade criteria will be used to assign points for this assignment:

_____ Background sources are authoritative primary and secondary

_____ Research File shows adequate background information

_____ Outline shows logical flow and uses proper format

_____ Introduction explains the relevance of information to your project

_____ The writing is clear and easy to understand

_____ Technical vocabulary is used correctly

_____ Documentation of Sources used

_____ Bibliography in proper format

_____ Minimum of five sources required in Introduction

Format (Grammar, Spelling, Typed, Style) ______

Content (Information, Documented, Reliable, Journal) ______

Creativity/Originality (Ownership of Project, Ingenuity) ______

EXCELLENT WORK: 28-30
SATISFACTORY WORK: 24-27
NEEDS IMPROVEMENT: 21-23

Total Points _____/30 points

Suggestions for Improvement:

STEP 3: DATA COLLECTION

Data collection is, for most students, the most enjoyable part of the project. Most scientists agree that work in the lab is fun. Here you will develop procedures, revise ideas, and collect data. You will have fun in experimentation, however you must document all work by recording everything that was done. Data is anything that we can measure or observe. Data can be placed into two different categories, quantitative and qualitative.

Quantitative data is any observation that is numerical in nature. This data is easily replicable as it is a number measurement. This type of data can be analyzed using a variety of statistical tests.   Good quantitative data is something that can be replicated by other research scientists. It is critical that accurate data be recorded for future use and reference. Because quantitative data has a specific measurement, it must have a specific unit of measurement that was used. Be sure to label all quantitative data with the proper unit.

Qualitative data is any written observations that you notice during experimentation. These may include possible problems that you encountered. They may be outside forces that you feel may help explain the quantitative results that are being recorded. Qualitative data are your interpretations of what you are observing. Due to this fact, qualitative data may not be replicable by other research scientists. Most judges will focus their attention on the quantitative data, however good qualitative notes can help you explain this data more clearly. All researchers should keep a good journal documenting both quantitative and qualitative data.

It is imperative that all data is taken and recorded as accurately as possible. A good journal/log book will help you verify your work and adds validity to your study. The data collection sheet is one way to record your data. You may keep this information in a bound journal or on separate sheets compiled together. A well-prepared data collection sheet will help you to identify exactly what you plan to collect. It also forces you to predict other possible data or problems that you may encounter. A well-designed data collection sheet will replace the journal entry during data collection. ISEF strongly suggests a well documented journal as part of the final display. Record keeping can be tedious, but it is critical for developing conclusions about the data collected.

Assignment 10: DATA COLLECTION SHEET

The data collection sheet is one way that you can keep track of all quantitative and qualitative data. Most students find it will save them time in the long run. The data collection sheet is one piece of paper that will include all of the major experimental information needed for a good journal. If you prepare a place to record your data, then when you are collecting the data it will be much faster. You will eliminate a lot of repetitive record keeping if you use the data collection sheet. It is very important that you record the data as you collect it. Don’t rely on your memory to recall critical data.

The data collection sheet should include, but is not limited to, the following information:

1. Date of data collection
2. Trial number (both control and experimental)
3. Brief procedure with independent variable(s) identified
4. Quantitative data (dependent variable)
5. Qualitative data (observations and notes – these may be very helpful later during conclusion writing and/or data analysis)
6. Constants (include items such as environmental conditions, location, set up, etc. that will stay the same in all testing)
7. Title
8. Your name and/or signature
9. LABEL EVERYTHING WITH UNITS MEASURED!!!!!!!!!!!
10. It is a great idea to record any other information that could affect your experiment - atmospheric conditions, lot numbers of chemicals, serial and model number of equipment used, etc.

You do not need to rewrite published procedures. Simply document the published work and you do not need to copy any lengthy procedures. You must describe any modifications that were made to the published procedure. It is a good idea to have a copy of the published procedure and reference in your files to refer to, however.

A poor example of a data collection sheet is shown below. Try to determine why this is a poor example. What is missing? What would make this data easier to understand?

DATA COLLECTION SHEET

Sunday

Green

5	4	4	3	2
5	6	6	7	8

Yellow

5	5	4	5	6
5	5	6	5	4

Data worked perfect!

A better example may look more like this example:

EFFECTS OF DENERVATION ON TRANSPORT MAXIMUM OF PHOSPHATES

Group 2: Saline Control Ken Mann
Trial # _____________ Date:_____________

Initial Mass of Rat:_____________grams

Constants: Inulin: 3% at 4.5 ml/hr
Saline: 0.9% at 2.0 ml/hr
Phosphate: 30 mmol at 2 ml/hr
60 mmol at 2 ml/hr
90 mmol at 2 ml/hr

Procedure:

```
       Inulin-----------------------------------------------------------------------------------------
       Saline-------------------30mmol Pi--------60mmol Pi--------90mmol Pi---------------
        !                          !                 !                 !
TPTX---!------------------------------!--------------------!--------------------!--------------------
Minute  0      60      120      150     165      185     200      220     235     255

                       P1                   P2                  P3                  P4

              U1R __________   U2R _________   U3R ________   U4R_______

              U2L __________   U2L _________   U3L ________   U4L_______
    Blood
    Pressure   _________mmHg  ________mmHg  _________mmHg  ________mmHg
```

Measured Data:

Period	Vu ml/min	In mg%	PO4 mM	Ca++ mM	Na mEq	K mEq	PAH mg%
P1							
P2							
P3							
P4							
U1R							
U1L							
U2R							
U2L							
U3R							
U3L							
U4R							
U4L							

Qualitative Notes:

ASSIGNMENT 10

1. Develop a data collection sheet for record keeping.

Assignment 11: JOURNAL

The journal is an essential part of your science fair project. The journal will document each step in your progress to project completion. The data is very important and should be accurately recorded. A data collection sheet will help you accomplish this. All other aspects of your project can be recorded and documented. You can use a spiral notebook, a bound notebook, or a three ring binder. You may use the sample journal sheets as described in the introduction to this book. The journal will provide verification of when you did your project. It should also document that this is your work. Two items that are important for your journal entries are the date and the signature. This should provide adequate documentation that this is your work. You may also prepare a cover page for your journal. This will help to identify your project. Your teacher can laminate the cover and bind your journal into a final product if you like. You will find sample journals in the classroom.

ASSIGNMENT 11

1. Develop a sample journal to use throughout your project.
2. Develop a cover page to identify your journal.

STEP 3 GRADE CRITERIA

E=Excellent S=Satisfactory N=Needs Work

The following grade criteria will be used to assign points for this task:

_____ data collection sheet shows key experimental plan aspects (title, variables, control, constants)
_____ brief procedure given to help understand how data is being collected

_____ quantitative and qualitative data shown on the data collection sheet

_____ journal cover page

_____ journal entries show date and signature

_____ adequate number of journal entries show project progress

Format (Grammar, Spelling, Typed, Style) ______

Content (Information, Documented, Reliable, Journal) ______

Creativity/Originality (Ownership of Project, Ingenuity) ______

EXCELLENT WORK: 28 - 30
SATISFACTORY WORK: 24 - 27
NEEDS IMPROVEMENT: 21 - 23

Total Points _____/30 points

Suggestions for Improvement:

STEP 4: DATA ANALYSIS

As soon as the data is completed, it is time to do some type of statistical analysis. If the average data for group A is 12 and the average data for group B is 8, does this mean that the two sets of data are different? Yes, 12 is bigger than 8 – but is it statistically significant? There must be a way that shows that your original hypothesis was supported by the data.

In order to reach a valid scientific conclusion about your hypothesis you must run some type of statistical analysis. There are many different types of statistics to use. In the following pages you will find information about a variety of different ways to analyze data. Your teacher will go over some of these key ideas and help you determine what type of analysis is best for the type of data collected. You may find it necessary to contact a local statistician at a college or university to help you with your specific project.

It is critical that you use the right type of analysis and that you understand what it is that you are doing. Without statistics, you can not say that your data supported or did not support your original hypothesis. The evidence that you obtain about your data will be necessary to adequately form a conclusion about your project. Don't hesitate to ask for help on this step!

You may find from your statistical analysis that more trials are necessary. In all my years of working with science fair projects, I have never had a student collect too much data. A common problem, however, is too little data. Most statisticians agree that thirty trials are necessary for adequate use of many statistical tests.

Assignment 12: STATISTICAL ANALYSIS

Statistical Analysis is not something that you will master in high school. It will be a continual learning experience as you learn more about how statistics can help you as the scientist to show your point. Basically, statistics can be broken down into three categories: descriptive, correlation, and inferential. All projects use descriptive statistics. These include making pictures of your data in the form of graphs and looking at trends of the data. Correlation statistics attempts to look for relationships between data sets to try to make a stronger explanation of what is happening. Inferential statistics uses mathematical principles to show proof that there is a causal relationship between the variables being tested (Blaisdell, 1993). Beginning projects will focus on the descriptive aspects. Intermediate projects should advance to the correlation level, while advanced projects will deal with inferential statistics. It is not recommended that a beginner project use inferential statistics, unless they can explain everything that was done. Parents and mentors should avoid doing the statistics for the student as most judges will be able to identify who completed and understands their own project.

ASSIGNMENT 12

1. To use statistical analysis to determine significance in your data.

2. To write a plan for what type of data you have collected, the type of statistical analysis you will attempt, the type of test to be used, and the level of significance that will be used to draw conclusions on your project. Remember this is a plan for what you hope to accomplish.

Assignment 13: MATERIALS AND METHODS

The materials and methods section is the next part of the paper to be completed. Basically, this section puts your procedures into paragraph form for your paper. This section describes how you conducted your study. It will include materials and equipment used and all procedures completed. This is not a list of steps, everything should be written in sentences placed in paragraph format. NO RESULTS should be included in the methods section. Please refer to Guidelines for Preparation and Presentation of Student Research by Martin and Brenstein (1998) as a guideline.

Samples can be found in the classroom. Sample papers are included at the back of this book. Note that pictures can be very helpful in describing your procedures. The pictures may be in the text or they can be placed in an appendix at the conclusion of the paper. If pictures are included in the paper, you must refer to them at some point in the written form. It is important that you include how data was collected and the number of trials performed. If you are using a published procedure, you simply need to document the source used for the procedure. If a large amount of time was needed to engineer or build your apparatus, you may include this here. In some cases a good labeled sketch is as good as or better than pictures. You may also use a combination of pictures and diagrams.

You may include pilot studies or failed attempts if your paper is not too lengthy. This shows your ability to work through the entire problem. It is not recommended for the advanced project, however, beginners may use this to show how they solved their problem from beginning to end.

Do not use first person writing style. Do not use "I" when writing this section. Instead of saying, "I then performed three tests." Say – "Three tests were then performed." You may need some help from a parent or teacher to help proofread this section. This is not an easy section to complete. Avoid the long and drawn out version which includes every minor detail. However, be sure you include enough detail for the reader so that they could replicate your work.

ASSIGNMENT 13

1. To write your procedures in paragraph form to be used in the body of the paper.

Assignment 14: GRAPHS/TABLES

As you analyze your data, you need to find a way to display your data in a way that judges will understand. A clear table or graph is the easiest way to show a lot of data in a small space. A well-organized result section will make it easier to write your final conclusions.

All data should be displayed in chart or graph form. A data table can show a lot of numbers in a small area. You will want to be selective in the types of graphs and tables chosen and what data to include. For example, if you have 60 individual trials, you will want to include the mean results only. All of the original data will be in your data journal, which will be available at your display for judges to review. Avoid duplicating data in table and graph format unless it is extremely important to your study. In these cases you may want to put the table and graph in the same chart.

The type of graph is very important. For example, a line graph is only used when you have continuous data. Independent data points, which are not found on a continuum, should use a bar or column graph. If you were showing percents or parts of a whole, a pie chart would be best. You can include qualitative observations in a survey format if you used a survey to collect information. Be sure to check with your parent or teacher to be sure you are using the best graphs or charts for the type of data you are displaying. A good source for graphing is Students and Research (Cothron, et al., 1989).

It is recommended that you put your data in a spreadsheet such as Microsoft Excel. The following directions will help you create a chart and graphs using the excel program.

How to Make a Chart and Graph with EXCEL (Mann, 2003)

1. Open Excel by clicking on Excel Icon on Desktop or from hard drive.
2. Click on Excel Workbook to open a blank document.
3. Enter data into cells where you want to enter your data. You can move around the Spreadsheet using the arrow keys or press enter to go to the cell below.
4. To make a column wider or a row higher you can put the cursor on the line between the columns on the top row (between letters) or between the rows on the first column (between numbers). Click and drag cursor when the plus arrow appears.
5. To change the font size, style or alignment simply click on view - toolbars – formatting. This will allow you to change a variety of formatting items.
6. To eliminate numbers and letters in the column or row headings click on file - page setup - sheet - headings or gridlines can be added or deleted.
7. To justify the numbers in the columns click on toolbar - formatting - center, left or right justify.
8. To add a function or statistics click on Fx icon - statistics - type you want (follow prompts)
9. To add a title click on view - header/footer - custom header - type title
10. To print click on file - print preview - page setup - sheet - adjust gridlines, labels, or headings - print

GRAPHING

1. Click on Chart Wizard Symbol
2. Highlight Chart Type - next.
3. Data Range highlights the data you want included (change if it is not correct).
4. Series allows you to change names or add or remove data if necessary.
5. Click on next and then add titles
6. Click next and identify chart location - save as a new sheet to easily modify later
7. Click Finish - Print Preview - Modify or Print
8. To edit graph - double click on location you want changed
   - font change font type or size, bold, color, underline

It is important that all parts of the table or graph are clearly labeled with units used in measurements, as well as a clear title. These tables or graphs should be able to stand-alone and still be clear. These will be used in your paper as well as your display board. You will probably want to print your final copy in color, however, color is not needed in rough draft copies.

ASSIGNMENT 14

1. To construct appropriate tables and graphs to analyze data.

Assignment 15: RESULTS and CONCLUSION/DISCUSSION (PAPER)

Now that you have completed all graphs and tables, you need to write about your results. This section of the paper should be written in paragraph form. You should present your results of your research findings in a logical order. You must refer to tables, charts, or graphs as you discuss the data. Tables and graphs should be numbered separately and include captions and should be placed in an appendix. Numbering will enable you to refer to each graph or table in the text easily. Be sure to give a reference back to the appendix that has the graph or table.

Even though you may present your results in a graphic form, you must explain in text the important features of each table, graph, etc. This is also the appropriate place to report the results of statistical analysis of your data. Remember to report the type of statistical test used and the p value used to determine significance (usually $p<0.05$).

Once again, avoid the use of first person writing style. Rather than "My data indicates…" you should write, "The data from this study indicates…"

The next section of the paper will be the conclusion section. You need to interpret your results in this section. Begin by restating your hypothesis and explain how your data either supported or rejected your initial research questions. Discuss your research findings in relationship to what is already known about the research problem (this is found reported in your introduction section). You may want to document previous research findings to help strengthen your conclusions. Your conclusions can include relevant, subjective observations or comments however you must state that these are speculation only.

Acknowledge any limitations, which affect the research results. Include major problems encountered. Be careful that these are problems that are out of your control, such as “the plants in the control seemed to die more than group 1”. Don’t imply that the problems were because you didn’t work or try hard enough such as “I didn’t read the thermometer correctly all the time.”

Include future experimentation plans, which are directly a result of your study. Statistical techniques used to manipulate data may have limitations. Some of the treatment effect might have been caused by a random, uncontrolled intervening variable. Again, acknowledge these limitations and other factors over which you had no control. State how these might have influenced the outcomes of the study. Possibilities for further research suggested by your study might also be presented.

Some excellent strategies for writing conclusions can be found in Students and Research (Cothron et al., 1989), Scientific Writing in Biology (Brooks and Wallace, 1995), and A Short Guide to Writing About Biology (Pechenik, 1997). You may find a variety of sources in your local library which will help you with your writing. Read samples and get an idea of what needs to be addressed in these two sections. Don’t hesitate to ask for help from your teacher. This step may involve a number of revisions to get it in its best form.

ASSIGNMENT 15

1. To put your results of your study into paragraph form, which will be used in the final paper.
2. To write a conclusion based on the relationship between the data collected and the original hypothesis.

STEP 4 GRADE CRITERIA

E=Excellent S=Satisfactory N=Needs Work

The following grade rubric will be used to assign points for this assignment:

_____ The experiment was repeated a sufficient number of times

_____ Data table with results clearly marked

_____ Materials and methods are described in enough detail to be replicated

_____ Data are presented in clear and easy to understand graphs and tables

_____ Results section is in paragraph form

_____ All charts, graphs and tables are referenced in the results section

_____ Interpretations accept or reject the original hypothesis

_____ Inconclusive findings and/or limitations of the research are identified (problem analysis)

_____ Implications of results and recommendations for further study are identified

Format (Grammar, Spelling, Typed, Style) ______

Content (Information, Documented, Reliable, Journal) ______

Creativity/Originality (Ownership of Project, Ingenuity) ______

EXCELLENT WORK: 28 - 30
SATISFACTORY WORK: 24 - 27
NEEDS IMPROVEMENT: 21 - 23

Total Points _____/30 points

Suggestions for Improvement:

STEP 5: PRESENTATION OF PROJECT

Now that you are almost completed with your project, you need to think about how you will communicate your project to the judges. You will need to finish the last parts of the written paper, complete your journal, place all materials on a display board, prepare a 12 minute oral presentation, and prepare to speak with judges about your project. The key to these final aspects of your project will be practice, practice, and MORE PRACTICE!!! If you are the expert on your topic, which you should be by now, it should be relatively easy to talk about what you did, why you did it, how you designed it, and what you plan to do in the future. Good luck, all of the hours of work are going to shine through at this time. A colleague once told me, the top ten percent will rise to the top while the bottom ten percent sink to the bottom. The middle eighty percent is a roll of the dice; hopefully the judges will like what you have to say. So where are you with your project? Are you the cream, the middle, or the rocks? There is no substitute for hard work.

Assignment 16: ABSTRACT

It is now time to begin the final piece of the puzzle, the abstract. This is a one-page summary of the entire project. An abstract gives the reader a quick overview of the entire project. The abstract should include parts of the introduction, purpose, hypothesis, procedure, results and conclusions. It should be single-spaced and no more than 200 words. You should use a readable font of 12 so the reader can see the words. Do not try to squeeze extra words by using a small font.

There is no standard way of writing an abstract. The arrangement is up to you. You will probably find that many drafts are required to get it just right. There is no harm asking other students, parents, scientists, or teachers to review your abstract. Some judges will only see this printed form, so make it memorable. For most judges this is the only written paper that they will read. Many will make comments about your project on the abstract sheet as they judge you. They will then refer to this as they assign judge points and ribbon placements.

According to Martin and Brenstein (1998) the abstract should be the summary of principal findings of the paper. It should be a stand-alone document that gives all essential information about your project. They suggest that the abstract should not include headings or include information that is not in the paper. You should not use first person style or include references, figures or tables. Avoid abbreviations and do not emphasize minor details. "While it is difficult to be both concise and descriptive at the same time, that is exactly what you should strive for when writing an abstract. Say only what is essential, using no more words than necessary to convey the meaning. Examine every word carefully." (Martin and Brenstein, 1998, pg. 4)

The abstract needs to have key information at the top. The title is always typed in all capital letters. The next line includes the student's last name then first. The third line is the address line. The author recommends that you use the school address here. This is given so readers may contact the author if necessary. The fourth line should have the school, city and state. Look at examples for spacing specifics. All type should be in font size 12 with a standard font style. The heading information does not usually count in the 200 word count.

Ask your teacher to show you examples from previous ISEF and state fairs to see samples relating to your topic.

ASSIGNMENT 16

1. To prepare an abstract for your project.

Assignment 17: FINAL PAPER

Things will wrap up very quickly in the next few days. The final paper is a compilation of all the steps that you have completed so far in your project. Your science project must be presented in written form so that it can be reviewed and studied by others. Scientists need to share their knowledge so others can learn as well.

As you arrange your paper you need to update any changes that have been made since that step was last evaluated. You want to be sure to write in a past tense mode. Most scientific papers will include the following parts: abstract, title page, table of contents, introduction (includes purpose and hypothesis), procedure, results, conclusions, acknowledgements, sources cited, and appendixes.

Remember that the symposium rules limit the paper to a total of 20 pages. The computer content should not exceed 1.6mB of space as these will be emailed to judges. Work to say the most that you can in a manageable space.

Three small parts of the paper that still need to be completed are the title page, the acknowledgement section, and the table of contents.

The title page is obviously the cover to your paper. The title page states the title of the research, the category of the research, the student's name and grade in school. The first thing that a judge observes on your project is the title. The title should be well thought out and carefully constructed. The title should catch the eye of the observer without being excessively detailed or over the head of the observer. The title should define your project, giving as much detail as possible. The title should be clear and concise. Don't use a lot of connecting words. The best titles are usually ten words or less. Keep it simple, yet intriguing.

The Junior Science and Humanities Symposium suggest that the following rules be followed:

1. do not write the title as a question
2. do not use abbreviations
3. avoid excess words such as a, an, or the
4. avoid phrases such as a study of or investigations of
5. length of title should be more than 2-3 words but less than 14-15 words (Martin and Brenstein, 1998)

Sample titles are included below. You can also find sample titles in the media center or any science fair project book. (Carnahan and Hartmann, 1988; Hulse and Mc Mullin, 1991; Press, 1998) Abstract books from previous ISEF are located in the classroom.

