

Experimental Design (XPD)

2017 Rules: B/C Division

XPD

- Statement of Problem
- Hypothesis
- Variables
 - Independent Variable (IV)
 - Dependent Variable (DV)
 - Controlled Variables (CV)
- Experimental Control
- Materials

XPD

- Procedure
- Qualitative Observation
- Quantitative Data
- Graphs
- Statistics
- Analysis of Results
- Experimental Errors

XPD

- Conclusions
- Recommendations for Future Research

Statement of Problem (4 pts)

- Concise statement or question, not a 'YES or NO' question.
- Defines the relationship you want to study.
- Must be testable with materials provided.

Hypothesis (8 pts)

“If the [IV] [increases/decreases] then the [DV] will [increase/decrease/stay the same.]”

- Must include both **IV** and **DV**
- Must take a stand and make a prediction.
- Must include a rationale for your prediction.
- [NEW] Include prior knowledge that contributed to the hypothesis.

Independent Variable (6 pts)

- Independent Variable
 - The variable **YOU** are in control of, the one you manipulate intentionally.
 - Must be operationally defined.
 - Include Units of Measurement
 - Include how the measurement is made.
 - Must include a minimum of 3 levels of the IV.

Dependent Variable (6 pts)

- Dependent Variable
 - The variable that is the outcome of the experiment, the one you measure as a result of your changing the **IV**.
 - Must be operationally defined.
 - Include units of measurement and how the measurement is made, if appropriate.
 - Make an odd number (3, 5, 7, etc.) of measurements for each level of the IV.

Controlled Variables (8 pts)

- Controlled Variables
 - Factors that could be IVs but are purposely held constant.
 - Factors that have a fixed value in the experiment.
 - Minimum of 4 listed.

Experimental Control (4 pts)

- Experimental Control or Standard of Comparison.
 - Used to detect hidden variables
 - Can be zero treatment, a level of IV, or and outside treatment.
 - Is specific to the experiment
 - Must include a rationale.

Materials (6 pts)

- In a list separate from procedure.
- List ONLY materials used, no extras.
- If using specialized equipment, include brand name, model number, and serial number.
 - ie, digital caliper, triple-beam balance, electronic balance.

Procedure (12 pts)

- Complete list of experimental steps.
- Sufficient detail to exactly reproduce the experiment.
- Can use, “... then repeat steps ...”
- Include 3, useful, diagrams.
- Repeat measurements for each level of the IV.

Qualitative Observations (8 pts)

- Descriptive observations throughout the experiment.
- Note any irregularities in procedure.
- Note extra observations that don't relate to the DV or other data.

Quantitative Data (10 pts/12 pts)

- Each table must have a title, be neat and organized. [C-Division Only] Must use correct significant figures. Include all raw data.
 - Data Table, displays all quantitative data collected.
 - Summary Data Table, includes most important data.
- Calculated values should have own column.
- Tables should have appropriate titles.

Graphs (10 pts)

- Appropriate type of graph used.
- Include:
 - Graph title (y-axis vs. x-axis)
 - Axes labeled properly
 - Units of measurement included
 - Appropriate scale of axes

Statistics (6 pts)

- Measures of Central Tendency
 - mean, median, mode
- Measures of Variation
 - range, standard deviation
 - frequency table, histogram
 - regression line - line of best fit
 - percent error

Statistics - Mean

- Mean = Sum of all measurements divided by the number of measurements.

$$\bar{X} = \left(\frac{1}{n} \right) \sum_{i=1}^n X_i \quad (\text{or})$$

$$\bar{X} = \left(\frac{X_1 + X_2 + X_3 + \dots + X_{n-1} + X_n}{n} \right)$$

Statistics - Median

- Median = The middle value of the data set when numbers are organized from least to greatest.
 - If n =odd, Median = middle number.
 - if n =even, Median = average of middle two numbers.

Statistics - Mode

- Mode = most frequently occurring number in a data set.
 - If numbers have the same frequency there is no Mode.
 - Be sure to explicitly state, “The mode cannot be determined because all measurements are unique.”

