A Comparison of the Scientific Method and the Design Process

Most projects will be experimental in nature using the scientific method and will fall into the experimental category. However, if the objective of your project is to invent a new device, procedure, computer program, or algorithm, then your project may fall into the design category.

Scientific Method	**Design Process**
Identify and write a testable question	Define a need or real world problem
Perform background research	Perform background research
Formulate a hypothesis and identify variables	Establish design criteria
Design an experiment, establish procedure	Prepare preliminary design(s)
Test the hypothesis by conducting the experiment	Build and test a prototype
Analyze the results and draw a conclusion(s)	Test and redesign as necessary
Present results	Present results

Scientific Method

1. IDENTIFY AND WRITE A TESTABLE QUESTION

   Decide what question you want to answer or what problem you want to solve. A testable hypothesis is answered through observations or experiments that provide evidence. Be sure to have adequate technical and financial resources available to conduct your research. State your objective clearly in writing.

2. PERFORM BACKGROUND RESEARCH

   Before you begin your project, you must become as knowledgeable as you can about your topic and about other research that has been done on that topic. You may use books, scientific literature, the Internet, or interviews with scientists or other knowledgeable people. This research not only helps you get ready to conduct your experiment, but will form the background for the Review of Literature **(page 15*)** required in your report.

Design Process

1. DEFINE A NEED

   Instead of stating a question, state a need. Can you describe in detail a problem that your design will solve? Does your research relate to a real world need?

2. PERFORM BACKGROUND RESEARCH

   For a design project, the background research may include:
   - A complete description of your target user(s)
   - Information about the science behind your design area
   - Answers to research questions about user needs
   - Information about products that meet similar needs
   - Research about design criteria
   - What existing solutions are out there already, and how well do they solve the problem?

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3. FORMULATE A HYPOTHESIS AND IDENTIFY VARIABLES Based on the background research, write a statement that predicts the outcome of the experiment. Many hypotheses are stated in an “If... then” statement where the “If” statement pertains to the independent variable, and the “then” statement pertains to the dependent variable. For example: ‘<u>If</u> plants are grown under various colors of light, <u>then</u> the plants grown under the blue and red lights will show the greatest increase in biomass.’	3. ESTABLISH DESIGN CRITERIA Engineering Projects: Decide what features your design must have, for example: size, weight, cost, performance, power, etc. Perhaps include a table showing how each design criterion will be addressed by the features of the product being designed. Computer Science Projects: Creating or writing a new algorithm to solve a problem or improve on an existing algorithm. Discuss the criteria of the algorithm. Mathematics Projects: Proofs, development of a new model or explanation, concept formation or mathematical model design.
4. DESIGN AN EXPERIMENT, ESTABLISH A PROCEDURE Decide what data you need to meet your research objective and how you will collect it. Be sure to consider possible hazards in your experimental approach and decide how you can conduct your research safely **(pages 10-14*)**. In addition, there are special rules concerning the use of human and non-human vertebrates in your research. Be sure to consult these rules before finalizing your experimental design. In order to obtain valid experimental results, consider the following items when designing the experiment: • Make sure the quantity and quality of data you collect provides a reasonable assurance that your research objectives will be met. • Identify all <u>significant</u> variables that could affect your results. • To the best of your ability, control any significant variables not manipulated in your experiment. • Include a control or comparison group in your experimental design. Be sure to establish deadlines for completing the different phases of your research. These phases might include building equipment, collecting data, analyzing the results, writing the report and construction your display board. Remember to use metric measurements whenever possible.	4. PREPARE A PRELIMINARY DESIGN Engineering projects should have a materials list, programming and mathematical projects do not need a materials list. Projects should include a block diagram, flowchart or sketch of the design that shows all of the parts or subsystems of the design. Describe how all of the parts of the design will work together.
5. CONDUCT THE EXPERIMENT Follow your experimental design to collect data and make observations. Be sure to keep a log as	5. BUILD AND TEST A PROTOTYPE (Programs, algorithms, and mathematical models may be considered prototypes)

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you conduct the experiment to record your data, any problems you encounter, how you addressed them, and how these problems might have affected your data. This log will be used when you write your report. Keep these points in mind when conducting your experiment: • If you get results that seem wrong or inconsistent, do not just throw them out. Try to figure out what happened. Maybe the data is correct and your hypothesis is flawed. Try to explain these “outliers” in your Data, Analysis, and Discussion section. • Don’t get discouraged when you encounter problems. Scientists often have to repeat experiments to get good, reproducible results. Sometimes you can learn more from a failure than you can from a success.	When others are conducting their experiment, investigators doing an engineering, computer programming, or mathematics project should be constructing and testing a prototype of their best design. For example, you may involve targeted users in your testing to get feedback on your design; or some projects may analyze data sets.
6. ANALIZE THE RESULTS AND DRAW CONCLUSIONS Make sufficient calculations, comparisons and/or graphs to ensure the reliability and repeatability of your experiment. In what way does this analysis confirm or refute) your hypothesis. What conclusion(s) can you draw from this analysis?	6. REDESIGN AND RETEST Evidence that changes in design were made to better meet the performance criteria established at the beginning of the project. Test results may be included in tables, if applicable. Data analysis/validation may also be a part of this step.
7. REPORT THE RESULTS Your report should provide all the information necessary for someone who is unfamiliar with your project to understand what you were trying to accomplish, how you did it, and whether you succeeded. It should be detailed enough to allow someone else to duplicate your experiment exactly. Be sure to include charts and graphs to summarize your data. The report should not only talk about your successful experimental attempts, but also the problems you encountered and how you solved them. Be sure to explain what new knowledge has been gained and how it leads to further questions. For IJAS judging, you must also prepare an oral report **(page 17*)** and a display board **(page l8*)** to accompany the written report. Be sure to consult the IJAS policy manual, section “Writing A Scientific Research Paper,” for report guidelines **(page 15*)**. These guidelines must be followed exactly.	7. REPORT THE RESULTS Your report should provide all the information necessary for someone who is unfamiliar with your project to understand what you were trying to accomplish, how you did it, and whether you succeeded. The report should not only talk about your successful design attempts, but also the problems you encountered and how you solved them. Be sure to explain what new knowledge has been gained and how it leads to further questions. For IJAS judging, you must also prepare an oral report **(page 17*)** and a display board **(page 18*)** to accompany the written report. Be sure to consult the IJAS policy manual, section “Writing A Scientific Research Paper,” for report guidelines **(page 15*)**. These guidelines must be followed exactly.

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