Title Examples:

Comparing Buffalo Fish Mucus and Synthetic Slime on Racing Swimwear

Concrete Reinforcement Phase III: Strengthening Concrete Beams Using Fiberglass Reinforced Plastic Rods and Carbon Laminates

The Impact of Electronic Tapes on Lesser Snow Goose Harvest Rates

Phase 3: The Effect of Radiation (X-Rays) on Sweet Corn Seeds

The Effects of Metal Hydroxide Sludge on Plant Growth

Automatic Packet Reporting System: Building a Large Scale Geospatial Database

The acknowledgement section allows you to thank and recognize those individuals or groups that significantly helped you with your research. You may want to check with organizations or individuals to be sure that they will allow you to put their name in your paper. Some companies and individuals are not allowed to put their name on your work. This is a nice thank you section for individuals that guided you through the process. **Acknowledgements may be included in the paper but are not allowed to be displayed on the display board.**

The table of contents will help to organize your paper. It will direct the reader to all of the major sections in your paper. Although this may seem like a trivial thing to do, it may mean the difference to advancing to the next level or staying at home. A well-organized paper will be easier to follow for the judges who are reading them.

The research paper that is submitted for competition must be stapled with one staple. No other binding is allowed for competition. NO PLASTIC COVERS, FOLDER, OR THREE-RING BINDER IS ALLOWED FOR JUDGING. You may bind your final paper for display purposes at your project display. No binding is allowed for the paper competition.

The paper is key to advancing to symposium. A strong effort here will be rewarded later in the science fair. You have put so much effort into your project that you don't want this part to be sloppy. An excellent paper should be able to be submitted for publication if everything works out.

ASSIGNMENT 17

1. Compile the entire project into a final paper presentation.
2. To prepare a title page for your paper.
3. To prepare the acknowledgement section for your paper.

4. To prepare the table of contents for the paper.

Assignment 18: BOARD DISPLAY

It is now time to begin the visual display for others to admire your work. Each display must be arranged so that it clearly identifies all aspects of the project. It should tell a story about how you solved your original problem. It should be neat, attractive, and be the focal point for the judges' attention. Your display needs to show the title, purpose or problem, hypothesis, procedure, results, conclusions and abstract. If room permits you may include pictures, display materials, video, etc. Most judges will read from left to right, so it is wise to begin the story on the top left side and end with the conclusion on the bottom right side.

The display size is limited to 76cm (30 inches) deep from front to back, 122cm (48 inches) wide from side to side, and 274cm (108 inches) tall from floor to top. Most tables are 76cm high (30 inches). You will want to refer to the latest copy of the ISEF display rules for the latest rules on what can be displayed.

Normally, power of 110 volt AC, single-phase service with 500 watts per exhibit will be available. Requests for other power needs must be made prior to the fair. Additional power costs will be the responsibility of the participant. The student should provide an adequate extension cord for the project. Power should be used only if necessary to power equipment that is absolutely essential to show the judges. Special effects, such as lights or a laptop, are not recommended unless critical for the judges to see. Remember that judges will cut through the fluff of the display to focus on the project content. If the power is not essential to the project content, avoid using it.

Each student is expected to assemble his or her own exhibit. Help will be limited to packing and unpacking or to situations where the physical size or weight is such that assistance is required. Be sure that you understand how everything fits together. You will need to bring the tools necessary to assemble your project. Check with your school or fair director to see if they provide basic tools. ISEF has a hub set up for tools and supplies that can be checked out by the presenter.

Perhaps the most important part of the display is lettering, so it should be done with great care. Stencils, pre-made letters, or computer signs may all be used. Focus on color combinations which will enhance your project. Be sure they are easy to read and bring focus to the key parts of your project. Size of the lettering is important. Titles should be at least 2 inches tall, while subtitles should be at least 1 inch letters. Paragraph writing should not be smaller than font size 20. Judges should be able to be read the display from a distance of four to five feet away. The display should be a summary of key ideas. It does not have to be in paragraph form. Bullets and short phrases are acceptable, and some judges prefer to not have to read lengthy paragraphs on the display. At ISEF, the judges read through the displays without the presenter present, prior to judging. Be sure the display is easy to follow without the presenter explaining everything. The author has found that most judges do not like the display if it is a copy of the written paper put on display. The paper should be available at the display for the judges to read if they want. Most display judging will only be 10 – 15 minutes in length. Be sure the judge is able to see all of the key ideas of your display and also have adequate questions answered.

Several types of arrangements can be used for your display. Avoid copy cat displays. Make your display unique to your project. It should be neat and well organized. AVOID CLUTTER! You will find that good pictures of your equipment may be more effective than a clutter of equipment. You will find several examples of display arrangements and pictures of displays in the Science room. The author has several pictures on a CD from previous ISEF fairs. Ask your teacher or parents if you need supplies to put your display together. Be creative and put together a fun display. Judges will remember unique displays; however the key always comes back to your knowledge and project content.

Please make sure your project display meets all ISEF rules. Here are some pointers. The following is taken directly from the ISEF web site display and safety page. The bolded underlined items are the most common violations we have at the state science fair. Please do everything you can to abide by these rules. Remember pictures say a thousand words! Instead of bringing in items, **TAKE PICTURES!**

Not Allowed at Project or in Booth

1) Living organisms, **including plants and fruit flies!**

2) **Taxidermy** specimens or parts

3) **Preserved** vertebrate or **invertebrate animals**

4) Human or animal food **including popcorn**

5) Human/animal parts or body fluids (for example, blood, urine) (**Exceptions:** teeth, hair, nails, dried animal bones, histological dry mount sections, and completely sealed wet mount tissue slides)

6) Plant materials (living, dead or preserved) usually which were part of the scientific experimentation and which are in their raw, unprocessed, or non-manufactured state (Exception: manufactured construction materials used in building the project or display)

7) **Laboratory/household chemicals including water** (Exceptions: water integral to an enclosed apparatus or water supplied by the Display and Safety Committee) **Please note this includes bottles with residue and toothpaste!**

8) Poisons, drugs, controlled substances, hazardous substances or devices (for example, firearms, weapons, **ammunition**, reloading devices)

9) Dry ice or other sublimating solids

10) Sharp items (for example, **syringes, needles, pipettes**, knives)

11) Flames or highly flammable materials

12) Batteries with open-top cells

13) Awards, medals, business cards, flags, **acknowledgements (this means you can not say "Thank you to Dr. Jones on your display"; an acknowledgement can be made in the paper)** etc. (Exception: The current year Intel ISEF medal may be worn at all times.)

14) Photographs or other visual presentations depicting vertebrate animals in surgical techniques, dissections, necropsies, or other lab procedures

15) Active Internet or e-mail connections as part of displaying or operating the project at the Intel ISEF

Allowed at Project or in Booth, BUT **with the Restrictions** Indicated

1) Soil or waste samples **if permanently sealed in a slab of acrylic**

2) Postal, Web and e-mail addresses, telephone and fax numbers **of finalist only**

3) Only photographs (that is, visual depictions) of the Finalist, the Finalist's family, photographs taken by the Finalist, and/or photographs for which **credit** is displayed (such as from magazines, newspapers, journals, etc.) **if not deemed offensive** by the Scientific Review Committee, The Display and Safety Committee or Science Service

4) Any apparatus with unshielded belts, pulleys, chains, or moving parts with tension or pinch points **if for display only and not operated**

5) Class II lasers **if**:

   a) Operated only by the Finalist.

   b) Operated only during Display and Safety inspection and during judging

   c) Labeled with a sign reading "Laser Radiation: Do Not Stare into Beam."

   d) Enclosed in protective housing that prevents physical and visual access to beam.

   e) Disconnected when not operating.

7) Class III and IV lasers **if for display and not operated**

8) Large vacuum tubes or dangerous ray-generating devices **if properly shielded**.

9) Pressurized tanks that contained non-combustibles **if properly secured**.

10) Any apparatus producing temperatures that will cause physical burns **if adequately insulated**

Electrical Regulations at the Intel ISEF

1) Finalists requiring 120 or 220 Volt A.C. electrical circuits must provide a UL-listed 3-wire extension cord which is appropriate for the load and equipment.

2) Electrical power supplied to projects and, therefore, the maximums allowed for projects is 120 or 220 Volt, A.C., single phase, 60 cycle. Maximum circuit amperage/wattage available is determined by the electrical circuit capacities of the exhibit hall and may be adjusted on-site by the Display and Safety Committee. For all electrical regulations, "120 Volt A.C." or "220 Volt A.C." is intended to encompass the corresponding range of voltage as supplied by the facility in which the Intel ISEF is being held.

3) All electrical work must conform to the National Electrical Code or exhibit hall regulations. The guidelines presented here are general ones, and other rules may apply to specific configurations. The on-site electrician may be requested to review electrical work on any project.

4) All electrical connectors, wiring, switches, extension cords, fuses, etc. must be UL-listed and must be appropriate for the load and equipment. Connections must be soldered or made with UL-listed connectors. Wiring, switches, and metal parts must have adequate insulation and over current safety devices (such as fuses) and must be inaccessible to anyone but the Finalist. Exposed electrical equipment or metal that is liable to be energized must be grounded or shielded with a non-conducting material or with a grounded metal box or cage to prevent accidental contact.

5) Wiring which is not part of a commercially available UL-listed appliance or piece of equipment must have a fuse or circuit breaker on the supply side of the power source and prior to any project equipment.

6) There must be an accessible, clearly visible on/off switch or other means of disconnect from the 120 or 220 volt power source.

Maximum Size of Project at the Intel ISEF - no demonstration may be outside of this space:

30 inches (76 centimeters) deep

48 inches (122 centimeters) wide

108 inches (274 centimeters) high including table

ASSIGNMENT 18

1. To prepare a display board which meet the needs of your project.

Assignment 19: ORAL PRESENTATION (PAPER COMPETITION)

The regional science fair has two types of competitions. The project competition is similar to the local science fair. Your display board is judged and you talk with 3-4 judges about your project. Each project judge will spend 10-15 minutes talking with you and asking questions. Don't spend a lot of time talking. Know your key points and allow the judge to ask you a lot of questions. The second competition is paper judging.

The paper is sent to the regional committee to be read by three different judges on the written aspects of your project. At the regional fair you are then judged by 3-6 judges in an oral presentation. The oral presentation is limited to 12 minutes for you followed by 6 minutes for judges to ask you questions.

The oral presentation should involve some visual items, however the project board display is not allowed. You may use posters, slides, video, computer slide presentation, or overhead slides. You want to pick the media that you feel comfortable working with. Work with your teacher to pick the appropriate style that fits you. If using PowerPoint presentations there are a few precautions. Be sure to create your slide show on the same computer that you plan to present it on. There is very little set up time for your presentation, so you can not afford computer problems. Be very careful that your disk or storage device is compatible with the presentation computer. From past experience this can be a big problem. Be sure to practice on the computer to be used at presentation to avoid any problems.

Avoid mixing too many media types within your presentation. It is difficult for a judge to shift from overheads to video to posters. Practice with your materials so you are very comfortable with your presentation. The paper presentation should be prepared to use all of the time available, while the project presentation is less prepared as each judge will ask different questions. Both require hard work in preparing for responses to questions that the judges may ask.

When presenting, begin by introducing yourself to the judges. Talk directly to your judges while maintaining good eye contact. Stand to the side of your visual so that you don't block the judges' view. Use a pointer to point out details that you are discussing. Avoid opening your presentation with, "My project is about…". When answering questions, be specific and honest. Don't try to make up an answer; the judge probably knows the correct answer. They are testing you to see how much you know about your topic. Be honest and say you don't know an answer: the judges will appreciate your honesty. Avoid using note cards for your presentation. Practice many times to have your responses to questions well prepared. Avoid a memorized approach, as this can be very robotic. Be flexible. If you have spent 100-200 hours on this project, you will have no problem talking for 12 minutes. Remember that you will be stopped at 12 minutes. PRACTICE, PRACTICE, PRACTICE. Do you get the feeling that there is a key theme to presenting?

Be enthusiastic, friendly, calm and in control. Always thank the audience for their attention and ask if they have any more questions. Remember that practice will be extremely important in how well you do on your oral presentation.

ASSIGNMENT 19

1. Complete an in class mini symposium and practice judging.

ASSIGNMENT 20: SCIENCE FAIR COMPETITIONS

You are now ready for competition. The science fair begins with the local science fair (usually held at the end of January or early in February). This is optional although it is good practice working with judges, especially if this is your first science fair. All projects are able to advance to the regional fair. The placing at local fair is simply a preliminary look at your project.

The second level of competition is the regional science fair. This fair is usually held at the end of February. The regional fair you compete at is determined by the location of your school (including public, private, charter, home school & on-line schools). The Twin Cities includes schools in Ramsey, Hennepin, Washington, & Dakota counties.

This fair is the springboard for all future competitions. You must be selected to advance to a higher level competition. Winners can advance to the State Science and Engineering Fair or the International Science and Engineering Fair. The Minnesota State Fair is a three day event, typically at the end of March or first days of April, often in the Twin Cities. The International Science Fair is held in various cities, usually the second week in May. There are many special awards at all levels of competition.

The paper competition begins at the regional science fair. Top papers advance to the North Central Regional Science and Humanities Symposium. This involves top papers from Minnesota, North Dakota, and South Dakota. This competition is usually the day before the MN State Science and Engineering Fair. The top 5 papers from this competition advance to the National Symposium. This is usually at the end of April and is located in different cities around the US. The top papers from National advance to the European Symposium in London. This is usually held the end of July.

Although winning awards should not be your only motivation, it is a great reward for the hours of hard work that you have put into your project. Most of the travel awards are paid by the regional or state competition. Awards vary at each science fair, but can be a financially fun experience. Scientists enjoy talking to young scientists. Have fun and share what you have discovered.

STEP 5 GRADE CRITERIA

E=Excellent S=Satisfactory N=Needs Work

The following grade rubric will be used to assign points for this task:

_____ Abstract clearly displays key aspects of the project.

_____ Key background information is well-documented throughout paper.

_____ Data collection methods precisely summarized.

_____ Results of statistical analysis are clearly presented.

_____ Graphs and tables clearly presented.

_____ Interpretations and conclusions addressed including problems, related scientific work, and implications for further study.

_____ Board display

_____ Oral Presentation

Format (Grammar, Spelling, Typed, Style) ______

Content (Information, Documented, Reliable, Journal) ______

Creativity/Originality (Ownership of Project, Ingenuity) ______

EXCELLENT WORK: 28 - 30
SATISFACTORY WORK: 24 - 27
NEEDS IMPROVEMENT: 21 - 23

Total Points _____/30 points

Suggestions for Improvement:

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www.sciencenewsforkids.org

http://www.societyforscience.org/index.html

Appendix 1: Sample Abstracts

Abstract Sample #1

TESTING THE EFFECTS OF BLADE TWIST ON A WIND TURBINE GENERATOR

Last Name, First Name
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Winona Senior High School, Winona, MN

The consumption and pollution of fossil fuels and other nonrenewable resources has led to a search for alternative sources of energy. The wind, though intermittent, could be bettered to supply the world with a renewable solution to this crisis. The purpose of this research was to determine whether a twist in the blade shape of a wind turbine would produce greater amounts of wattage compared to a straight bladed turbine. It was hypothesized that the wind turbine with twisted blades would produce greater amounts of wattage compared to a straight bladed turbine. Data was collected by testing both turbines on a generator at all three fan settings. The amount of voltage and amperage produced by the turbines was recorded and multiplied together to discover the wattage outputs of the turbines. Drag and Lift tests were conducted in a wind tunnel to determine the lift to drag ratios of the turbine blades. A relatively high lift to drag ratio is the prime objective in wind turbine design. The lift to drag ratio for the twisted blade (877/283) was higher than that for the straight blade (397/209). The turbine with the twisted blades produced the greatest amount of wattage at all three wind speeds (setting 1: 12.5; setting 2: 67.5; setting 3: 263) compared to the straight bladed turbine (setting 1: 8.01; setting 2: 29.8; setting 3: 78.7) thus supporting the original hypothesis. This was thought to have happened because the angle of attack was less at the tip of the twisted blade than at the base of it which caused the tip to produce less drag as it rotated around the hub of the turbine allowing the turbine to rotate faster, thus producing greater amounts of wattage.

Abstract Sample #2

NITROGEN AND SEDIMENT LOADING TO THE UPPER MISSISSIPPI RIVER: ASSESSMENTS OF 27 WATERSHEDS IN MINNESOTA AND WISCONSIN

Last Name, First Name
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This study was designed to test the hypothesis that Southeastern Minnesota and West Central Wisconsin tributaries are contributing disproportionately more sediments and nutrients to pools 5-8 of the Upper Mississippi River during summer, and that these pools would be retaining sediments and exporting nutrients. Turbidity and nitrates were measured monthly at each of 25 tributaries and Lock and Dams 4-8. Discharges were measured at 21 tributaries, whereas discharges at four tributaries and the Lock and Dams were obtained online. GIS watershed and land use data were used to determine percentage row crops in each watershed, and then compared to sediment and nitrate loads to determine if row crop agriculture increased sediment and nitrate stream loads. Tributary drainages comprised 11.8% of the watershed area upstream of Lock and Dam 8, but contributed 22.1% of sediments and 12.4% of nitrates delivered to Lock and Dam 8. When percentages of row crops per watershed were compared to sediment and nitrate loads, no significant ($P>0.40$) correlations were found either on a monthly or total summer basis. Pools 5-8 were exporting sediments, with output (107 metric kilotons) exceeding inputs (100 metric kilotons). Nitrates also were exported, with outputs (17.9 metric kilotons) equaling inputs (17.9 metric kilotons). Disproportionate contributions of sediments and nitrates from the Southeastern Minnesota and West Central Wisconsin tributaries to pools 5-8 of the Mississippi River are degrading the river environment by increasing sediment load and contributing additional nutrients to the Gulf of Mexico Dead Zone.

Abstract Sample #3

THE IMPACT OF GRASS HEIGHT AND DENSITY ON DUCK NESTING SUCCESS

Last Name, First Name
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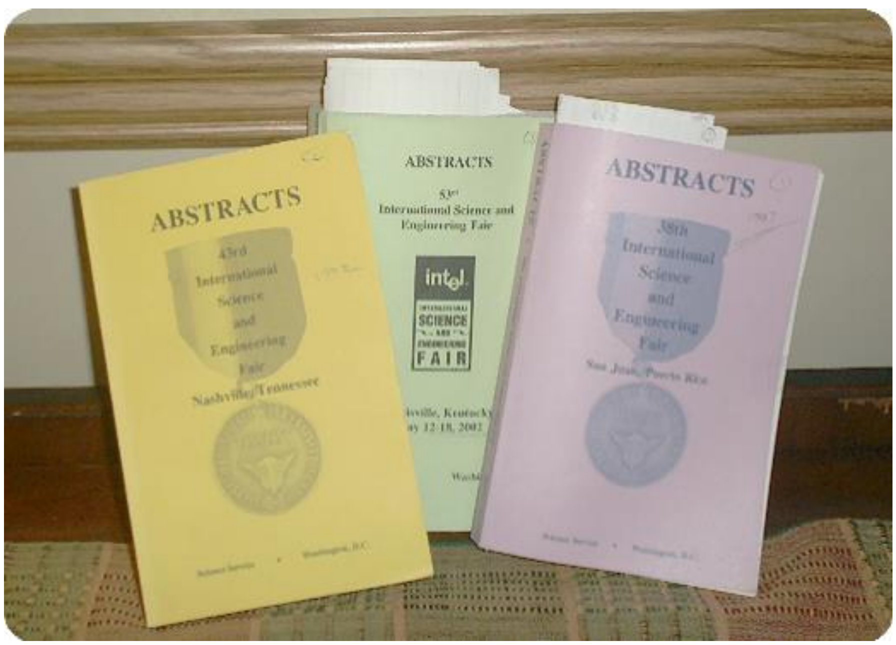
The Prairie Pothole Region of the United States and Canada is North America's single most important waterfowl breeding area. Dotted with millions of shallow wetlands formed by glaciers 10,000 years ago, the Prairie Pothole Region encompasses over 250,000 square miles and supports more than 50% of the continent's ducks. In some portions of the region, potholes and their associated prairie uplands support over 100 breeding pairs of ducks per square mile. The purpose of this study was to determine the impact of grass height and density on duck nesting success. Duck nests are greatly affected by predation. Mammalian and avian predators are destroying thousands of duck eggs each year (Ducks Unlimited). It was hypothesized that duck nests in denser and taller habitat will be more effective. It is believed to be so because in a denser habitat, the hen can hide in the grass and predators will be less likely to find her and her eggs. All data was collected between June 9, 2003 and June 30, 2003. The Long Lake and Beck Game Production areas, consisting of 3,160 acres were located in the counties of Codington and Brookings, South Dakota. Thirty-five nests were located on the Game Production Areas by either using a 6-foot willow switch or a 25-foot chain (Vaa, 2003). Grass height (cm) and density (stalks per $10cm^2$) were measured. A comparison was made, examining the success of nests in different grass heights, and the nest distance to water. The odds of a nest being successful in high grass height (above 60 cm) were eight times more likely than in low grass. This was statistically significant at .03, using a logistics regression test. The standard p value (.05) was used in this study. Duck nests in high grass height were more successful than nests in low grass height. This is probably due to the fact that visibility is restricted in high grass height. In a high-density situation, nests were more likely to be depredated, than in a low density. The majority of the data collected did support the original hypothesis.

