# Experimental Design

Dr. Kaarin Goncz
kaarin.goncz@nmt.edu

# EXPERIMENTAL DESIGN

**DESCRIPTION**: This event will determine the participant's ability to design, conduct, and report the findings of an experiment conducted entirely on site.

**A TEAM OF UP TO**: 3
**EYE PROTECTION**: yes
**APPROXIMATE TIME**: 50 minutes

# What Students Do

Students will design an experiment that is simple in design and involves only one independent variable and one dependent variable.

Multiple trials will be made and a report will be prepared within the event time period, which is about 50 minutes

# EXPERIMENTAL DESIGN

**EVENT PARAMETERS:**

- Participants must bring goggles and writing utensils. Chemicals that require other safety clothing will not be used.

- ***Division B teams*** may bring one timepiece, one linear measuring device, and one stand-alone non-programmable non-graphing calculator.

- ***Division C teams*** may bring one timepiece, one linear measuring device, and one stand-alone calculator of any type.

- The event supervisor will supply a report packet, based on the Experimental Design Checklist posted on the event page at soinc.org, for recording their experimental information and data.

- The event supervisor will provide each team with identical sets of materials either at a distribution center or in an individual container.

# Set of Materials

# EXPERIMENTAL DESIGN

**THE COMPETITION:**

- The teams must design, conduct, and report the findings of an experiment actually conducted on site that addresses the assigned question/topic area provided by the event supervisor.

- The assigned question/topic area should be the same for all teams and allow the participants to conduct experiments involving relationships between independent and dependent variables (i.e., height vs. distance).

- During the first 20 minutes of the event, participants will receive the assigned question/topic area, materials, and the first half of the report packet so they can focus on designing and conducting their experiment.

# EXPERIMENTAL DESIGN

- After the first 20 minutes, participants will receive the last half of the report packet and while they may continue experimenting, participants will also begin to analyze their data and report findings.

- Each team must use at least two of the provided materials to design and conduct an experiment. The materials will be listed on the board or placed on a card for each team. If provided, both the card and the container will be considered part of the materials. The identity of the materials will be unknown until the start of the event.

- When a team finishes, all materials must be returned to the event supervisor along with all written materials and reports.

# EXPERIMENTAL DESIGN

**SCORING:**

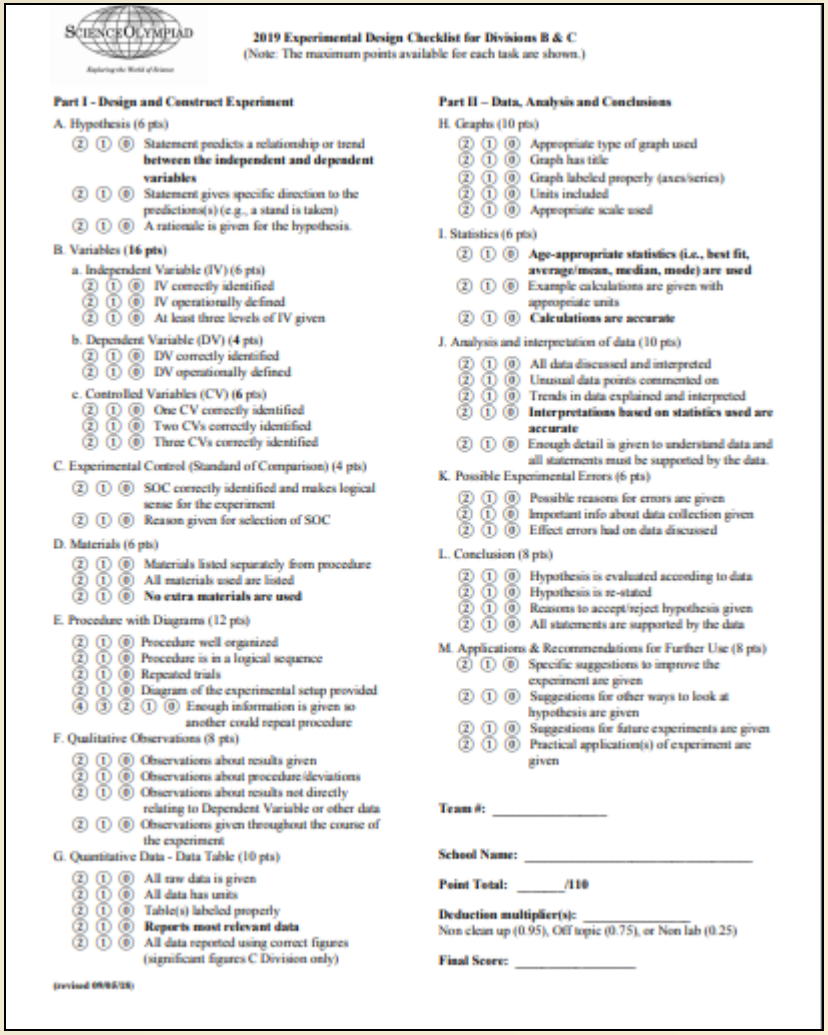
- High score wins. Scoring will be done using the Experimental Design Checklist found on the Science Olympiad website (soinc.org).