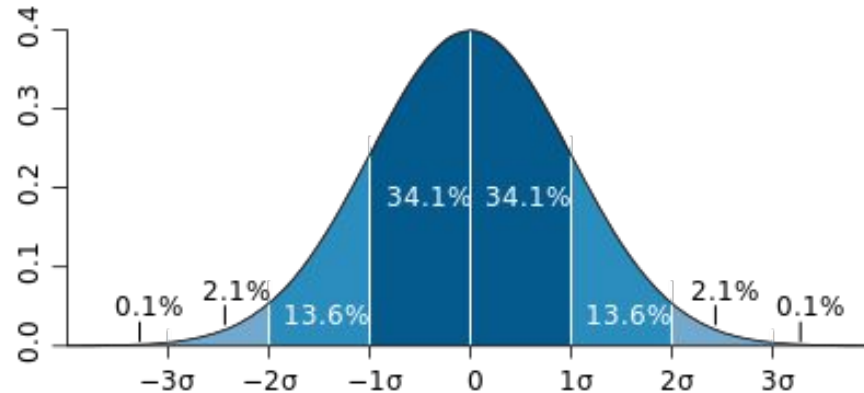
Statistics - Range

Range = The maximum value minus the minimum value of the data set.

$$R = X_{max} - X_{min}$$

Statistics - Standard Deviation

- Standard Deviation is a measure of how closely numbers are arranged around the Mean.



Statistics - Standard Deviation

- Formula

$$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \mu)^2}$$

Statistics - Standard Deviation

- 68-95-99.7 Rule
 - ~68% of the data falls within $\pm 1\sigma$
 - ~95% of the data falls within $\pm 2\sigma$
 - ~99.7% of the data falls within $\pm 3\sigma$

Statistics - Confidence Interval

- 95% Confidence Interval
 - 95% CI = (Mean or Median) +/- (0.5)*Range
- 99% Confidence Interval
 - 99% CI = (Mean or Median) +/- (0.75)*Range
- Use median with 3 measurements, use mean with 4+ measurements.
- Measurements outside the CI are outliers and should be discarded.

Statistics - other

- Frequency Table
 - Expression of variability for Qualitative Data.
- Histogram
 - Pictorial representation of a Frequency Table.
- Regression Line
 - Best Fit Line showing nature of data trend
- Percent Error
 - Proximity of experimental to expected value

Analysis/Interpretation (8 pts)

- Explanation of data, trends found, relevant statistics.
- Discussion and explanation of meaning.
- Discussion of data and significance.
- Discussion of which data should be retained or discarded.
- Do **NOT** just restate data, actually discuss.

Possible Experimental Errors (6 pts)

- Separate from analysis section.
 - Experimenter Error - Known errors in execution of procedure.
 - Random Error - Errors caused by inaccurate measurement tools, may make numbers higher or lower.
 - Systematic Error - Errors caused by faulty equipment, may make numbers either all higher or all lower.

Conclusion (8 pts)

- One paragraph summary stating purpose, major findings, and explanation of findings.
- Restate and evaluate hypothesis in light of data and statistics.
- Accept or reject hypothesis based on data.
- Do **NOT** include lots of numbers.

Application/Future Use (8 pts)

- Include a minimum of one improvement specific to your experiment.
- Discuss other possible experiments that could examine the same hypothesis.
- Include a minimum of one suggestion for a future experiment.
- Include at least one practical application.

Final Recommendations

- Know scoring rubric forward and backwards.
- Practice, practice, practice.
- Scores are generally very high, attention to the smallest detail can move you into the medals.

Coaches' Files

- This presentation
- Graphing Guide
- Example prompt

Event Supervisor Recommendations

3b) The event supervisor **MUST** assign a question/topic that determines the nature of the experiment.

- Get help
- Make sure grading is consistent
- Each spot on the rubric is 2 points
 - 118 pts. B-Div / 120 pts. C-Div