Appendix 2: Sample Research Paper

Analysis Of Statistical Methods Documented In ISEF Project Abstracts



Name
Grade: 9
Category: Behavioral / Social Science
Winona Senior High School

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ANALYSIS OF STATISTICAL METHODS DOCUMENTED IN ISEF PROJECT ABSTRACTS

Last Name, First Name
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Generally speaking there are three classes of statistics. The first class is descriptive followed by the second class, correlation, and class three, inferential statistics. The purpose of this study was to determine which types of statistical testing were used in International Science and Engineering Fair (ISEF) project abstracts. This study also looked at what variables may make an award-winning project. It was hypothesized that the students who ran the highest class of statistics and most complex project would receive the highest awards. 140 abstracts were analyzed from the year 2002. Starting with each category, ten abstracts were analyzed and recorded, five abstracts that won awards, and five that did not. Once the testing began it became apparent that determining the type of statistical testing would not be possible because the projects did not list what type used. However, some of the projects mentioned the use of statistical analysis in their abstract. The variables were project category, whether or not statistics were mentioned, number of factors, number of variables, number of groups, and number of observations. Number of variables was found to be the most interesting results. The more variables in the project, the complexity and level of the award (if any) increased. The overall results slightly supported the hypothesis. Because the type of statistical analysis could not be found, part of the hypothesis could not be answered. However, it was found that the higher the variables and complexity of the project, the higher the award was, supporting the original hypothesis.

INTRODUCTION

For students today, statistics is not even a question; in fact it, does not even exist. Many students do not understand the basic rules of statistics, along with many teachers. In today's world, statistics is a very broad and confusing branch of mathematics to learn. For statistical conclusions to be valid the appropriate statistical methods must be used for the situation. For this reason, it is critical that the students not only be taught the statistics, but also the specific conditions under which each method should be applied.

Generally speaking there are three classes of statistics. With each class, the statistics used become more advanced. The first class describes the results in a process called descriptive statistics. The next class, correlation, compares and looks at different patterns. The final class is inferential statistics or statistical analysis.

Descriptive statistics is the process of collecting data, summarizing it, and then describing its characteristics (Anagnoson, 1996). Students have often used descriptive statistics without even knowing it. Some examples include being a scorekeeper for sports teams, keeping accounts on favorite players, keeping track of boy/girl scout sale records, and finding average grades in school. Usually in this level of statistics, the mean, median, mode, and variance are determined and analyzed.

Central tendency is the measures of the center of a given data set. The mean is the most commonly used measure of central tendency (Journot, 2001). Another measurement of central tendency is the median. The median is often referred to as the middle number and is usually used when the measurements contain an outlier. The mode is a third measure of central tendency and sometimes does not exist in a set of data. The mode is a certain value that occurs more often than any of the other values in a set of data. However, if two values occur the same amount of times in a set of data, the data is is bimodal. It is called multimodal if there are more than two values that occur the same amount of times. The measurement of how a set fluctuates relative to their mean is the variance (Blaisdell, 1993).

The second class of statistics is focused on finding a pattern. First, a guess is made on what pattern exists. Some examples are a line, an exponent, a curve, etc. The correlation is then found, where the data is analyzed to see how close it fits to a pattern. One of the most common ways to see how close the data fits a line is the Pearson's sample product-moment (Quarterman, 2003). This model looks at how close data points can come to a straight line. According to Blaisdell, there are seven properties of Pearson's test that the data must follow in order to determine the pattern of the data.

1. The value of r is always between –1 and 1.
2. r has the same sign as b_1, the slope of the least squares line.
3. r is near +1 when the data points fall close to a straight line that is rising, this is, when y tends to increase as x increases.
4. r is near –1 when the data points fall close to a straight line that is falling, that is, when y tends to decrease and x increases.
5. If all the data points fall exactly on a straight line with positive slops, then r= + 1.
6. If all the data points fall exactly on a straight line with the negative slope, then r = -1.
7. A value of r near 0 indicates little or no linear relationship between y and x.

(Blaisdell, 1993, pg. 121)

The most complex class of statistics is statistical significance or analysis of variance. There are four steps that are identified and used with statistical significance testing. The first step is the null hypothesis, which is a hypothesis about a population parameter (Ott, 1990). The null hypothesis is a prediction that there is no difference between any sets of data. The null hypothesis sometimes is designated by the symbol H_0. A parameter is a numerical characteristic of the population, and the population is the entire collection of elements of interest in a study (Smith, 1997). The second step is the alternative hypothesis, which is a hypothesis that is accepted if the null hypothesis is rejected (Ott, 1990). The alternative hypothesis uses the symbol H_a. The statistical testing is step three, which is a quantity computed from the sample data. The final step is rejection region, which is a set of values for the test statistic that are contradictory to the null hypothesis and imply its rejection (Ott, 1990).

The purpose of this study was to determine which types of statistical testing were used in International Science and Engineering Fair (ISEF) project abstracts. The study looked at age and grade of the students, and what awards the students had won. As a very active math and science student, statistics are often mentioned. However, determining which type of statistics to use has always posed a large problem. This study will answer many of the questions that are frequently asked by both students and teachers. Not only will the study determine what type of statistics to use but it will also give the teachers a better understanding of what to teach their students and at what age level to do so. Another variable that was examined was determining if a correlation exists between statistical content and project success (ISEF grand awards).

It was hypothesized that out of all the ISEF categories that the Mathematics category would conduct the most statistical testing. The older students were hypothesized to have used a higher class of statistics because they are thought to have a better understanding of them. It was further hypothesized that out of the categories that were studied; behavioral/social would have the most variety for the type and class of statistics used. It is also hypothesized that the t-test will be the most common type of statistical testing used. The t-test is a common analysis technique that many teachers show their students. Because the t-test is a very common statistical analysis, there is a lot of information for running the test which is easily accessible. The final hypothesis was that the students who won awards would run a higher level of statistics along with having more variables, factors, groups, and observations (For definitions see Appendix A under key definitions).

MATERIALS AND METHODS

A copy of the International Science and Engineering Fair (ISEF) project abstract books for the year 2002 was obtained. A data collection sheet was constructed that recorded specific variables collected in the project (See Appendix A). There were fourteen categories that were analyzed, which resulted in one hundred and forty copies of the data collection sheet for each year analyzed. The abstracts were placed randomly into the abstract books by category before publication, creating no particular order. Starting with each category, ten abstracts were analyzed and recorded, each on a separate data collection sheet. Five of the abstracts from the category were projects that had won grand awards, five did not. The grand awards included any of the first prize through fourth prize awards, which were presented by Intel. All categories were then analyzed and recorded. Through the comments section on the data collection sheet, the awards that the students won were recorded along with the appropriate class of statistics identified. This was then used in the data analysis.

In all, the following data was collected for each subject, project category, type of statistical testing, age of student (for year 2002), number of factors, number of variables, number of observations, number of groups, and awards won. After one year was completed, the remaining two years were then recorded, analyzed, and then combined into an overall group. Once the data was collected, it was analyzed to determine if a relationship existed between winning an award and one or more of the data items collected. The data was analyzed by graphing results, determining percent differences, and a standard Analysis of Variance (ANOVA) test using an acceptance level of 0.05. The category, year, number of factors, observations, variables, groups, and awards won were compared to the type of statistical testing used in the project.

RESULTS

When collecting the data, it quickly became apparent that the abstracts did not clearly define which types of statistics were used. Fortunately it was discovered that the design of the experiment could be analyzed by researching the abstracts.

From that point forward, the project concentrated on researching the abstracts to identify the number of factors, groups, variables and observations that were used in each of the projects. It is this data that was analyzed to determine any relation to the success of the project.

All graphs can be found in the back of the paper in Appendix B. A table of the raw data can be found in Appendix C.

Graph 1 shows the effect of the amount of factors by categories (14) for grand award winning projects (70 projects) vs. non-winning projects (70 projects). The largest noticeable difference was for the categories of computer science and mathematics. In computer science, the projects that won awards (5 projects for each category) had on average 1.4 more factors then the projects that didn't win awards (5 projects for each category). It was the opposite results in mathematics, the projects that won awards had on average 1.2 less factors than the non-award winners. Results continued to vary depending on the project category.

Graph 2 shows the effect of the amount of groups by categories for grand award winning project vs. non-winning projects. One of the largest differences was in the categories of botany and gerontology. In gerontology the students who won awards had an average amount of 11.20 less groups then the non-winners. The botany students who won awards had an average amount of 7.40 more groups than the non-winners. The amount of groups varied more than the amount of factors for each category. On average, the projects that had fewer groups received awards.

Graph 3 shows the effects of the amount of variables by categories for award winning projects vs. non-award winning projects. In thirteen out of the fourteen categories, the projects that have more variables received awards. The highest amount of variables was in microbiology with 8 variables. The only category where having more variables didn't matter for the awards, was in behavioral science; the projects that had a lower number of variables (2.5 on average) received awards.

Graph 4 shows the effects of the amount of observations by category for award winning projects vs. non-award winning projects. The observations were difficult to graph because some of the abstracts did not mention the amount of observations. The largest noticeable differences were for the behavioral and earth and space science categories. For behavioral, the more observations found (399 on average) the higher the chance for winning an award, whereas for earth and space the smaller amount of observations (91 on average), the higher the chances for winning an award.

Graph 5 shows the effects of statistical analysis being mentioned by category for award winning projects. This graph shows only award winning abstracts. It was found that in behavioral and social, earth and space, engineering, environmental, and mathematics, 80% of the winning projects mentioned the use of statistical analysis (5 projects were analyzed from each category for this graph). For chemistry and medicine and health only 20% mentioned statistical analysis.

Graph 6 shows the effect of statistical analysis being mentioned by category for non-award winning projects. In biochemistry and mathematics none of the projects analyzed (5 abstracts) mentioned statistical analysis. The highest percent of statistical analysis being mentioned was in botany with 60% (3 out of 5).

Because the abstracts did not mention which type of statistical analysis was used, sections of the original hypothesis were not explored. However, the section of the original hypothesis that stated that the students who won awards would have a higher level of statistics along with factors, variables, observations, and groups was partly supported. It was found that the variables had a major impact on the projects success. When looking at the factors, observations, and groups the impact they had could be determined within the categories. It was also found that running statistical analysis might have a positive impact on the project success, depending on the category.

CONCLUSIONS

The purpose of this research was to determine if a correlation exists between the statistical content, project parameters and project success. The original hypothesis was that the higher level of statistics used along with the a type of statistics may increase the likelihood of winning an award. However, research showed that the type of statistical testing was not always listed, but the parameters of the experiment was, along with whether or not statistical analysis was used. Another hypothesis stated that the more factors, groups, observations, and variables in a project, the more likely the project was to win an award.

While looking at the comparison between the categories and amount of awards, the number of variables appeared to have a positive effect. This may be due to the fact that the more items measured, the more advanced the project becomes. With each new variable, the project explores more open options and is able to narrow down the possibilities of further questions. Along with adding more variables, the project may also become more complex, which is what the judges may look for. It is reasonable to assume that the more complex the project, the more time and energy the students put into the project.

Another comparison found between the amount of awards and variables was in the behavioral and social science category. It was found that the smaller amount of variables, the greater the likelihood of winning an award increases. This could be due to the fact that with behavioral studies there are so many variables to look at, and sometimes describing them all can become confusing. With only focusing on two or three variables, the point may be a lot easier to get across.

The original hypothesis stated that the higher the level of statistics run would increase the likelihood of winning awards. Although the type of statistic was unable to be determined, the fact that statistical analysis was run was still evident. With recording that statistical analysis was run, the difference between running statistics and not running them became noticeable. It was found that in a whole running statistics might have a positive impact on project success. I could be thought that with running statistical analysis it is just another way of advancing your project and eliminating many of the confusing or unclear parts in the research.

Another variable that was found while measuring the variables was that certain categories on average had a higher number of no only variables but also observations, factors, and groups. This might be due to the fact that with certain projects it is easier to collect a lot of data and analyze it while for others it is better to collect only a small amount. Every category and project is different and is going to be looking at different things to analyze making a lot of variation.

For future studies it would be nice to take this study to the International Science and Engineering Fair (ISEF) committee and ask to make a standard format for the abstracts. With making a format for the abstracts, it would be easy to learn about the project without having to take a long time to analyze it. It would also make the projects easier to compare to one another and see the differences and similarities. It would also be nice to analyze other years from five, ten or fifteen years back to see if the same trends still existed or of there was a different variables that may have increased project success.

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Dr. Blumberg was another help to my project. She helped me with some of the designing of my project, by helping me lay it all out in front of me and stay organized. She also helped me with data analysis by teaching me how to run the analysis of variance (ANOVA) test.

Mr. Mann has been one of the biggest guides in my projects. He is constantly creating new methods to try to help everybody with their projects. Along with Mr. Mann my classmates and friends have been very supportive with everything and very helpful when I needed them the most.

1.

2.

3. Appendix A

Name Subject Number
9th Grade Date
4. Awards Won:

5. Abstract Information

Procedure: Fill in date (subject numbers have already been randomly assigned). Read through students abstracts. Fill in the correct information below by using the information given in the abstract. If any problems arise write down in the comments section. (bottom)

Category of Project (Circle One)

Behavioral and Social Sciences	Biochemistry
Botany	Chemistry
Computer Science	Earth and Space Sciences
Engineering	Environmental Science
Gerontology	Mathematics
Medicine and Health	Microbiology
Physics	Zoology

Type of Statistical Testing (Circle One)

t test for independent samples	*t* test for dependent samples		analysis of variance
Pearson product correlation	chi square test	median test	Mann-Whitney *U* test
Wilcoxon signed rank test	Kruskal-Wallis test	Friedman test	Spearman's rho

Other: ______________________________

Year of Project (Circle One)

1987
1992
1997
2002

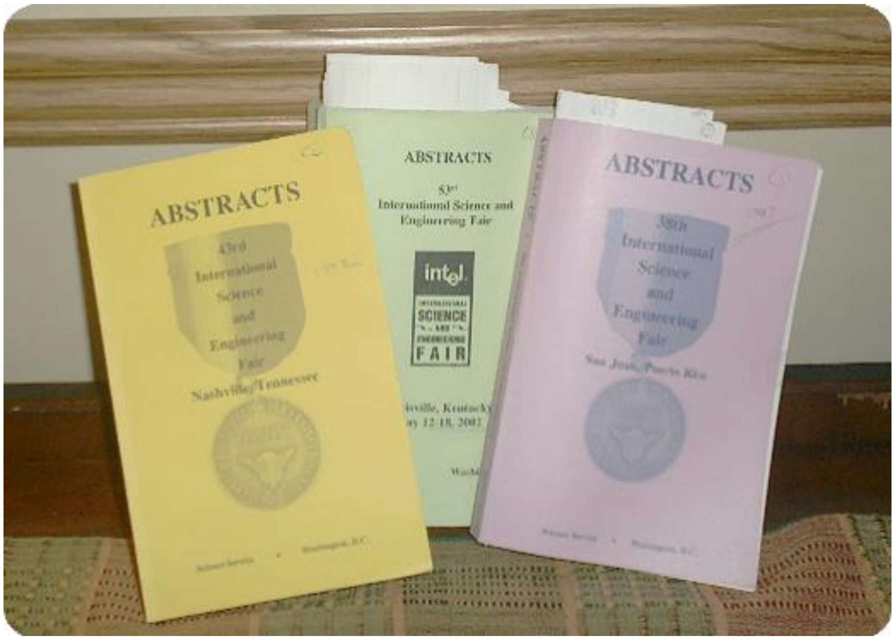
Factors: ___________ Observations: ___________

Groups: ___________ Variables: ______________

Comments:

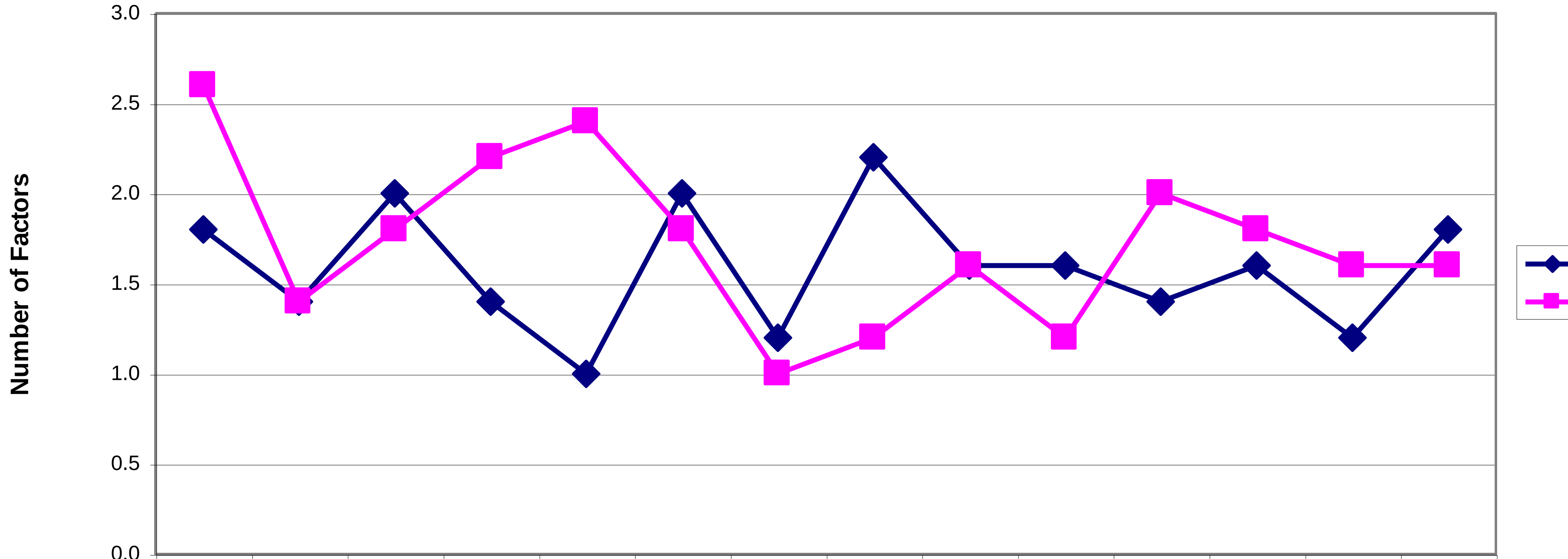
KEY DEFINITIONS

6. Winner/Non Winner
7. Page
8. Subject No
9. Date
10. Category = Subject that the project relates to. (14 categories) determined by ISEF Abstract Book.
11. Statistics Type = See data collection sheet.
12. SAM = Statistical Analysis Mentioned (answered in yes or no)
13. Year
14. Factor = What is Manipulated (e.g. Gender, Grade)
    a. To be Factors in the same experiment, the factors MUST BE MUTUALLY INCLUSIVE
    b. In the Gender and Grade example every 10'th, 11'th and 12'th grader is also a male or female
    c. In Subject 21, pp54 1987 there were 3 levels of additive in two salt solutions and a separate experiment with 5 levels of additive to two levels of a salt/sugar solution. You could not have said there was 3 factors (salt, sugar, additive) because they did not all describe the same data.
15. Levels = Number of distinct Categories for the Factor (e.g. male/female – 9'th, 10'th, 11'th)
16. Groups = SumΣ_1^n Levels in Factor 1 x Levels in Factor 2 x Levels in Factor n (e.g. 2 x 3 = 6)
17. Variable = What is measured (e.g. number of pictures recalled)
18. No of Observations
19. Award


ABSTRACTS
43rd
International
Science
and
Engineering
Fair
Nashville, Tennessee
ABSTRACTS
53rd
International Science and
Engineering Fair
intel
SCIENCE
FAIR
ABSTRACTS
38th
International
Science
and
Engineering
Fair
San Juan, Puerto Rico

Appendix B

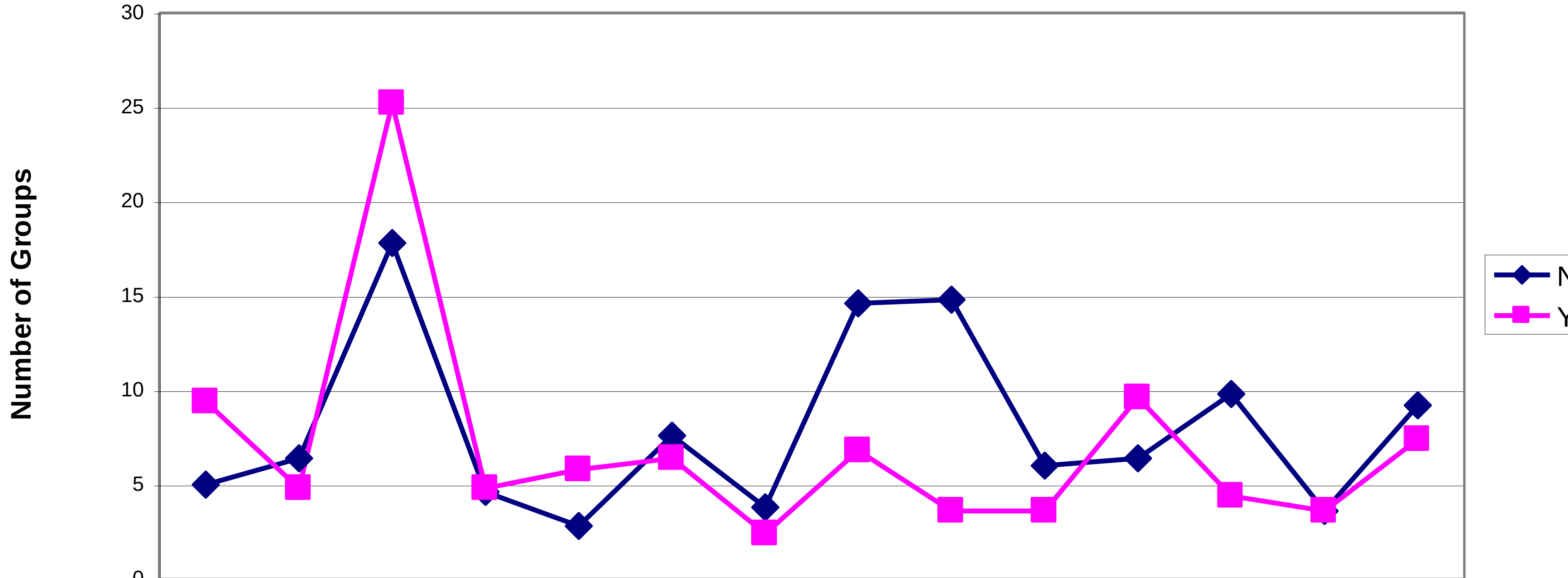
Award vs. No of Factors by Category
(n = 10 for all)