- Points will be awarded depending upon the completeness of the response. Zero points will be given for no responses as well as illegible or inappropriate responses.

- Ties will be broken by comparing the point totals in the scoring areas in the following order:

1. Variables
2. Procedure
3. Analysis of Results (Claim, Evidence, & Reason)
4. Graph
5. Raw Data Table

# Experimental Design Checklist



**2019 Experimental Design Checklist for Divisions B & C**
(Note: The maximum points available for each task are shown.)

**Part I - Design and Construct Experiment**

A. Hypothesis (6 pts)
- ② ① ⓪ Statement predicts a relationship or trend **between the independent and dependent variables**
- ② ① ⓪ Statement gives specific direction to the prediction(s) (e.g., a stand is taken)
- ② ① ⓪ A rationale is given for the hypothesis.

B. Variables (**16 pts**)

a. Independent Variable (IV) (6 pts)
- ② ① ⓪ IV correctly identified
- ② ① ⓪ IV operationally defined
- ② ① ⓪ At least three levels of IV given

b. Dependent Variable (DV) (**4** pts)
- ② ① ⓪ DV correctly identified
- ② ① ⓪ DV operationally defined

c. Controlled Variables (CV) (**6** pts)
- ② ① ⓪ One CV correctly identified
- ② ① ⓪ Two CVs correctly identified
- ② ① ⓪ Three CVs correctly identified

C. Experimental Control (Standard of Comparison) (4 pts)
- ② ① ⓪ SOC correctly identified and makes logical sense for the experiment
- ② ① ⓪ Reason given for selection of SOC

D. Materials (6 pts)
- ② ① ⓪ Materials listed separately from procedure
- ② ① ⓪ All materials used are listed
- ② ① ⓪ **No extra materials are used**

E. Procedure with Diagrams (12 pts)
- ② ① ⓪ Procedure well organized
- ② ① ⓪ Procedure is in a logical sequence
- ② ① ⓪ Repeated trials
- ② ① ⓪ Diagram of the experimental setup provided
- ④ ③ ② ① ⓪ Enough information is given so another could repeat procedure

F. Qualitative Observations (8 pts)
- ② ① ⓪ Observations about results given
- ② ① ⓪ Observations about procedure/deviations
- ② ① ⓪ Observations about results not directly relating to Dependent Variable or other data
- ② ① ⓪ Observations given throughout the course of the experiment

G. Quantitative Data - Data Table (10 pts)
- ② ① ⓪ All raw data is given
- ② ① ⓪ All data has units
- ② ① ⓪ Table(s) labeled properly
- ② ① ⓪ **Reports most relevant data**
- ② ① ⓪ All data reported using correct figures (significant figures C Division only)

(revised 09/05/18)

**Part II – Data, Analysis and Conclusions**

H. Graphs (10 pts)
- ② ① ⓪ Appropriate type of graph used
- ② ① ⓪ Graph has title
- ② ① ⓪ Graph labeled properly (axes/series)
- ② ① ⓪ Units included
- ② ① ⓪ Appropriate scale used

I. Statistics (6 pts)
- ② ① ⓪ **Age-appropriate statistics (i.e., best fit, average/mean, median, mode) are used**
- ② ① ⓪ Example calculations are given with appropriate units
- ② ① ⓪ **Calculations are accurate**

J. Analysis and interpretation of data (10 pts)
- ② ① ⓪ All data discussed and interpreted
- ② ① ⓪ Unusual data points commented on
- ② ① ⓪ Trends in data explained and interpreted
- ② ① ⓪ **Interpretations based on statistics used are accurate**
- ② ① ⓪ Enough detail is given to understand data and all statements must be supported by the data.