	Behav	Bio Chem	Botany	Chem	Comp Sci	Earth Sci	Engrg	Env Sci	Gerent	Math	Med	Micro Bio	Phys	Zoo
No	1.8	1.4	2.0	1.4	1.0	2.0	1.2	2.2	1.6	1.6	1.4	1.6	1.2	1.8
Yes	2.6	1.4	1.8	2.2	2.4	1.8	1.0	1.2	1.6	1.2	2.0	1.8	1.6	1.6

Category

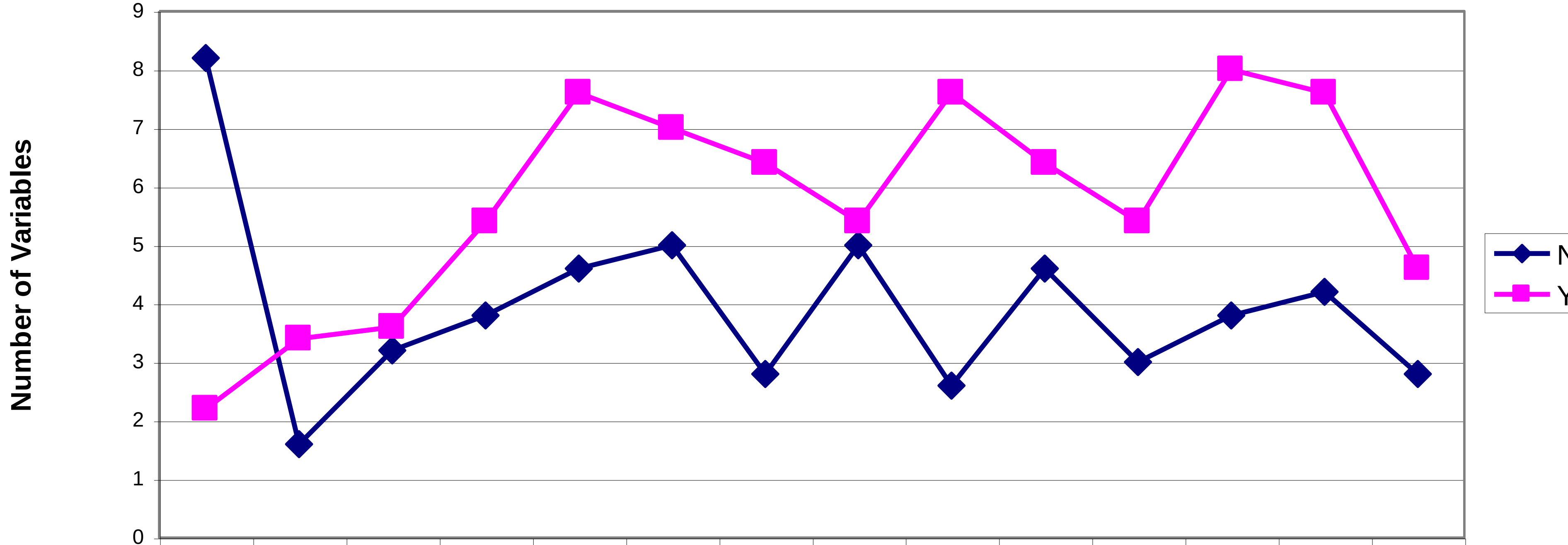
Award vs No of Groups by Category



	Behav	Bio Chem	Botany	Chem	Comp Sci	Earth Sci	Engrg	Env Sci	Gerent	Math	Med	Micro Bio	Phys	Zoo
No	5	6.4	17.8	4.6	2.8	7.6	3.8	14.6	14.8	6	6.4	9.8	3.6	9.2
Yes	9.4	4.8	25.2	4.8	5.8	6.4	2.4	6.8	3.6	3.6	9.6	4.4	3.6	7.4

Category

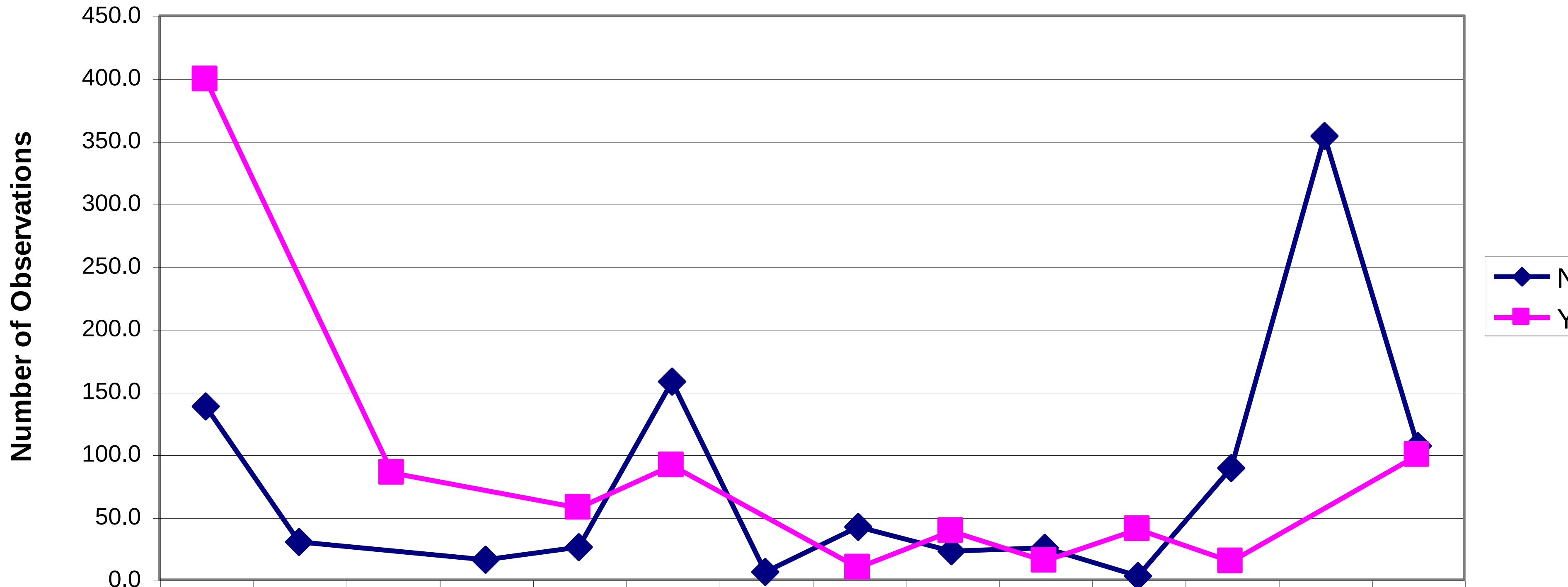
Award vs No of Variables by Category
(n = 10 for all)



	Behav	Bio Chem	Botany	Chem	Comp Sci	Earth Sci	Engrg	Env Sci	Gerent	Math	Med	Micro Bio	Phys	Zoo
No	8.2	1.6	3.2	3.8	4.6	5	2.8	5	2.6	4.6	3	3.8	4.2	2.8
Yes	2.2	3.4	3.6	5.4	7.6	7	6.4	5.4	7.6	6.4	5.4	8	7.6	4.6

Category

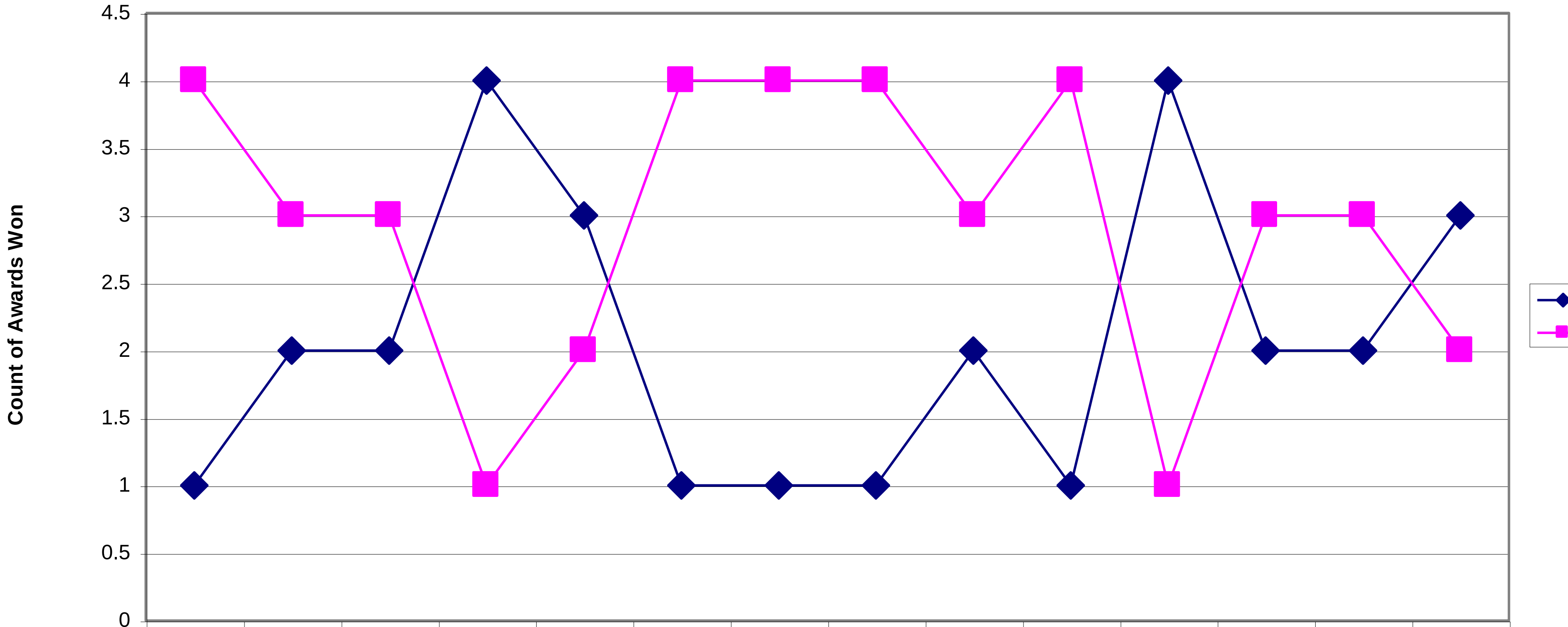
Award vs No of Observations by Category



	Behav	Bio Chem	Botany	CHem	Comp Sci	Earth Sci	Engrg	Env Sci	Gerent	Math	Med	Micro Bio	Phys	Zoo
No	138.3	30.0		16.0	26.0	158.0	6.0	42.0	22.7	25.5	3.0	89.0	354.0	106.7
Yes	399.0		85.0		57.3	91.0		9.5	38.7	15.0	40.0	14.3		99.3

Category

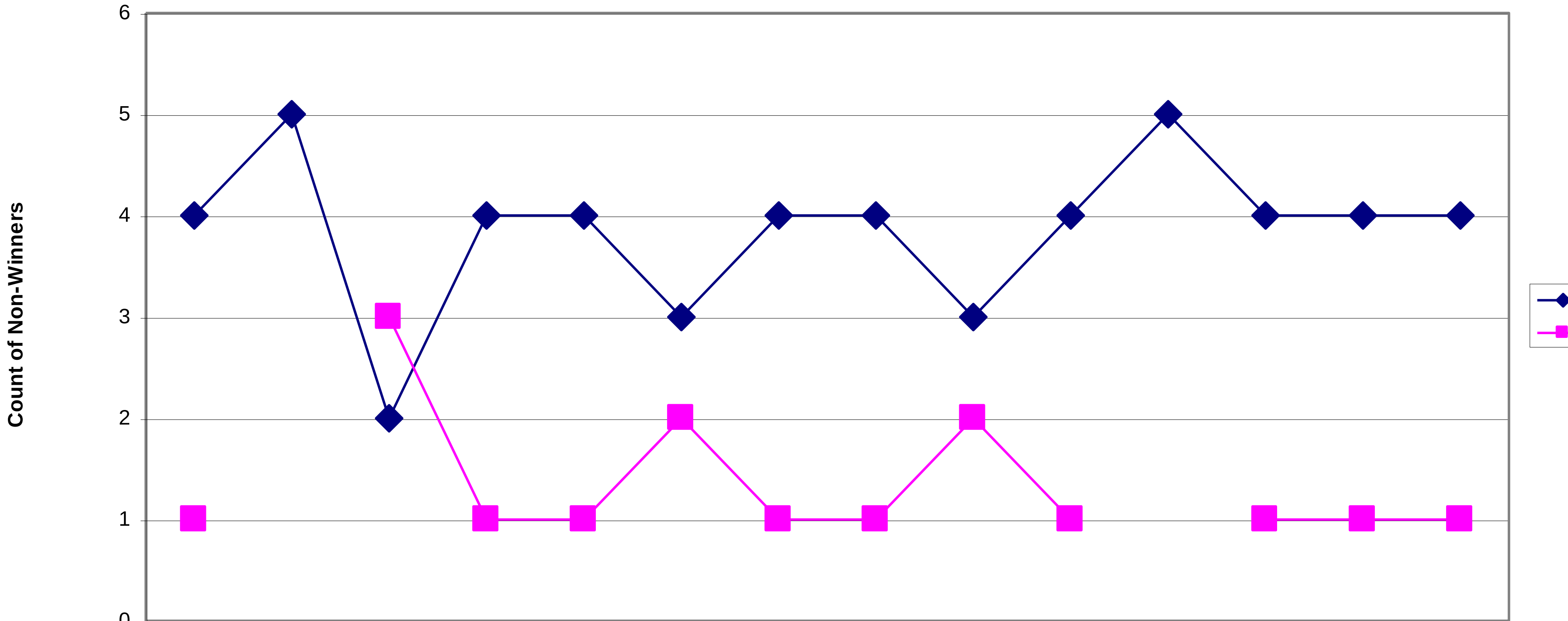
Award Vs Stastistical Analysis Mentioned by Category



	Behav	Bio Chem	Botany	Chem	Comp Sci	Earth Sci	Engrg	Env Sci	Gerent	Math	Med	Mirco Bio	Physics	Zoo
No	1	2	2	4	3	1	1	1	2	1	4	2	2	3
Yes	4	3	3	1	2	4	4	4	3	4	1	3	3	2

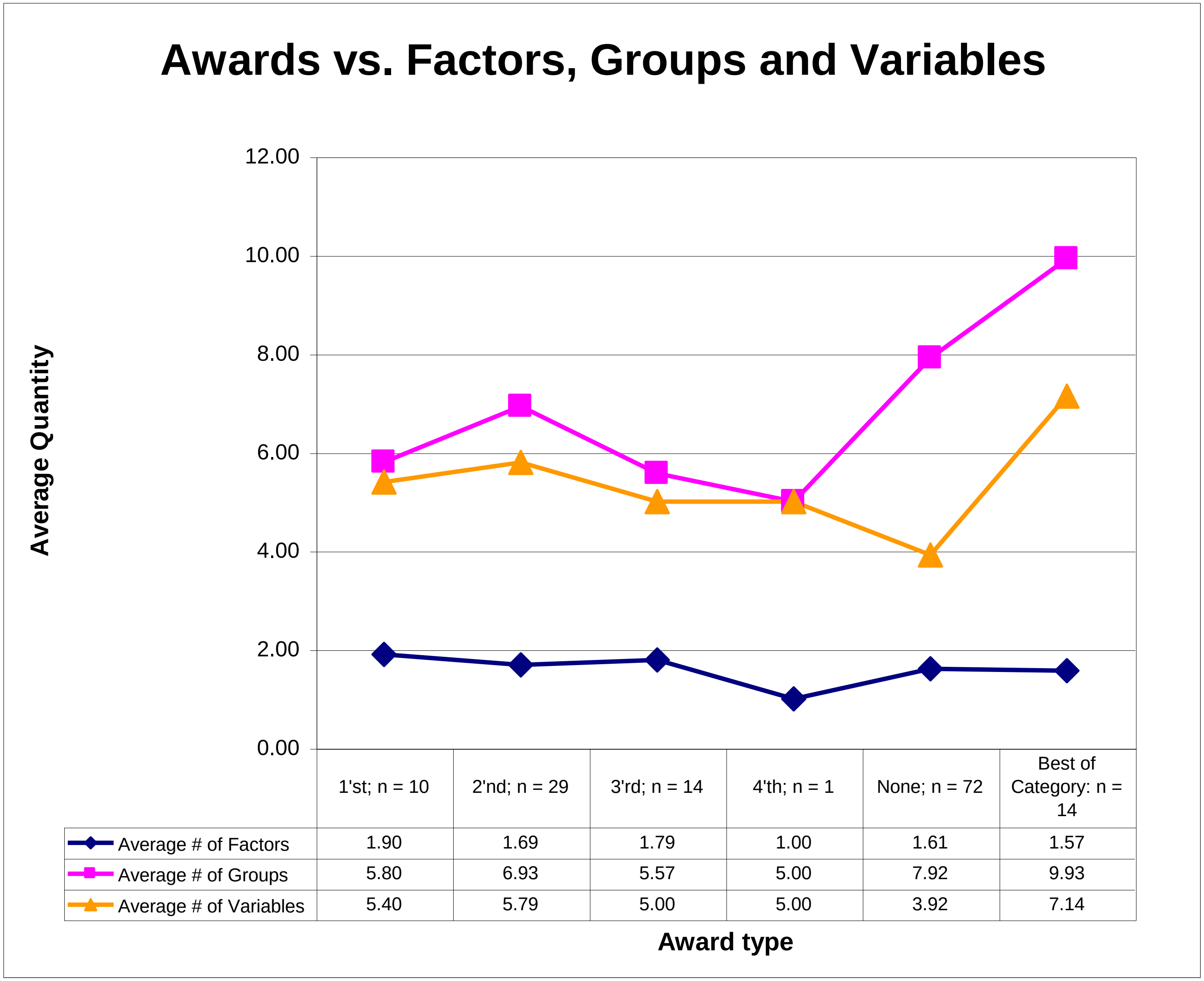
Category

Non Award Vs Statistical Analysis Mentioned by Category



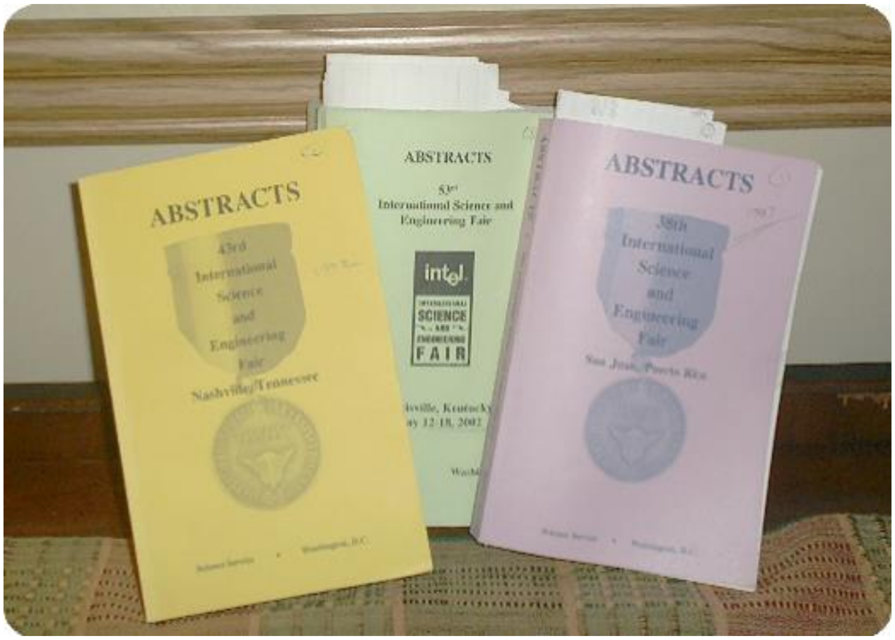
	Behav	Bio Chem	Botany	Chem	Comp Sci	Earth Sci	Engrg	Env Sci	Gerent	Math	Med	Micro Bio	Physics	Zoo
No	4	5	2	4	4	3	4	4	3	4	5	4	4	4
Yes	1		3	1	1	2	1	1	2	1		1	1	1

Category



	1'st; n = 10	2'nd; n = 29	3'rd; n = 14	4'th; n = 1	None; n = 72	Best of Category: n = 14
Average # of Factors	1.90	1.69	1.79	1.00	1.61	1.57
Average # of Groups	5.80	6.93	5.57	5.00	7.92	9.93
Average # of Variables	5.40	5.79	5.00	5.00	3.92	7.14

74


ABSTRACTS
43rd
International
Science
and
Engineering
Fair
Nashville, Tennessee
ABSTRACTS
International Science and
Engineering Fair
intel
INTERNATIONAL
SCIENCE
AND
ENGINEERING
FAIR
ABSTRACTS
38th
International
Science
and
Engineering
Fair
San Juan, Puerto Rico

Appendix C

Subject Number	Page	Yes	Date Collected	Category	Statistics Type	SAM - Yes or No	SAM type	Year	Factors	Groups	Variables	C
1	1	No	11/10/03	Behavioral Science	Unknown	No		2002	2	6	30	
2	1	Yes	11/10/03	Behavioral Science	Unknown	Yes		2002	3	5	4	U
3	2	No	11/10/03	Behavioral Science	Unknown	No		2002	1	2	3	
4	3	Yes	11/14/03	Behavioral Science	Unknown	No		2002	3	28	1	
5	5	No	11/14/03	Behavioral Science	Unknown	No		2002	2	4	3	
6	5	No	11/15/03/	Behavioral Science	Unknown	No		2002	2	9	2	
7	11	Yes	11/15/04	Behavioral Science	Unknown	Yes		2002	5	10	1	U
8	17	No	11/15/03	Behavioral Science	Unknown	Yes		2002	2	4	3	U
9	21	Yes	11/16/03	Behavioral Science	Unknown	Yes		2002	1	2	4	U
10	23	Yes	11/16/03	Behavioral Science	Unknown	Yes		2002	1	2	1	U
11	33	No	11/19/03	Biochemistry	Unknown	No		2002	2	4	1	
12	40	Yes	11/19/03	Biochemistry	Unknown	No		2002	2	4	1	U
13	41	No	11/19/03	Biochemistry	Unknown	No		2002	1	4	1	U
14	45	Yes	11/19/03	Biochemistry	Unknown	Yes		2002	2	9	1	U
15	43	No	11/20/03	Biochemistry	Unknown	No		2002	2	16	1	U
16	44	No	11/22/03	Biochemistry	Unknown	No		2002	1	6	1	
17	49	Yes	11/22/03	Biochemistry	Unknown	Yes		2002	1	5	4	U
18	46	No	11/23/03	Biochemistry	Unknown	No		2002	1	2	4	U
19	47	Yes	11/23/03	Biochemistry	Unknown	No		2002	1	3	6	U
20	62	Yes	11/23/03	Biochemistry	Unknown	Yes		2002	1	3	5	U
21	68	No	11/24/03	Botany	Unknown	Yes		2002	3	3	5	U
22	68	Yes	01/24/04	Botany	Unknown	Yes		2002	2	10	3	
23	69	No	11/28/03	Botany	ANOVA	Yes		2002	2	9	5	U
24	69	Yes	11/28/03	Botany	Unknown	No		2002	1	1	4	U
25	871	Yes	11/29/03	Botany	Unknown	No		2002	2	2	3	
26	81	No	11/29/03	Botany	Unknown	No		2002	1	11	2	U
27	85	Yes	11/29/03	Botany	T for Indep	Yes		2002	2	64	5	
28	85	No	12/04/03	Botany	Unknown	No		2002	3	64	1	U
29	97	Yes	12/04/03	Botany	Unknown	Yes		2002	2	49	3	
30	96	No	12/04/03	Botany	Unknown	Yes		2002	1	2	3	U
31	111	No	12/04/03	Chemistry	Unknown	Yes		2002	3	3	4	U
32	111	Yes	12/09/03	Chemistry	Unknown	No		2002	4	4	4	U
33	116	Yes	12/09/03	Chemistry	Unknown	Yes		2002	1	3	8	U
34	116	No	12/09/03	Chemistry	Unknown	No		2002	1	4	2	
35	118	Yes	12/10/03	Chemistry	Unknown	No		2002	2	9	3	U
36	118	No	12/10/03	Chemistry	Unknown	No		2002	1	12	2	

37	124	Yes	12/10/03	Chemistry	Unknown	No		2002	2	4	5	U
38	125	No	12/10/03	Chemistry	Unknown	No		2002	1	2	2	U
39	130	Yes	12/11/03	Chemistry	Unknown	No		2002	2	4	7	U
40	130	No	12/11/03	Chemistry	Unknown	No		2002	1	2	9	U
41	140	Yes	12/11/03	Computer Science	Unknown	Yes		2002	1	3	5	U
42	141	No	12/12/03	Computer Science	Unknown	No		2002	1	3	2	U
43	142	No	12/12/03	Computer Science	Unknown	Yes		2002	1	2	4	
44	143	Yes	12/12/03	Computer Science	Unknown	No		2002	3	8	9	
45	151	Yes	12/20/03	Computer Science	Unknown	Yes		2002	3	12	6	U
46	151	No	12/20/03	Computer Science	Unknown	No		2002	1	2	4	U
47	154	No	12/20/03	Computer Science	Unknown	No		2002	1	5	8	U
48	155	Yes	12/20/03	Computer Science	Unknown	No		2002	4	4	8	
49	162	No	12/21/03	Computer Science	Unknown	No		2002	1	2	5	U
50	162	Yes	12/21/03	Computer Science	Unknown	No		2002	1	2	10	
51	170	No	12/21/03	E & S Science	Unknown	Yes		2002	2	21	7	
52	171	Yes	12/21/03	E & S Science	Unknown	No		2002	1	4	6	U
53	72	Yes	12/26/03	E & S Science	Unknown	Yes		2002	1	6	6	
54	172	No	12/26/03	E & S Science	Unknown	No		2002	3	6	6	U
55	178	Yes	12/26/03	E & S Science	Unknown	Yes		2002	2	6	9	U
56	178	No	12/26/03	E & S Science	Unknown	No		2002	1	1	4	
57	186	Yes	12/27/03	E & S Science	Unknown	Yes		2002	2	8	6	U
58	186	No	12/27/03	E & S Science	Unknown	Yes		2002	2	6	3	
59	190	No	12/27/03	E & S Science	Unknown	No		2002	2	4	5	U
60	191	Yes	12/28/03	E & S Science	Std Deviation	Yes		2002	3	8	8	
61	206	Yes	12/28/03	Engineering	Unknown	No		2002	1	2	4	U
62	207	No	01/01/04	Engineering	Unknown	No		2002	1	2	2	U
63	210	No	01/01/04	Engineering	Unknown	No		2002	1	3	3	U
64	210	Yes	01/02/04	Engineering	Unknown	Yes		2002	1	3	7	U
65	216	No	01/02/04	Engineering	Unknown	No		2002	1	5	2	
66	217	Yes	01/02/04	Engineering	Unknown	Yes		2002	1	2	5	U
67	223	Yes	01/02/04	Engineering	Chi Square	Yes		2002	1	3	8	U
68	224	Yes	01/02.04	Engineering	Unknown	Yes		2002	1	2	8	U
69	225	No	01/02/04	Engineering	Unknown	Yes		2002	1	4	2	U
70	226	No	01/02/04	Engineering	Unknown	No		2002	2	5	5	U
71	252	No	01/02/04	Environmental Science	Unknown	No		2002	2	16	4	U
72	255	Yes	01/02/04	Environmental Science	Unknown	Yes		2002	1	3	6	
73	258	No	01/02/04	Environmental Science	Unknown	No		2002	4	40	5	U
74	259	No	01/05/04	Environmental Science	Unknown	No		2002	2	6	7	U
75	274	Yes	01/05/04	Environmental Science	Unknown	Yes		2002	2	12	9	U
76	274	No	01/05/04	Environmental Science	Unknown	No		2002	1	2	7	
77	280	Yes	01/05/04	Environmental Science	Unknown	Yes		2002	1	3	5	U

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82	317	Yes	01/11/04	Gerontology		No		2002	1	1	6	U
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85	321	No	01/11/04	Gerontology		Yes		2002	1	2	1	U
86	322	Yes	01/11/04	Gerontology		Yes		2002	2	6	5	U
87	323	No	01/11/04	Gerontology		Yes	ANOVA	2002	2	6	5	
88	324	Yes	01/11/04	Gerontology		Yes		2002	1	1	11	
89	324	No	01/11/04	Gerontology		No		2002	2	4	2	
90		No	01/11/04	Gerontology		No		2002	2	60	1	U
91		No	01/11/04	Mathematics		Yes	Mann-Wh	2002	1	1	4	
92		Yes	01/11/04	Mathematics		Yes		2002	1	2	6	U
93	334	Yes	01/11/04	Mathematics		No		2002	1	4	6	U
94	335	No	01/13/04	Mathematics		No		2002	3	18	5	U
95	336	Yes	01/13/04	Mathematics		Yes		2002	2	6	7	U
96	337	No	01/13/04	Mathematics		No		2002	2	6	4	
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98	339	No	01/13/04	Mathematics		No		2002	1	3	6	U
99	346	Yes	01/13/04	Mathematics		Yes		2002	1	2	7	
100	347	No	01/13/04	Mathematics		No		2002	1	2	4	U
101	358	Yes	01/13/04	Medicine and Health	ANOVA	Yes		2002	1	6	5	U
102	359	No	01/13/04	Medicine and Health		No		2002	2	8	3	U
103	360	Yes	01/16/04	Medicine and Health		No		2002	1	2	5	
104	361	No	01/16/04	Medicine and Health		No		2002	1	6	3	U
105	366	No	01/16/04	Medicine and Health		No		2002	2	12	4	U
106	367	Yes	01/16/04	Medicine and Health		No		2002	1	2	7	U
107	372	Yes	01/16/04	Medicine and Health		No		2002	4	20	6	U
108	372	No	01/16/04	Medicine and Health		No		2002	1	4	2	
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111	408	No	01/17/04	Microbiology		No		2002	1	2	5	
112	408	Yes	01/17/04	Microbiology		No		2002	2	4	8	
113	410	No	01/17/04	Microbiology		Yes		2002	1	3	4	
114	410	Yes	01/18/04	Microbiology		Yes	Correlation	2002	2	4	7	
115	414	No	01/18/04	Microbiology		No		2002	2	24	2	
116	415	Yes	01/18/04	Microbiology		No		2002	2	6	10	
117	420	No	01/20/04	Microbiology		No		2002	2	16	3	U
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119	435	Yes	01/20/04	Microbiology		Yes		2002	1	2	8	U
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123	452	Yes	01/23/04	Physics		Yes		2002	2	4	14	U
124	452	No	01/23/04	Physics		Yes		2002	2	6	4	U
125	456	No	01/23/04	Physics		No		2002	1	6	4	
126	460	Yes	01/23/04	Physics		No		2002	2	4	6	U
127	460	Yes	01/23/04	Physics		No		2002	1	2	4	U
128	461	No	01/25/04	Physics		No		2002	1	1	4	U
129	462	No	01/25/04	Physics		No		2002	1	3	4	
130	463	Yes	01/25/04	Physics		Yes		2002	1	4	7	U
131	482	Yes	01/25/04	Zoology		No		2002	3	16	4	U
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138	492	No	02/01/04	Zoology		Yes		2002	3	16	3	
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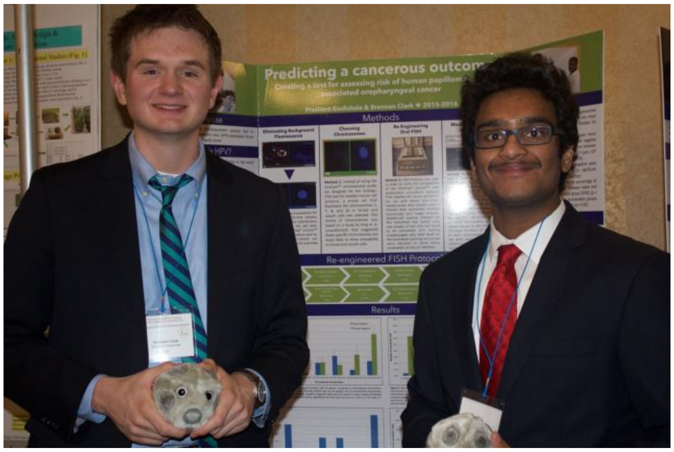
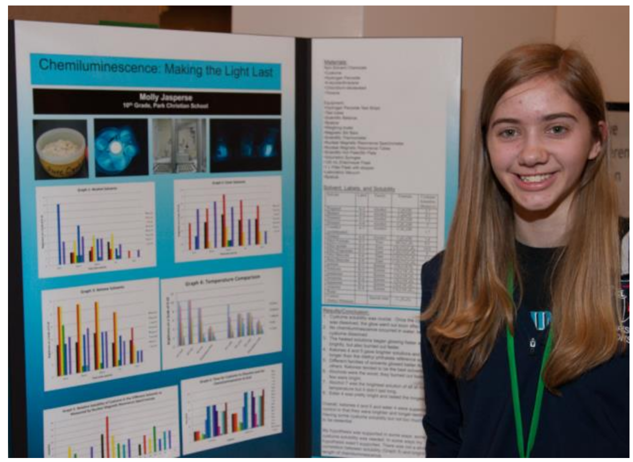
Appendix 3: State Fair Photos


Methods
Results


BACKGROUND
Eutrophication
Phosphorus Sources
Nutrient Reduction Strategy
Stormwater Ponds
Procedure

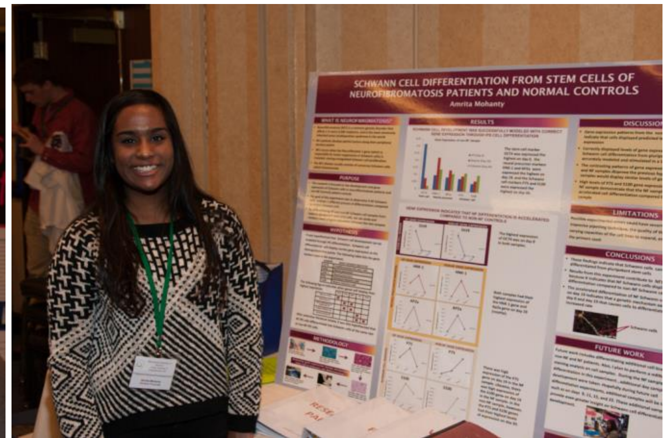

Pitch
Explored
Conclusion
Discussion


Chemiluminescence: Making the Light Last
Molly Jasperse

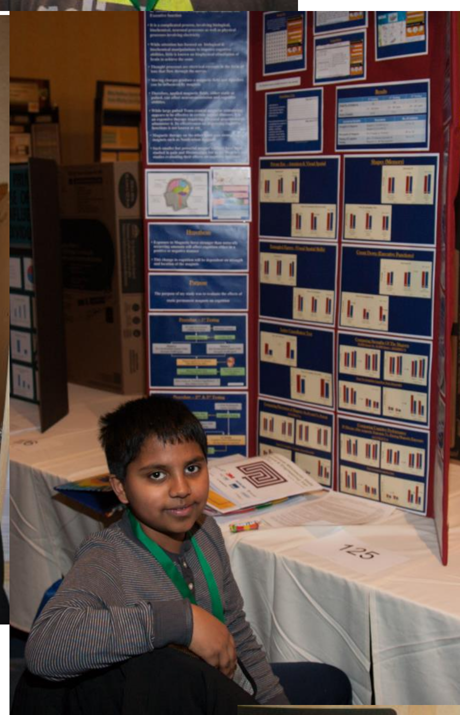

THE EFFECTS OF VODKA ON THE
Conclusion
Sources of Error


PARENTAL INFLUENCE IN CHILDREN'S GRADES
Abstract
Results

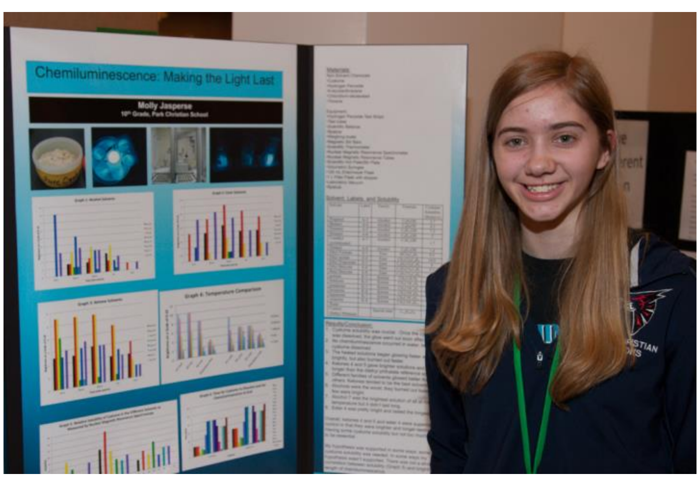

Conclusion


SCHWANN CELL DIFFERENTIATION FROM STEM CELLS OF NEUROFIBROMATOSIS PATIENTS AND NORMAL CONTROLS
Amrita Mohanty
RESULTS
DISCUSSION
LIMITATIONS
CONCLUSIONS
FUTURE WORK


Predictive Modeling of Re-Hospitalization Using Health Care Claims Data


125


Application Testing
Nutri-Grain
RESULTS


Chemiluminescence: Making the Light Last
Molly Jasperse
10th Grade, Park Christian School

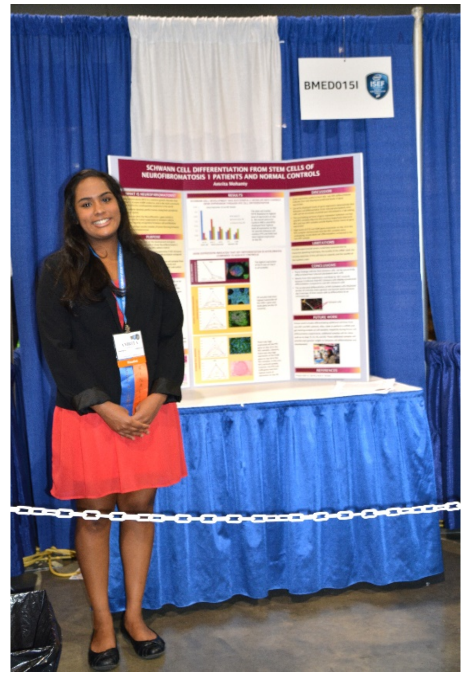

Electricity from Mud:
Optimizing the Microbial Fuel Cell
YEAR II
GENERATOR
9011
9012

Appendix 4: ISEF Photos

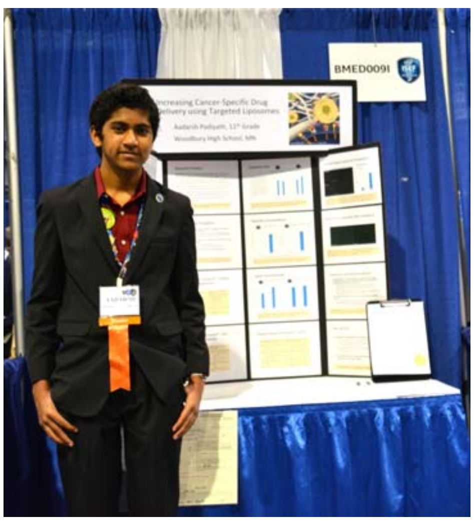
TCRSF Finalists at International Science & Engineering Fair in Pittsburgh, PA 2015 www.tcrsf.org

Finalist 2013, 2014 & 2015 – Western Suburbs
3rd Grand Award in Material Science, $1000
Full scholarship Florida Institute of Technology, valued approx. $150,000
3rd Place at National JSHS, $4,000 scholarship

Finalist 2015 – Western Suburbs

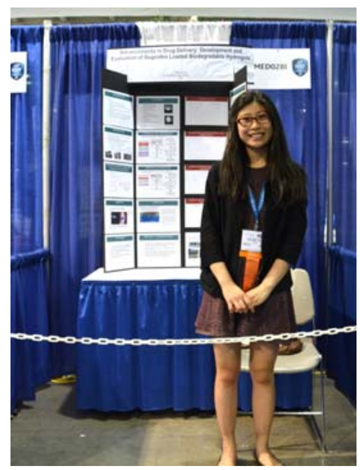


Finalist 2014 & 2015 – Twin Cities

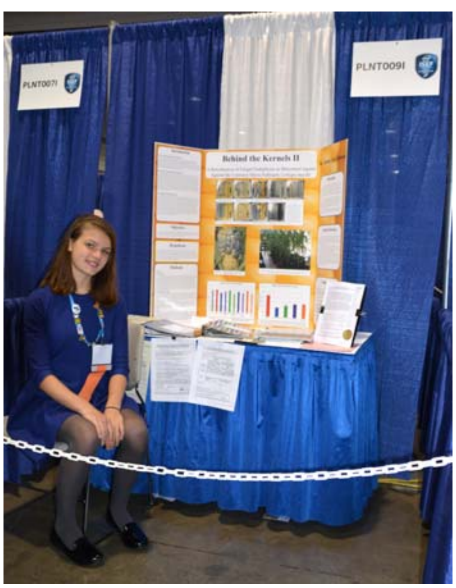


Finalist 2015 – Twin Cities

2nd Grand Award in Energy Chemical
Finalist 2015 – Twin Cities



Finalist 2015 – St. Paul

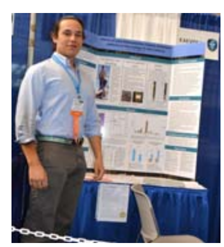


Finalist 2015 – St. Paul

Finalist chosen at State 2014 -2015 -Western Suburbs

Finalist chosen at Native American Nationals 2015 Twin Cities

Finalist chosen at State 2015 -Western Suburbs



Finalist chosen at Native American Nationals 2015 Western Suburbs

Finalist chosen at State 2015 -Western Suburbs
National Semifinalist
Science Talent Search