K. Possible Experimental Errors (6 pts)
- ② ① ⓪ Possible reasons for errors are given
- ② ① ⓪ Important info about data collection given
- ② ① ⓪ Effect errors had on data discussed

L. Conclusion (8 pts)
- ② ① ⓪ Hypothesis is evaluated according to data
- ② ① ⓪ Hypothesis is re-stated
- ② ① ⓪ Reasons to accept/reject hypothesis given
- ② ① ⓪ All statements are supported by the data

M. Applications & Recommendations for Further Use (8 pts)
- ② ① ⓪ Specific suggestions to improve the experiment are given
- ② ① ⓪ Suggestions for other ways to look at hypothesis are given
- ② ① ⓪ Suggestions for future experiments are given
- ② ① ⓪ Practical application(s) of experiment are given

**Team #:** _____

**School Name:** _____

**Point Total:** _____/110

**Deduction multiplier(s):** _____
Non clean up (0.95), Off topic (0.75), or Non lab (0.25)

**Final Score:** _____

# EXPERIMENTAL DESIGN

- Any participant not following proper safety procedures will be asked to leave the room and will be disqualified from the event.

- The final score of a team will be multiplied by 0.95 if they do not follow cleanup procedures.

- The final score of a team will be multiplied by 0.75 if their experiment does not address the assigned question/topic area.

- The final score of a team will be multiplied by 0.25 if they do not conduct an experiment (i.e., performing a dry lab, making up data or trials).

Recommended Resources: The Science Olympiad Store (store.soinc.org) carries the Experimental Design CD and Problem Solving/Technology CD; other resources are on the event page at soinc.org

# What are Students Likely to Encounter

- A topics, like light, flight, paper airplanes, simple machines, biological relationships, the properties of water, absorbency, properties of material substances as mystery “rocks”, a construction project, or gravity will be introduced

- Or, a question for experimentation

# Then what ….

Once the broad topic or question for experimentation is known, it becomes necessary to narrow the topic in order to develop a testable problem.

The **problem is a statement that defines the topic of the experiments and identifies the relationship between the two variables to be tested. It is a cause and effect relationship where the change or manipulation of a variable will cause the response by another variable.**

# The Hypothesis is Key

This relationship must be testable with the materials available and the response must be measurable with the instruments and measuring devices available. It must specific enough to allow the design of an experiment.

It should generalize the factors being tested as “The effect of the (independent or manipulated variable) upon the (dependent or responding variable).” Notice that the statement will specify what relationship is being tested. An example would be “The effect of the molasses concentration upon the carbon dioxide production of yeast.”

# Strategy for Designing Experiment

The best place to start is to consider the factors or variables, which might be manipulated in relationship to the broad topic and the list of materials available. The topic is broad in nature and the list of materials is extensive enough to allow for the design of several different experiments so a strategy for developing testable problems is a good idea.

This strategy for developing a testable problem includes the following steps:

- Make a list of the possible variables.
- Determine the relationships between the variables. (Be sure they fit the topic)
- Write these relationships in the format of a testable problem as “The effect of the (independent or manipulated variable) upon the (dependent or responding variable).” or “What is the effect of the (independent variable being manipulated) upon the dependent or responding variable ”
- Be sure to specify how the variable will be manipulated and what kind of response to anticipate.
- Examine the relationships to be sure that they are specific enough to test just on aspect or the variable.
- Choose which relationship you will design an experiment to test.

# Practice - Materials

- table salt
- sugar – sucrose
- water
- a triple beam balance
- celery stalks
- 3” baby carrot pieces
- 2” potato cubes
- food coloring
- 5 plastic cups
- 2 plastic spoons

List the properties that might be tested using this topic and this list of materials. These are the relationships which might be tested.

1. Osmosis
2. Capillary action
3. Diffusion
4. Homeostasis

What factors or variables can be changed or manipulated for each of the relationships that you listed? (Manipulated or Independent Variable)

What factors or variables can be changed or manipulated for each of the relationships that you listed? (Manipulated or Independent Variable)

1. Concentration of salt
2. Concentration of sugar
3. Thickness of potato slices
4. Amount of color

What factors or variables might respond to the changes listed in question 2? (Responding or Dependent Variable)

What factors or variables might respond to the changes listed in question 2? (Responding or Dependent Variable)

1. Movement of water up celery stalk
2. Depth of color penetration into potato slices
3. Weight change of carrot pieces

Formulate a list of testable problems for the Biology topic using the supplied materials. Use the format: The effect of (manipulated variable) on the (responding variable).

1. The more salt in the water the less the colored water will penetrate into the potato

**Note**: *The effect of the independent variable on the dependent variable is specific and states an "increase" or "decrease"*

# Then Conduct the Experiment

- Write down everything that is required
- The process is key – the results don't have to match the hypothesis!
- Have fun ☺

# Final Tips

- Remember to include a control
- Remember to note what variables are being held constant
- Short precise statements are preferable to lengthy explanations that try to cover everything!