Finalist chosen at State 2015 –Twin Cities

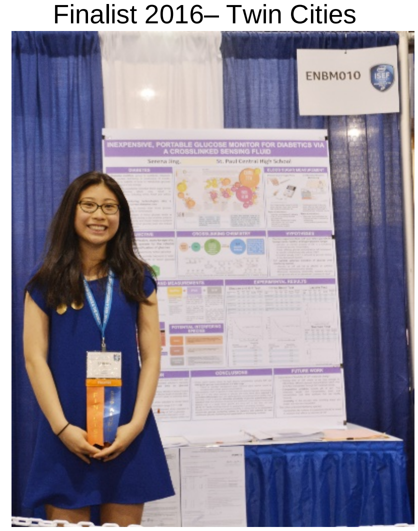
TCRSF Finalists at International Science & Engineering Fair in Phoenix, AZ 2016 www.tcrsf.org

Finalist 2015 & 2016 – Twin Cities

Finalist 2016 – Western Suburbs
Best in Category Translational Medical Science $5000, 1st Grand Award $3000; Intel Foundation Cultural and Scientific Visit to China, Ceres program asteroids named for students, Sigma Xi award $1000. nationals JSHS

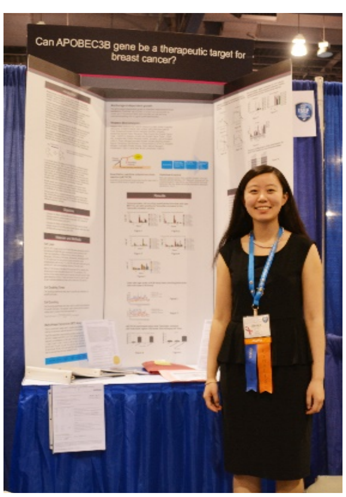
Finalist 2016– Twin Cities

Finalist 2016 – Twin Cities
Arizona State University full scholarship



Finalist 2015 & 2016 – St. Paul
4th Grand Award $500,
China Association for Science & Technology Award $1200

Finalist 2015 & 2016 – St. Paul



Finalist 2016 - Western Suburbs
National Semifinalist
Science Talent Search

◄ Finalist chosen at State 2016 –Western Suburbs
2nd Grand Award Biomedical Engineering & Ceres program asteroids named for students

Finalist 2016 – Western Suburbs

◄ Finalist chosen at State 2016 –Western Suburbs; 2nd Grand Award Computational Biology & Bioinformatics, & Ceres program asteroids named for students

Appendix 5: Illinois JSHS Guidelines

See http://www.jshs.org/guidelines.html under "**Selected articles - Conducting research"** section on page

Junior Science and Humanities Symposium

Guidelines for Preparation & Presentation of Student Research

This booklet has been prepared as a general guide to writing a research paper for submission to the Junior Science & Humanities Symposium (JSHS).

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Written by Linda Martin and Robert Brenstein
College of Science,
Southern Illinois University Carbondale.
Revised 1997, 1998 by Linda Martin.

Contents

The JSHS Research Paper

Definition

The **JSHS research paper** is a written report describing original research results in science, mathematics, or engineering. The paper should rely on previously published literature primarily for background and comparative purposes.

Contents

The typical JSHS paper is organized as follows:

- title page, or cover page
- abstract
- acknowledgments
- table of contents
- list of tables and/or list of figures
- introduction
- materials and methods
- results
- discussion and conclusions
- references, or literature cited
- appendices (optional)

Comment

Please format according to JSHS guidelines. The format for an JSHS paper differs somewhat from a paper submitted to science fair.

- ***Do not*** add separate sections entitled Purpose, Hypothesis, and Review of Literature—include that in the Introduction.
- ***Do not*** include forms from other science competitions, e.g., Safety Sheet.
- ***Do not*** include your name in headers /footers on each page.

Sequence

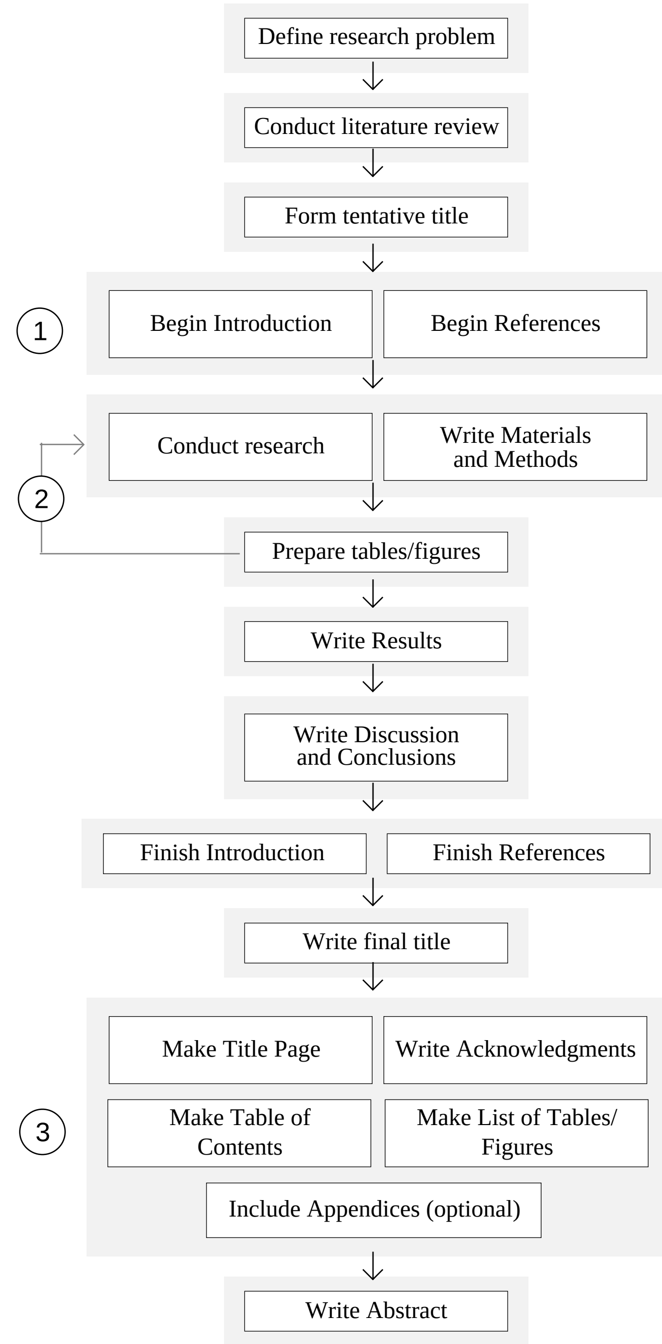
See page 2 for a suggested sequence for conducting the research and writing the paper. Side-by-side blocks indicate concurrent actions. The following comments correspond to numbers on page 2:

① Begin writing the Introduction after you conduct your literature review. You will not *complete* the Introduction, however, until later in the sequence. As you cite sources throughout your paper, add them to the References section.

② When preparing tables or figures, you might notice gaps in your data. If so, return to the experimental mode and collect the missing data.

③ Completed in any order.

Sequence



Title

Introduction

In scientific writing, the title is always intended to *convey information*. Scientific writing is *not* creative writing, nor advertising. A good *scientific* title simply orients the reader to the content of your paper in the fewest words possible.

Definition

The **title** is a concise identification of the main topic of the paper.

Description

A title is:
- concise,
- descriptive, and
- informative.

Rules

When writing a title:
- ***do not*** write the title as a question;
- ***do not*** use abbreviations.
- avoid "excess" words such as *a*, *an*, or *the*, or phrases such as *a study of* or *investigations of*.
- consider its length. A two or three word title may be too short, but a 14 or 15 word title is probably too wordy.

Example

Poor: Bugs and Drugs
Fair: Effects of Antibiotics on Bacteria
Good: Effects of Penicillin on Gram Negative Bacteria
Best: Lysis of Gram Negative Bacteria by Penicillin

The first example is concise, but neither informative nor descriptive. It is not scientific style. The second example is concise but too general. What effects? What antibiotics? What bacteria? The third example is more specific, both in describing the antiobiotic and the bacteria, but it still lacks description. The fourth example is written in scientific style.

Sequence

A tentative title can be written after the literature review. The purpose of writing the title at this early stage is to help you clarify your aims and intentions. Examine your title after the paper has been written and make sure it accurately reflects the content of the paper. (See page 2.)

Abstract

Introduction

The abstract is the reader's first encounter with your paper. Reviewers will form first impressions of your research by reading the abstract. Day (1994) states, "Usually, a good abstract is followed by a good paper; a poor abstract is a harbinger of woes to come."

Definition

The **abstract** is a:
- brief summary of the principal findings of the paper.
- preview of the paper.
- stand-alone, self-contained document that can be read independent of the paper.

Contents

The abstract should *briefly* state:
- the purpose of the research or the research problem (introduction),
- how the problem was studied (methods),
- the principal findings, including statistical analyses (results), and
- what the findings mean (discussion and conclusions).

While it is difficult to be both concise and descriptive at the same time, that is exactly what you should strive for when writing an abstract. Say only what is essential, using no more words than necessary to convey the meaning. Examine every word carefully.

Rules

The abstract should be:
- one or two paragraphs,
- no more than 175 words, and
- on the JSHS abstract form.

The abstract should:
- ***not*** include subheadings such as "Purpose" or "Results."
- ***not*** use first person, e.g., "I."
- ***not*** include information or conclusions that are *not* stated in the paper.
- ***not*** emphasize minor details.
- ***not*** contain bibliographic references, figures, or tables.
- ***not*** use jargon or abbreviations *(unless* they are commonly used and do not require explanation, e.g., DNA or UV light*)* .

Sequence

Write the abstract after the paper is completed. Make sure it accurately reflects the paper's contents . (See page 2.)

Acknowledgments

Introduction — As a matter of scholarly courtesy, you should acknowledge those who helped you technically, intellectually, and financially.

Definition — The **Acknowledgments** is a short paragraph where the researcher acknowledges the contributions of others to the research study.

Contents — The Acknowledgments should state:

- where the research was conducted,
- when the research was done, and
- the names of those who provided major assistance with the study, including:
  - ✓ selection of topic,
  - ✓ planning or guiding course of research,
  - ✓ construction of apparatus,
  - ✓ use of equipment or laboratory space, and
  - ✓ other direct assistance.

Note — As a researcher, you are neither rewarded nor penalized by the judges for utilizing special advisors or equipment (Cousens, 1997). However, it is important that you properly acknowledge any assistance.

Table of Contents

Introduction — A Table of Contents is *not* considered a part of a typical scientific research paper and is *not* a numbered page. However, JSHS guidelines require a Table of Contents.

Definition — A **Table of Contents** is an outline that indicates the location of the sections and subsections of the paper.

Purpose — The main purpose of a Table of Contents is to enable the reader to quickly find any section of the paper.

Rules — When making a Table of Contents:

- list *only* the number of the first page of any section, e.g., "1," not "1-4."
- keep the right margin of the column of page numbers even by using a right-aligned tab.
- consider using leaders, a series of horizontal dots, to "lead" the eye across the page to the right number.
- ***do not*** use the word "page" with the number. It is self-explanatory.

List of Tables & List of Figures

Definition — A **List of Tables** and a **List of Figures** are outlines that indicate the location of any tables or figures in the paper.

Rules — When making a List of Tables, include:

- table numbers,
- titles, and
- page numbers.

When making a List of Figures, include:

- figure numbers,
- captions, and
- page numbers.

Comment — If the figure caption has more than one sentence, include *only* the first sentence in the List of Figures.

Introduction

Definition

The **Introduction** is:
- a clear statement of the problem or project and why you are studying it (Dodd, 1986).
- a map of the path you're going to take from problem to solution (Day, 1994).

It is ***not*** simply a literature and concept review.

Contents

The Introduction should contain:
- sufficient background information to allow the reader to understand and evaluate the results of your study (Day, 1994);
- a *brief* literature review. *Cite* and discuss previous research from *relevant* literature, and state how your research relates to or differs from others' work;
- the rationale for your study. Why did you choose that subject, and why is it important? and
- a simple statement of the most important point(s) that you will address in your paper.

Rules

The Introduction should:
- proceed from the general to the specific. It should introduce the problem, present necessary background information, show the continuity between previous work and the work *you* did, and indicate *your* purpose and rationale.
- include only background information and studies that are *relevant* to the present study. ***Do not*** try to include *everything* that you know about the topic.
- cite the relevant literature sources in the text.
- assume that the reader is scientifically literate but *not* familiar with the specifics of the study.

Sequence

A literature review should be done *before* you conduct your research. However, you should not *finish* writing the Introduction until *after* the Discussion and Conclusions section (see page 2).

Materials and Methods

Introduction

The cornerstone of the scientific method is reproducibility (Day, 1994). This section should describe the experimental design with sufficient detail for a trained researcher to replicate your experiments and obtain similar results.

This section should also enable the reader to evaluate the appropriateness of your methods and the reliability and validity of your results (APA, 1994).

Definition

The **Materials and Methods** section describes:
- how you conducted your study,
- what materials and equipment you used, and
- what methods or procedures you followed.

It is ***not*** a numbered list of experimental steps or a cookbook recipe.

Rules

The Materials and Methods section should be written:
- in narrative, paragraph format.
- precisely—be specific. Don't leave the reader with unanswered questions.

The Materials and Methods section should ***not*** include any of the Results.

Materials

Materials are ***not*** listed separately, but rather included in the description of Methods. Include exact technical specifications for:
- chemicals: purity and names of suppliers. Use generic or chemical names, *not* trade names *unless* the known difference is critical.
- apparatus: type, brand, model. Describe your apparatus only if it is not standard and was constructed for your study. Use figures, if appropriate, to help the reader picture the equipment.
- techniques: standardization methods, solvent, concentrations, times, temperature.
- experimental animals, plants, and microorganisms: genus, species, special characteristics such as age and sex.

✓ Use *metric* units for all quantities and temperatures.
✓ Include method of preparation.
✓ Include criteria for selection and an "informed consent" statement when human subjects are used.

Materials and Methods (cont.)

Methods

- include precise description of the sample;
- include methods of data collection;
- provide all needed detail for *new*, *non-standard*, or *modification* of standard methods; and
- cite the literature reference and give only the details specific to your experiment when using a *standard* method.

Example

Make sure you specify your methods precisely. As an example, suppose you collect water samples or collect organisms from lakes, wells, etc.

- What were the criteria for choosing the lakes/wells? the sampling locations in the lakes?
- Were the lakes/wells different in water quality or some other relevant characteristic?
- Did you include other "kinds" of lakes/wells?
- Were the procedures standardized (controlled)?
- Can you demonstrate that your sampling technique produced a random sample (i.e., that it wasn't biased)?
- What was your period of data collection? How many times did you sample? Dates?
- What were the weather conditions prior to sampling? Had it rained? Was the temperature notably different?
- Take a sample from several lakes/wells to see if you find the same occurrence in all.

Sequence

It is a good practice to write the Materials and Methods section as you conduct your experiments so technical details are fresh in your mind. (See page 2.)

Results

Introduction

The Results present the data, the most important part of the paper. The whole paper must stand or fall on the basis of the Results (Day, 1994).

Definition

The **Results** section contains all the major experimental findings of the study and their statistical analyses, presented in a logical order with text and visuals that complement and supplement the other.

Contents

The Results section contains:

- visuals (tables, figures, and/or illustrations) where necessary for clarity and conciseness,
- text that summarizes the data collected and points out highlights of visuals, and
- any appropriate statistical analyses of the data.

Visuals

The visuals should:

- highlight an important point and be referred to somewhere in the text.
- be well designed so they are clearly understood *without* reference to the text.
- ***not*** be redundant. ***Do not*** present the *same* results in multiple visual formats, e.g., presenting the same results in both a table and a graph. Choose the best format for presentation. Are shapes and trends more important to the readers, or exact values?

Text

The text should:

- summarize the data collected, point out the important features, and connect the results with one another.
- ***not*** *interpret* the results and discuss the conclusions of the results (a trend can be mentioned, but no *interpretation* or extended *discussion* occurs in this section).
- ***not*** include raw data. This data should be in a table or in an appendix.

Sequence

Prepare your tables or figures *before* writing the text. The visual representations will help you clarify your own thinking and make it easier for you to write the Results. This will also help reveal whether there are gaps in the data and whether more experimental work should be done.

Results (cont.)

Tables

Use tables to show large amounts of data (usually numbers) in a small space. If exact values must be listed, a table is normally preferred over a graph.

Rules

- Put table number and title above the table. The word "table" should be all caps (*TABLE 2. Chemical and…*). Tables should be numbered with Arabic numerals (in the order of appearance in text). Numbering will enable the writer to refer to them quite easily (*Table 2 shows that…*).
- Place columns to be compared next to each other, if possible.
- Label each column with a column heading. Make the headings clear but concise. Abbreviations may be used, but do not use periods. Capitalize first words in column headings.
- Include units of measure in the headings if appropriate, e.g., *Nitrates (mg/L)*.
- Use horizontal rules, or lines, if needed. Vertical rules are normally not used; columns are defined by spacing.
- Use single spacing for data and headings. In some instances, you may want to use wide space (extra line) to separate groups of data.
- Align numbers in each column on the right. However, if decimal points are used, the numbers should be aligned on the decimal point.
- Use an initial zero before the decimal (*0.25*).
- Use notes for more extensive explanation of data or headings. Notes are placed below the table and referenced by superscript letters.
- Order the notes to a table in the following sequence:
  - general notes provide information relating to the table as a whole; place the letter reference at the end of the title
  - column (row) notes refer to a particular column (row); place the letter reference at the end of column (row) heading
  - probability level notes indicate the results of tests of significance
- Tables should be placed as near as possible to the discussion in the text.

Figures

Figures are used to convey the overall pattern of the results at a quick glance. The most common figures are graphs, photographs, and diagrams.

Rules

- Make all figures in black and white for reproduction purposes. If color is integral to the research, a request for an exception should be made to the Symposium Director, and *12 copies of each figure must be provided* for the paper reviewers .
- Number all figures with Arabic numerals in order of discussion in the text. Number figures separately from tables.
- Label both axes on graphs with the variable being measured, the units of measurement, and the scale.
- Place the figure caption and legend below the figure. A caption is a brief but descriptive title. For example, *FIGURE 2. Average Nitrate Content of Wells.* A legend consists of one or more sentences that describe what is shown in the figure and point out important features. Sometimes a caption and legend are combined. For example, *FIGURE 2. Average Nitrate Content of Wells. The average of all seven readings of the nitrate level for each well is given. The dotted line represents the maximum contaminant level (MCL) which the EPA has established for public drinking water.*
- Figures should be placed as near as possible to the discussion in the text.

Bar Graphs

Bar graphs are appropriate for showing discrete values and comparisons. They emphasize individual amounts rather than trends or direction. They have the most impact when used to display relatively few values of one or more series (Woolston, 1988).

Line Graphs

Line graphs are used to show trends and relationships. They allow plotting values of a quantity as a function of another variable. The horizontal axis most often depicts time (Woolston, 1988).

Pie Graphs

Pie graphs are 100-percent graphs and are used to show percentage distribution of parts of the whole. They are intended to provide an overview rather than exact values (Woolston, 1988).

Discussion and Conclusions

Introduction

The Discussion and Conclusions can be the hardest section to write because you *interpret* your results in this section and draw conclusions.

Definition

A **Discussion and Conclusions** section is an *analysis* of your results. It is a concise discussion of your most important results in the context of other peoples' work (as reported in the Introduction) and the conclusions drawn based upon your research findings (as reported in the Results).

Contents

It should:

- briefly restate your hypotheses; explain how your data either supported or rejected your initial research question(s);
- show how your results agree (or contrast) with previously published work (include appropriate literature citations);
- state your conclusions as clearly as possible; (Remember: not all papers have earth-shattering conclusions.)
- summarize your evidence for each conclusion;
- acknowledge any limitations which affect the results; discuss any other factors over which you had no control; explain their possible effect on study outcomes;
- include suggestions for procedural improvements, if applicable;
- discuss any theoretical implications or practical applications of your work; and
- make recommendations for future research.

Rules

The Discussions and Conclusions should:

- proceed from most specific (your results), through the more general (others' results), to the most general (implications drawn from your study)
- ***not*** simply *restate* the results. This section should *analyze* the results.

References

Introduction

Virtually all scientific papers rely to some degree on previously published work. When a fact or an idea is borrowed (whether directly or paraphrased) from another source, it must be acknowledged, or cited, in the text and the origin of the information must be revealed.

Definition

A <u>citation</u> is the formal acknowledgment within the text. The citation serves as a link between the text in which it appears and the formal, alphabetical list at the end of the paper called <u>References</u> (Ebel, 1987).

Citing in Text

Although there are several systems for citing in text, the IJSHS follows the author-date system. The citation (author and date) should be placed naturally into the flow of the sentence.

Pascal and co-workers (1981) first isolated a mutant of <u>E.</u> <u>coli</u> K-12 which could no longer ferment glucose.

Examination of codon usage predicts ADH to be a highly expressed protein in <u>E. coli</u> (Ikemura, 1985).

If the name of the author appears as part of the text, as in the first example, cite only the year of publication in parentheses. Otherwise, place both the name and year, separated by a comma, in parentheses as in the second example.

When there are two authors, cite them both (*Smith and Kaplan, 1980)*, but in the case of three or more authors, cite only the name of the first author and indicate the rest by using "et al." (*Lurz et al., 1979*), which is Latin for *and others*.

Rule

All *citations in text* must appear in the *References*; and all references in the *list* must be cited in the *text*. A References list differs from a Bibliography, in which you list everything you have read, whether it is cited or not.

Punctuation

For end-of-sentence citations, the period for the sentence is placed *after* the citation, *not* before it.

*The diencephalic structure which controls classification responds better to positive **reinforcement (Knowlton and Squire, 1993).***

NOT**...** ***reinforcement. (Knowlton and Squire, 1993)***

References (cont.)

Formatting the List

- left justified margin with additional lines indented five spaces (1/2")
- single spaced; double space *between* references
- arranged alphabetically by first author's last name
- Periods separate major components.
- Colons separate titles from subtitles, cities from publishers, and volumes from pages.

Authors

- A single-author entry comes before a multi-author entry if they begin with the same name.
- Works by the same person are arranged chronologically by date of publication.
- When a work has more than one author, their names are listed in the order in which they appear on the title page.
- When a book or pamphlet has no individual author's name, or group of authors' names, and is published by an agency, association, or named group: the name of the group may serve as the author's name in citations in text and in the References list. The name of the group is spelled out in the first citation and abbreviated thereafter.
- Major reference works, such as encyclopedias, with a large editorial board: list the name of the lead editor or directing editor if no author is cited.
- Name of the author or editor is unknown: list alphabetically by the first important word in the title.

Contents

- For *journals*, include author, year of publication, title of article, abbreviated journal name, volume number (if every issue begins with page 1), and page numbers.
- For *books*, include author (or editor), year published, book title, location of publisher, and name of publisher.
- For *sources other than a book or journal*, include enough information so that the source can be identified and located.

Titles

- Article and book titles are capitalized in sentence style.
- Journal titles are capitalized in heading style.
- Book and journal titles are italicized.
- Article titles are **not** italicized or enclosed in quotations.

Misc.

- Locations that are well known can be listed without a state abbreviation, e.g., New York, Boston, Chicago.

Book: one author	Day, R.A. 1994. *How to write and publish a scientific paper*. 4th ed. Phoenix: Oryx Press.
more than one author	Woolston, D.C., P.A. Robinson, and G. Kutzbach. 1988. *Effective writing strategies for engineers and scientists*. Chelsea, MI: Lewis Publ.
Dictionary, editor	Urdag, L., ed. 1972. Magnet. In *The Random House college dictionary*. New York: Random House.
Encyclopedia: with author	Hart, L.W. 1988. Magnet and magnetism. In *World Book*. Vol. 13. Chicago: World Book.
editor/ no author	Lorimer, L.T., ed. 1993. Magnet and magnetism. In *Encyclopedia Americana*. Vol. 15. New York: Americana Corp.
Internet	Martin, Linda. 08 Nov 1997. General Information. <http://www.science.siu.edu/ijshs/info.html> Accessed 20 Nov 1997.
Interview	Barber, J.D. 8 May 1995. Interview by author. Carbondale, IL.
Journal Article: one author	Clark, D.P. 1989. The fermentation pathways of *Escherichia coli*. *FEMS Microbiol. Rev.* 63:223-234.
more than one; title & subtitle	Kohara, Y., K. Akiyama, and K. Isono. 1987. The physical map of the whole E. coli chromosome: application of a new strategy for rapid analysis and sorting of a large genomic library. *Cell* 50:495-508.
Magazine, paginated by issue	Cowley, G. 23 Jan 1995. HIV's raw aggression. *Newsweek*. 75(4):58.
Newspaper: no author	Study finds free care used more. May 1989. *APA Monitor*. 14.
discontinuous pages	McDonald, K.A. 15 Dec 1995. Researchers ponder a stormy forecast. *The Chronicle of Higher Education*. A12, A16.
Pamphlet, organization as author	American Society for Microbiology. 1994. Slide and poster requirements. Pamphlet. Washington, DC: ASM.
Telephone conversation	Barber, J.D. 8 May 1995. Personal communication

Appendices (optional)

Introduction

Appendices contain supplemental information such as lists of terms, definitions, and questionnaires that are useful but not essential to the body of the research paper. Most readers will not bother to check appendices.

Rules

Appendices should be included *only* if they help readers to understand, evaluate, or replicate the study (APA, 1994). For example, you have a large table of raw data, but most of it is *not* essential to the discussion in the paper. You could include the complete table as an appendix and a smaller table with a subset of data in the text.

Writing, Revising, and Proofreading

First Draft

Have a clear purpose in mind when you begin writing, but don't try to think of everything at once. Papers are rarely written correctly on the first draft. This means you must be sure to allow yourself enough time for writing *and revising*.

Review

After the first draft is written, set it aside for at least a day or so, then re-read it to yourself. Also, allow enough time in the process to give the draft to your science and English teachers, as well as someone who is not familiar with your research project, for comments. Ask them to mark any section that was confusing or they had to read twice to understand.

Revise

When you revise, aim for improving clarity.

- Use third person in grammar, when possible.
- Examine the verb tenses throughout your paper.
  - ✓ Most or all of the Abstract should be written in past tense.
  - ✓ Present and past tenses are correct in the Introduction.
  - ✓ Past tense or present perfect tense (*researchers have shown*) is appropriate for the literature review and the description of the Materials and Methods.
  - ✓ Use past tense to describe Results .
  - ✓ Use the present tense for the Discussion and Conclusions. The present tense allows your readers to join you in your consideration of the matter at hand.
- Examine your use of pronouns, especially "it." Is the meaning clear?
- Examine your sentences for needless words.

Proofread

Proofread for correct spelling and sentence structure! Computer spell-checkers do not recognize misspelled words if they are valid words, nor do they check the grammar.

Any errors in spelling, grammar, sentence structure, punctuation, or misuse of a word is distracting and affects the reader's confidence in you.

A paper with writing and typing errors may score poorly even if the research itself is excellent.

Typing Specifications

Rules

- All papers must be typed, using standard 12-point, serif typeface (such as Times), and double-spaced.
- Papers must be printed single-sided on 8 1/2 x 11 inch paper with one-inch margins (on all sides).
- Output from dot matrix printers is not acceptable.
- The typical research paper should be between 5 and 12 pages. It may not exceed 20 pages. Lengthy papers are neither necessary nor desired.
- The title page shows the title of the paper, the author's name, school name, and date of submission.
- All pages except the title page, abstract, acknowedgments, and table of contents must be numbered. Type the numbers, using Arabic numerals, within the one-inch margin on the *bottom* of the page. These numerals should be centered and one-half inch from the bottom edge of the paper.
- Do *not* include your name on each page of the paper. The papers are "blind" reviewed, which means that all identifying information such as name and school must be removed prior to paper review.
- Each section of the paper should be identified by a heading, centered within the page margins, and typed using the same typeface and font size as text. All letters are capitalized.
- Use abbreviations sparingly, but if a very long name or term is repeated throughout the paper, an abbreviation is acceptable.
- Abbreviations should be defined the first time they appear in text by placing the abbreviation in parentheses following the spelled-out word. For example, *No molecule with a single 4-member ring was isolated until tetramesityl cyclodisiloxane (TMCDS) obtained by oxidation of disilene. TMCDS was …*

The Oral Presentation

Timing

The presentation may not exceed 15 minutes and is followed by a five (5) minute question-and-answer period.

- A session moderator will aid the student speaker in maintaining the time and in fielding questions from the audience.
- The timing procedure includes a 12-minute warning signal from the moderator, and a 15-minute stop time. At the 15-minute point, the presentation will be stopped, even if the student speaker has not finished.

Answering Questions

Following the presentation, the session moderator will ask for questions from the judges, followed by questions from the audience.

- The speaker *must* repeat or paraphrase each question before answering it so the audience understands the entire dialogue.
- Questions intended to harass the student speakers will not be allowed by the session moderator.

Suggestions

Explain your research in enough detail so the audience understands what you did, how you did it, and what you learned. Be sure your presentation is logical and easy to follow. Make your message clear.

- Avoid jargon or terminology the audience might not understand. If it is essential to use specialized terms, remember to explain them *briefly*. Be prepared to define terminology used, if necessary.
- Graphs, tables and other illustrations may help explain your results. Remember to name the variables on each axis of a graph, and state the significance of the position and shape of the graph. Do not, however, read each number in the table/figure. Call attention instead to important points.
- Deliver your presentation at a comfortable pace. Time yourself. Classroom practice sessions provide an excellent "live" audience and help build confidence. Videotape the presentation, if possible. Listen and watch for "ah's," "er's," or nervous mannerisms.
- Plan to speak for 12 minutes; that "builds in" time to finish within the allotted 15 minutes.

The Oral Presentation (cont.)

- Acknowledgments are presented at the *end* of an oral presentation.
- No written handouts are permitted.
- Research apparatus may be demonstrated only if it is integral to the presentation and only if the apparatus is hand-held.

Visuals

General Guidelines

- Available audio-visual equipment includes 35 mm slide projector with remote control, overhead projector, laser pointer, and videocassette player (if requested; see restrictions below on using VCR's.)
- Visuals (overhead transparencies or slides) should be laser printed or professionally done.
- Number your visuals in sequence so they can be easily identified. Many times, visuals need to be reshown during questions.
- The first visual should be equivalent to the title page of the paper.
- Visuals should be brief, simple, and uncluttered. Focus on important information. Each visual should make one simple statement and supplement what you are saying while the visual is on the screen.
- Use good judgment in determining the number of visuals and balance their contents. Although you do not want to quickly flash multiple visuals, you should not spend too much time on a single visual either. Typically, a 15-minute presentation will have 5-6 visuals (Ebel, 1987).

Overhead Transparencies

- Be sure that your transparencies are legible from a distance. Titles: at least 18 points and sans serif typeface, e.g., Helvetica. Blocks of text: 16 points (14 points minimum) and serif typeface, such as Times. Recommended line spacing is 1.5 lines.
- Although the stage area of the overhead projector generally measures about 10 by 10 inches, restrict your visual to a rectangular "message area" of about 7 1/2 by 9 1/2 inches.

Overhead Transparencies (cont.)

- Horizontal orientation generally works better. On a square screen, the audience has difficulty seeing the bottom fourth of a vertical format transparency.
- Bulleted items should be no more than 2-3 lines per bullet with extra white space (1/2 to 1 line) between items.
- Commercially-available frames make a transparency easy to handle, and key words can be written on the frame.

Slides

- Use 2 x 2-inch (35 mm) slides.
- When preparing text for slides, use no more than 9 double spaced lines per slide. Each line should be at most 4.5 inches wide (about 50 characters in non-proportional font).
- If you can read the slides without a magnifier, people in the audience can probably read them on the screen. It is better to have the letters too large than too small.
- Thumb spot all slides in the lower left corner when the slide reads correctly on hand viewing. Add sequence numbers.
- Have slides in carousel tray with thumb spot visible in upper right hand corner.

Color Choices

- Color is not required. Color should be used only to clarify or make the visual more legible.
- Overhead transparencies most commonly have black letters on white (clear), but slides are frequently made using other colors.
- Most legible are black letters on yellow. The following are listed in descending order of legibility: green, red, or blue on white (clear); white (clear) on blue; black on white (clear); and yellow on black (Heinich et al., 1993).
- Do not overuse color. Use good judgment.

VCR/Computer Restrictions

Introduction

Students using VCR's and computers during their presentation must abide by the following rules. Improper use will not only distract the audience but also could affect evaluation by the judges.

Rules

- If using computers or video, notify the Symposium Director at least two weeks in advance of the meeting to discuss and review specific technical details (e.g., projection, set-up, etc.) and to allow for availability of video equipment. Students must provide their own computer equipment and software.
- The use of software such as PowerPoint may be used to prepare or to drive slides or overheads.
- Only VHS, 1/2" tape, format is permitted.
- The video component cannot make up more than two (2) minutes of the presentation.
- No audio or background music is permitted other than sounds that are an integral part of the research. Recorded or mechanically produced narration is not permitted. Narration must be done in person by the speaker.
- Computer generated graphics, video (and audio, if any) may be used only for those aspects of the presentation that cannot be adequately presented by slides or overheads.
- Computer-based material must be an integral part of the research and should not be used for presentation of common procedures, illustrating equipment or showing laboratory facilities.
- Videos and computers should illustrate work that was done and should not be used for stimulation or aesthetic value.

Judging Criteria

The Student's Involvement with Science:

Problem & Hypothesis

- originality in identification of problem and hypothesis
- clarity in stating problem
- objectives and reasons for performing the research

Background Information & Prior Research

- acknowledgment of sources

Design of Investigation

- extent of student's involvement in designing the procedures

Investigative Procedures

- identification of important variables; control of variables
- laboratory skills and techniques
- selection of proper equipment for research task
- quantity and quality of data generated by investigative procedures: observations/ measurements/data gathering/statistical analysis
- recognition of the limitations in the accuracy and significance of the results obtained
- interpretation of data; conclusions supported by data
- problem solving

Overall

- creativity/originality
- evidence of student's understanding of the scientific or technological principles employed in investigation
- applications, next steps, or future research

Judging Criteria (cont.)

The Student's Effort and Performance:

Overall
- duration of project and amount of work involved
- acknowledgment of major assistance
- evidence of student's understanding

Written Presentation
- organization of the paper
- composition (spelling, grammar, clarity of thought)
- abstract (content, format, grammar, organization)

Oral Presentation
- clarity in stating problem and hypothesis
- clarity in describing design, procedures, problems, and how they were handled
- clarity in presenting data, interpretations, and conclusions
- overall organization
- definition of terms as necessary
- appropriate use of visual aids
- clarity of enunciation and voice projection
- response to questions

Note
The presentation is important in the evaluation; however, content, not form, will be given the major weight.

The Poster

Definition
The poster is a hybrid between the research paper and the oral presentation.

Comment
Most of the comments from the preceding pages also apply to posters. However, this section will emphasize the differences and unique aspects of poster presentations.

Poster Session
The JSHS Poster Session will be organized similar to those at scientific and professional meetings. The poster session will be scheduled as a regular part of the Symposium with no other activities occurring at the same time.

Submission
To participate in the Poster Session, you must submit the following:

- Up to a five (5) page typed paper describing the original research project and main findings. The paper should have the same sections as the poster, i.e., Introduction, Methods, Results, Conclusions, Acknowledgments.
- An abstract on the JSHS Abstract Form
- A Biographical Sketch form
- A student photo

Comment
The biographical sketch and photo are included, along with the student's abstract, in the program booklet that is distributed to all Symposium participants.

Composition
The poster contains the following sections:
- Title
- Student's name and school
- Abstract
- Introduction
- Methods
- Results
- Conclusions
- Acknowledgments

The Poster (cont.)

Differences

The most important differences are:

- A poster is more concise since the author is present to explain and elaborate. You should typically have a single page for each section.
- There is more emphasis on graphics.
- You can use photographs in addition to other illustrations.
- Figures may be in color.

Display

A display wall (approximately 1 meter wide by 2 meters high) will be provided for each participant.

- All display materials must be attached to the wall. Table space will **not** be available.
- It is best to have materials pre-mounted on large-size (color) mounting boards.
- Posters should be readable from a distance of 4 feet.
- The title should be at least one inch (72 pts.) in height. The student's name and school should be 3/4 inch high (54 pts.). All other lettering should be in 24-point font size.
- Use sans serif typeface (such as Helvetica) for poster title, student's name and school, and major headings.
- Blocks of text should be serif typeface (such as Times).
- The poster should be balanced and organized in a logical, sequential order.
- Determine in advance what you will display and how it will be organized.
- Keep the amount of text to a minimum. Emphasize graphics—tables, charts, graphs, and photos.
- Use white space to make the reading easier.

Presentation

In the poster session, poster presenters remain close to their posters and are available to answer questions and discuss their research.

- Each poster presenter will be given three (3) minutes to highlight the significance of the research to a panel of judges. Questions by the judges will follow.
- Other participants of the Symposium will be viewing the displays during judging.

Poster Judging Criteria

Research Design

- Clarity in stating the problem
- Identification of important variables
- Appropriateness of research equipment
- Recognition of limitations in the data
- Degree to which the data supported the conclusions
- Originality of the research topic

Poster

- Effective use of tables and/or figures in presenting data
- Accuracy of spelling and grammar
- Neatness and organization of poster

Presentation

- Organization of presentation
- Handling of questions from judges

Non-Human Vertebrates

Rules

The Junior Science and Humanities Symposium has adopted the following rules on non-human vertebrate experimentation (adapted from Bonkalski et al., 1994).

- Only animals that are lawfully acquired shall be used in experimentation and their retention and use shall be in every case in strict compliance with state and local laws and regulations.
- Animals used in experimentation must receive every consideration for their bodily comfort; they must be kindly treated, properly fed, and their surroundings kept in a sanitary condition.
- No intrusive techniques may be used, including surgery, injections, or taking of blood.
- When animals are used by students for their education or the advancement of science, such work shall be under the direct supervision of an experienced teacher or an investigator at a research institution with an approved active protocol for the use of vertebrate animals for this research.

Human Subjects

Rules

The Junior Science and Humanities Symposium has adopted the following rules on research involving human subjects (adapted from Bonkalski et al., 1994).

- No project may use drugs, food, or beverages in order to measure their effect on a person.
- Projects that involve exercise and its effect on pulse, respiration rate, blood pressure, and so on are approved if a valid normal physical examination is on file and provided the exercise is not carried to the extreme.
- If your research involves administration of questionnaires or surveys, a proper consent from subjects must be obtained.
- If you are conducting research that involves human subjects and your school has no formal policy regarding such research, contact the JSHS Director for guidelines.

- No cultures involving human cultures of any type–mouth, throat, skin, or otherwise–will be allowed.
- Tissue cultures purchased from reputable biological supply houses or research facilities are suitable.
- The only human blood that may be used is that which is either purchased or obtained from a blood bank, hospital, or laboratory. No blood may be drawn by any person or from any person specifically for a science project. This rule does not preclude a student making use of data collected from blood tests not made exclusively for a science project. Blood may not be drawn exclusively for a science project.

Sample Pages

Pages 31-34

These pages show selected sections of a former research paper (reprinted with permission).

ACKNOWLEDGMENTS

This research was conducted during the months May–December 1998. Research laboratory space, equipment, supplies, and assistance were provided by Dr. Jim Eilers, Dr. Virginia Bryan, Dr. Dennis Kitz, Ms

Illinois University Edwardsville (SIU

regarding statistical analysis. Mr. Bi

microscope. Dr. Beverly Friend dev

complete this project. Well owners

Abstract Form 20th Annual Illinois Junior Science and Humanities Symposium
Southern Illinois University Carbondale • **March 22–24, 1998**

Chemical and Microbiological Quality of Private Well Water

Valerie Wappelhorst, 305 Catalpa, Roselle, IL 60172
Lake Park High School, Roselle, IL
Mentor: Dr. Beverly Friend

The chemical and microbiological quality of water from six private wells in Madison and St. Clair counties was evaluated. Samples were collected over an eight-month period and were analyzed for nitrate, pH, total solids, heterotrophic plate count, coliforms, *Escherichia coli (E.coli)*, and fecal streptococci. Microbial isolates were selected and characterized using selective and differential media, biochemical tests, and microscopy.

The nitrate nitrogen values varied from 0 to 21.2 mg/L with one well exceeding the Maximum Contaminant Level (MCL) of 10 mg/L for drinking water. Nitrates were significantly different for wells ($p<0.001$) but not for dates. The pH and solids levels differed significantly for both wells and dates. The heterotrophic counts ranged from 1,200 to >5.7 x 10^6 colony forming units (CFU)/100 ml, and were significantly different for wells ($p<0.05$) but not dates. All samples exceeded the recommendation of 100 CFU/100 ml. Coliforms ranged from 0 to 6,600 CFU/100 ml and were significantly different for wells ($p<0.01$) and dates ($p<0.01$). Over 90% of the samples exceeded the MCL of zero coliforms. *E. coli* was found in three of the wells. The presence of high nitrates and extensive microbial contamination in these wells indicates that well owners should routinely sample and treat their wells.

TIONS

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Chemical and Microbiological Quality of Private Well Water

Valerie Wappelhorst
Lake Park High School

January 16, 1998

INTRODUCTION

The National Primary Drinking Water Regulations of the United States Environmental Protection Agency (EPA) apply to all public potable water systems in the United States. There are primary regulations establishing a maximum contaminant level (MCL) for microbiological, inorganic, organic, and radiological contaminants and secondary regulations (non-enforceable guidelines) for taste, odor, and aesthetics. There are no primary standards for either pH or total dissolved solids in public drinking water. The secondary standard for pH is 6.5 to 8.5 and for solids is 500 mg/L (35 Illinois Administrative Code).

U.S. obtain drinking water from

s 400,000 private wells supplying

ral areas (Korab, 1993). Since water

typically do not test their wells as

ply wells.

g/L nitrate nitrogen for public

LIST OF TABLES

LIST OF FIGU

1

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TABLE 2
Chemical and Microbiological Content of Well Waters

Sample	Dates	pH	TDS[a]	Nitrate N	HPC[b]	Coliform	*E. coli*	Fecal Strep
		units	mg/L	mg/L	CFU/100ml	CFU/100ml	CFU/100ml	MPN/100ml
MCL		6.5-8.6[c]	500[c]	10[c]	200[c]	0	0	0
Well 1 Madison	5/09	8.0	90	9.3	20600	1200	0	
	6/13	7.2	59	8.2	9100	400	0	
	7/11	7.2	50	7.1	1400	100	0	
	8/08	7.0	30	7.9	3200	600	0	
	9/12	7.1	69	8.0	14000	0	0	170
	11/14	6.5	50	5.6	9300	200	0	30
	12/12	6.2	40	7.8	8800	100	0	
					11100	1200	700	
					83000	1000	500	
					2800	800	600	
					10500	2800	1200	
					3900	0	0	60
					16400	300	0	70
					10000	200	0	
					9400	400	0	
					9600	600	0	
					1200	1000	800	
					2200	100	0	
					337700	0	0	90
					2000	200	0	200
					3050	0	0	
					12300	1600	0	
					3500	600	0	
					15600	600	0	
					51000	4400	0	
					30000	700	0	110
					282500	1500	0	90
					17300	600	0	

RESULTS

As shown in Table 2, the pH levels ranged from 5.6 to 8.3 and were significantly different for both wells (p<0.001) and dates (p<0.001) as determined by two factor ANOVA using ranked data. Solids ranged from 10 to 140 mg/L and also were significantly different for wells (p<0.001) and dates (p<0.01). The nitrate nitrogen in the wells varied from 0 to 21.1 mg/L. These values were significantly different for wells (p<0.001) but not for dates. The nitrate levels for well 1 (7.7 + 1.2 mg/L) and well 4 (7.4 + 0.8 mg/L) were slightly less than the MCL (10mg/L) and the mg/L) exceeded the MCL by almost two-fold (Fig

The heterotrophic counts ranged from 1,2 mL and were significantly different for wells (p<0 values are higher than the recommended level of 2 drinking water. The coliforms ranged from 0 to 6, significantly different for wells (p<0.01) and dates 42) of the samples exceeded the MCL of zero coli wasfound in four of the seven samples from well 2 from wells 3 and 6. Fecal streptococci (30 to >2.4 present in all wells. The average microbial conter Figure 4.

A total of 23 isolates were identified on th morphological and biochemical characteristics (A

9

MATERIALS AND METHODS

Sampling Sites and Protocols

Wells 1-3 were located in Madison County, Illinois, and wells 4-6 were located in St. Clair County, Illinois. Well location, construction, age, and depth are shown in Table 1. None of the wells had been chlorinated. Seven samples from each well were collected in sterile containers and held at 10 °C for no more than 24 hr prior to microbial analysis.

Chemical Analyses

The pH of each sample was determined with an Orion pH meter which was standardized prior to use (American Public Health Association [APHA], 1989). The total dissolved solids were determined in a drying oven using the Total Solids Dried at 103-105 °C Method (APHA, 1989).

Nitrate nitrogen was determined using the NitraVer 5 cadmium reduction method (Hach Company, 1992). All glassware was prewashed in 0.1 N HCl and rinsed in deionized water prior to use. Potassium nitrate standards were prepared at concentrations of 1, 5, 10, and 20 mg/L nitrate. Duplicate 5.0 g portions of each standard and two 5.0 g portions of deionized water (blank) were placed in test tubes. One packet of NitraVer 5 was added to each tube and the tube shaken vigorously for 1 min. The absorbance at 385 nm was determined in a Spec 20 which had been previously zeroed against the blank. Water samples were treated and analyzed the same way as the standard solutions.

Microbiological Analyses

The heterotrophic plate count was determined with Redigel Aerobic Count plates (3M Microbiology Products, 1995). Both 1.0 and 0.1 ml aliquots were plated in duplicate and incubated at 35 ± 0.5 °C for 24 hrs and counted using standard methods. Coliforms

6

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of nitrate and nitrite in drinking

DISCUSSION AND CONCLUSIONS

The purpose of this project was to evaluate the chemical and microbiological quality of private well water and test the hypothesis that quality varies between wells and sampling dates. The pH, total solids and coliforms were significantly different for both wells and dates, while nitrates and heterotrophs were significantly different for wells only. The nitrate data are consistent with those of Panno et al. (1966) who reported that nitrate levels differed significantly for wells but not for periods. The variabili fluctuations in both te

Although the total dissolved solids, were close to the MCI of 10 mg/L (Table 1, F private wells in Illinoi 1966). Water containi for human adults and l months of age (Bicki a that these levels may b 1992; Ward et al., 199

The nitrate le mg/L found during the

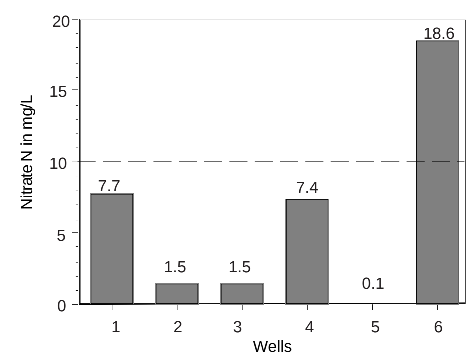

FIG. 2. Average Nitrate Content of Wells. The average of all seven readings of the nitrate level for each well is given. The dotted line represents the maximum contaminant level (MCL) which the EPA has established for public drinking water.

EDITORIAL NOTE: This figure has been enlarged for ease of reading. It would not be scaled as such in an actual paper.

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Appendix 6: Judging Scoresheets - rubrics

Twin Cities Regional Science Fair

Judges' Scoring Sheet for Project Presentation

This sheet is judges' use only. It will not be returned to the students.

Judge Number:
Judge Name:
Project Number:
Student(s):
Title:
Category:

	Max Score	Actual Score
Research Question or Problem: For Science Projects: ☐ Clear and focused purpose ☐ Identifies contribution to field of study ☐ Testable using scientific methods For Engineering Projects: ☐ Description of a practical need or problem to be solved ☐ Definition of criteria for proposed solution ☐ Explanation of constraints	**(10)**	
Design and Methodology: For Science Projects: ☐ Well-designed plan & data collection methods ☐ Variables and controls defined, appropriate & complete For Engineering Projects: ☐ Exploration of alternatives to answer need or problem ☐ Identification of a solution ☐ Development of a prototype/model	**(15)**	
Execution: Data Collection, Analysis, and Interpretation For Science Projects: ☐ Systematic data collection & analysis ☐ Reproducibility of results ☐ Appropriate application of mathematical & statistical methods ☐ Sufficient data collected to support interpretation & conclusions For Engineering Projects: ☐ Prototype demonstrates intended design ☐ Prototype has been tested in multiple conditions / trials ☐ Prototype demonstrates engineering skill & completeness	**(20)**	
Creativity: For Science Projects: ☐ Project demonstrates significant creativity in more or more of the above criteria For Engineering Projects: ☐ Project demonstrates significant creativity in more or more of the above	**(20)**	
Poster Presentation: (For both science & engineering projects) ☐ Logical organization of material ☐ Clarity of graphics and legends ☐ Supporting documentation displayed	**(10)**	
Interview Presentation: (For both science & engineering projects) ☐ Clear, concise, thoughtful responses to questions ☐ Understanding of basic science relevant to project ☐ Understanding interpretation and limitations of results & conclusions ☐ Degree of independence in conduction project ☐ Recognition of potential impact in science, society and/or economics ☐ Quality of ideas for further research ☐ For team projects, contributions to and understanding of project by all members	**(25)**	
Total:	**(100)**	

Judge #:___________ Project #____________

Improvements & Comments

Check areas that need improvement:

- ☐ Independent thought not clearly demonstrated
- ☐ Communication and understanding of experiment's implications unclear
- ☐ Variables not clearly defined
- ☐ Lack of proper experimental control
- ☐ Statistical analysis missing or not understood
- ☐ Lab notebook not available
- ☐ Bibliography not present or too limited for scope of project
- ☐ Conclusions are not based on repeated observations
- ☐ Scientific understanding has errors or was not clearly communicated
- ☐ For TEAMS only: Team members did not clearly demonstrate individual roles and contributions to the project.

Additional Comments:

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Twin Cities Regional Science Fairs
Research Paper Competition Score Sheet

Judge Number: _________ Judge Name: ____

Research Paper Title:____
Paper Author:___________________________________
Grade: _____ Category:____

Guide for grading scale within each division (middle school or high school):
Excellent (90-100) Good (80-89) Fair (60-79) Poor (1-59)

Possible Points	Evaluation Criteria	Points assigned
(5)	Background of Problem or Objective Source of the idea, evidence of literature search, summary of what others have done on the topic	_____
(5)	Statement of Purpose or Identification of Problem Clear objectives clearly stated, recognition of implications or importance of problem	_____
(25)	Research Design, Procedures (Materials & Methods), Results For Science: Appropriateness of research design & procedures, identification and control of variables, reproducibility, reasonable assumptions, innovative technique For Engineering, Computer Science, Technology: Workable solution that is acceptable to a potential user, recognition of economic feasibility of solution, recognition of relationship between design and end product, design	_____
(20)	Data For Science: Validity, accuracy, precision, recognition of sources of error For Engineering, Computer Science, Technology: Tested for performance under conditions of use, reproducibility, results offer an improvement over previous alternatives	_____
(15)	Discussion and Conclusions Clarity in stating conclusion(s), logical conclusion that is relevant to the research problem or design objective and the results of testing or experimentation, recognizes limits and significance of results or design achievement, evidence of student's understanding of the scientific or technological principles, theoretical or practical implications recognized, what was learned?, relate back to hypothesis or design objective	_____
(5)	Further Ideas Predictions, ideas about refining study or design, ideas about Increasing precision/accuracy, new questions or ideas raised	_____
(25)	Written Presentation – Skill in communicating results (20) Clear presentation, correct grammar, good organization, logical developments, includes bibliography (references, works cited), definition of terms as necessary, appropriate use of diagrams or charts	_____
	(5) Acknowledgement of Sources and Major Assistance Received	_____

TOTAL out of 100 possible: _____

Judge #:__________ Paper #___________

Twin Cities Regional Science Fairs
Research Paper Improvements & Comments

Congratulations on writing a scientific research paper and competing in the Twin Cities regional level! This is a high honor, which few young people will achieve. Here are some specific things that you can work on to help you advance even further next year.

- ☐ Spelling and/or grammar need work.
- ☐ Bibliography/Works Cited is missing or needs work in form or content. Use original sources, not sources that are quoted by your sources. Include the URL and date accessed for web site references. (OR) Acknowledgements statement is missing, if needed. Major help from others (labs, professionals, parents, etc.) must be acknowledged.
- ☐ Pages of the body of the paper must be numbered.
- ☐ Hypothesis and/or Problem (or design objective) needs to be clearly stated.
- ☐ Metric measurements are expected in scientific research.
- ☐ The Scientific Method needs to be apparent in your work. Knowledge of variables, controls, and sources of error should be demonstrated. The experimental work presented must be that of the student. (For design projects, must be a workable solution to design objective – economically or technologically feasible.)
- ☐ Charts and graphs should be clearly labeled.
- ☐ The abstract is missing, not clearly stated, or is over the 250 word limit.
- ☐ Conclusions must be based on repeated observations; design projects must have some sort of testing of the design.

Additional Comments:

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Judging Criteria for Intel ISEF

The following evaluation criteria are used for judging at the Intel ISEF. As shown below, science and engineering have different criteria, each with five sections as well as suggested scoring for each section. Each section includes key items to consider for evaluation both before and after the interview.

Students are encouraged to design their posters in a clear and informative manner to allow pre-interview evaluation and to enable the interview to become an in-depth discussion. Judges should examine the student notebook and, if present, any special forms such as Form 1C (Regulated Research Institution/Industrial Setting) and Form 7 (Continuation of Projects). Considerable emphasis is placed on two areas: *Creativity* and *Presentation,* especially in the *Interview* section, and are discussed in more detail below.

Creativity: A creative project demonstrates imagination and inventiveness. Such projects often offer different perspectives that open up new possibilities or new alternatives. Judges should place emphasis on research outcomes in evaluating creativity.

Presentation/Interview: The interview provides the opportunity to interact with the finalists and evaluate their understanding of the project's basic science, interpretation and limitations of the results and conclusions.

- If the project was done at a research or industrial facility, the judge should determine the degree of independence of the finalist in conducting the project, which is documented on Form 1C.
- If the project was completed at home or in a school laboratory, the judge should determine if the finalist received any mentoring or professional guidance.
- If the project is a multi-year effort, the interview should focus ONLY on the current year's work. Judges should review the project's abstract and Form 7 (Intel ISEF Continuation Projects) to clarify what progress was completed this year.
- Please note that both team and individual projects are judged together, and projects should be judged only on the basis of their quality. However, all team members should demonstrate

significant co an understanding of the project.

Judging Criteria for Science Projects

I. Research Question (10 pts)

___ clear and focused purpose

___ identifies contribution to field of study

___ testable using scientific methods

II. Design and Methodology (15 pts)

___ well designed plan and data collection methods

___ variables and controls defined, appropriate and complete

III. Execution: Data Collection, Analysis and Interpretation(20 pts)

___ systematic data collection and analysis

___ reproducibility of results

___ appropriate application of mathematical and statistical methods

___ sufficient data collected to support interpretation and conclusions

IV. Creativity (20 pts)

___ project demonstrates significant creativity in one or more of the above criteria

V. Presentation (35 pts)

a. Poster 10 pts)

___ logical organization of material

___ clarity of graphics and legends

___ supporting documentation displayed

b. Interview (25 pts)

___ clear, concise, thoughtful responses to questions

___ understanding of basic science relevant to project

___ understanding interpretation and limitations of results and conclusions

_ degree of independence in conducting project

___ recognition of potential impact in science, society and/or economics

___ quality of idea ... rch

___ for team projects, contributions to and understanding of project by all members

Judging Criteria for Engineering Projects

I. Research Problem (10 pts)

___ description of a practical need or problem to be solved

___ definition of criteria for proposed solution

___ explanation of constraints

II. Design and Methodology (15 pts)

___ exploration of alternatives to answer need or problem

___ identification of a solution

___ development of a prototype/model

III. Execution: Construction and Testing(20 pts)

___ prototype demonstrates intended design

___ prototype has been tested in multiple conditions/trials

___ prototype demonstrates engineering skill and completeness

IV. Creativity (20 pts)

___ project demonstrates significant creativity in one or more of the above criteria

V. Presentation (35 pts)

a. Poster (10 pts)

___logical organization of material

___clarity of graphics and legends

___ supporting documentation displayed

b. Interview (25 pts)

___ clear, concise, thoughtful responses to questions

___ understanding of basic science relevant to project

___ understanding interpretation and limitations of results and conclusions

_ degree of independence in conducting project

___ recognition of potential impact in science, society and/or economics

___ quality of ideas for further research

___ for team projects, contributions to and understanding of project by all members

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Junior Science & Humanities Symposium
Judging Score Sheet
Research Paper Presentation

http://www.jshs.org/guidelines.html

Name of Student: ____________________________________ Name of Judge: ____

JSHS recognizes students for original research achievements in the sciences, technology, engineering or mathematics (STEM). The overall test is that students demonstrate valid investigation and experimentation aimed at discovery of knowledge. The judging criteria and scoring for JSHS are presented. A total score of 30 points is assigned using the below scale and serves as the basis for discussions among the judging team. Rank each students' oral presentation using the following criteria and weights:

5 = Superior **4 = Excellent** **3 = Good** **2 = Satisfactory** **1=Fair**

Judging Criteria	Suggested Weight
Statement and identification of research problem • Is the problem clearly stated? • Does the presenter demonstrate understanding of existing knowledge about the research problem?	1 2 3 4 5
Scientific thought, creativity/originality • Student demonstrates his or her individual contributions to and understanding of the research problem • Appropriate duration of collection and data analysis • Innovation of Original Concept and Scientific Thought/Process o Standard Protocol/Design o Innovative Protocol/Design	1 2 3 4 5
Research design, procedures (materials & methods), results **1. Science** • Appropriateness of research design and procedures • Process skills demonstrated by the student in the solution to the research problem and/or the research design • Identification and control of variables • Reproducibility **2. Engineering, computer science, technology** • Workable solution that is acceptable to a potential user • Recognition of economic feasibility of solution • Recognition of relationship between design and end product • Tested for performance under conditions of use • Results offer an improvement over previous alternatives	1 2 3 4 5
Discussion/Conclusions • Clarity in stating conclusion • Logical conclusion that is relevant to the research problem and the results of experimentation or testing • Recognizes limits and significance of results • Evidence of student's understanding of the scientific or technological principles • Theoretical or practical implications recognized • What was learned?	1 2 3 4 5
Skill in communicating research results-- Oral Presentation and written report • Clarity in communicating research results to non-specialized audience and to judges • Definition of terms as necessary • Appropriate use of audio-visuals • Response to questions from audience and judges	1 2 3 4 5
Includes References/Bibliograhy and major assistance received	1 2 3 4 5
TOTAL SCORE	

Appendix 7: Research Plan Instructions

The research plan is a typed Word document. The updated research plan instruction sheet is provided in the current year forms from Society for Science for ISEF.

See the Rules and Forms at: https://student.societyforscience.org/intel-isef-forms

Research Plan/Project Summary Instructions

A complete Research Plan/Project Summary is required for ALL projects and must accompany Student Checklist (1A).

1. All projects must have a Research Plan/Project Summary written prior to experimentation following the instructions below to detail the rationale, research question(s), methodology, and risk assessment of the proposed research.
   a. If changes are made during the research, such changes can be added to the original research plan as an addendum, recognizing that some changes may require returning to the IRB or SRC for appropriate review and approvals. If no additional approvals are required, this addendum serves as a project summary to explain research that was conducted.
   b. If no changes are made from the original research plan, no project summary is required.

2. Some studies, such as an engineering design or mathematics projects, will be less detailed in the initial project plan and will change through the course of research. If such changes occur, a project summary that explains what was done is required and can be appended to the original research plan.

3. The Research Plan/Project Summary should include the following:
   a. **RATIONALE:** Include a brief synopsis of the background that supports your research problem and explain why this research is important and if applicable, explain any societal impact of your research.
   b. **RESEARCH QUESTION(S), HYPOTHESIS(ES), ENGINEERING GOAL(S), EXPECTED OUTCOMES:** How is this based on the rationale described above?
   c. Describe the following in detail:
      - **Procedures:** Detail all procedures and experimental design including methods for data collection. Describe only your project. Do not include work done by mentor or others.
      - **Risk and Safety:** Identify any potential risks and safety precautions needed.
      - **Data Analysis:** Describe the procedures you will use to analyze the data/results.
   d. **BIBLIOGRAPHY:** List major references (e.g. science journal articles, books, internet sites) from your literature review. If you plan to use vertebrate animals, one of these references must be an animal care reference.

Items 1–4 below are subject-specific guidelines for additional items to be included in your research plan/project summary as applicable.

1. **Human participants research:**
   a. Participants: Describe age range, gender, racial/ethnic composition of participants. Identify vulnerable populations (minors, pregnant women, prisoners, mentally disabled or economically disadvantaged).
   b. Recruitment: Where will you find your participants? How will they be invited to participate?
   c. Methods: What will participants be asked to do? Will you use any surveys, questionnaires or tests? What is the frequency and length of time involved for each subject?
   d. Risk Assessment: What are the risks or potential discomforts (physical, psychological, time involved, social, legal, etc.) to participants? How will you minimize risks? List any benefits to society or participants.
   e. Protection of Privacy: Will identifiable information (e.g., names, telephone numbers, birth dates, email addresses) be collected? Will data be confidential/anonymous? If anonymous, describe how the data will be collected. If not anonymous, what procedures are in place for safeguarding confidentiality? Where will data be stored? Who will have access to the data? What will you do with the data after the study?
   f. Informed Consent Process: Describe how you will inform participants about the purpose of the study, what they will be asked to do, that their participation is voluntary and they have the right to stop at any time.

2. **Vertebrate animal research:**
   a. Discuss potential ALTERNATIVES to vertebrate animal use and present justification for use of vertebrates.
   b. Explain potential impact or contribution of this research.
   c. Detail all procedures to be used, including methods used to minimize potential discomfort, distress, pain and injury to the animals and detailed chemical concentrations and drug dosages.
   d. Detail animal numbers, species, strain, sex, age, source, etc., include justification of the numbers planned.
   e. Describe housing and oversight of daily care
   f. Discuss disposition of the animals at the termination of the study.

3. **Potentially hazardous biological agents research:**
   a. Give source of the organism and describe BSL assessment process and BSL determination.
   b. Detail safety precautions and discuss methods of disposal.

4. **Hazardous chemicals, activities & devices:**
   • Describe Risk Assessment process, supervision, safety precautions and methods of disposal.