Natural Sciences Department
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Instructions on how to write a proper lab report

Data Processing and Presentation (DCP1)

1. Begin all data collection with qualitative observations. This will include descriptions and measurements in addition to the data collected. In field work this would be diagrams, photographs and descriptions of the habitat. We would also expect to see a range of measurements from the habitat such as temperature, light levels, Soil pH, river flow rates etc. In a laboratory experiment in addition to diagrams and photographs we would expect notes detailing what you had seen, heard, smelled. Remember to record the control variables such as the actual temperature of a waterbath. E.g. When you are carrying out a comparative study of different ecosystems (or parts of) you should collect enough measurements that will allow you to precisely characterize the location.
2. You must present all of your raw data. These are the measurements/ counts made during the experiment.
3. The data table should have a meaningful title. Normally this would include a reference to the independent and dependent variable along with the item or location of study.
4. This must be a fully ruled, closed table.
5. Each column should have a very clear heading which immediately identifies the type of data recorded. Tyr to avoid abbreviations that make the interpretation of the table difficult for another reader.
6. Adjust column headings to accommodate all the information rather than cut the information short.
7. State the units used in the measurement in the column headings using the appropriate symbols.
8. State the error associated with the measurement in the column heading. This will be stated immediately after the units as a plus and minus the value e.g. +/- 0.1g
9. The data in your table must all have the same number of decimal places. You can't have 23, 23.2 this should be 23.0, 23.2
10. All data should be centred.
11. When data logging is used, raw data is defined as any data produced by software and extracted by you from tables or graphs to be subsequently processed.
12. Students may present raw data collected using data logging as long as they are responsible for the **majority of software settings**. A screen shot of the data logging setting could be provided as evidence as an annex to the report.
13. The number of decimal places used in recorded data should not exceed that expressed by the sensitivity of the instrument used. In the case of electronic probes used in data logging, students will be expected to record the sensitivity of the instrument.
14. Data will be downloaded onto a spreadsheet (Excel) for presentation.

DCP (2) Analysis of Data

1. It may be necessary to calculate data in that case
   - Explain the choice of calculation.
   - Give the formula or pathway of the calculation
   - Give an example of at least one fully processed calculation.
2. Descriptive statistics such as the averages may be calculated. Justify the choice of average such as mean (integral data).
3. Add units of averages (can often be taken to one more decimal place) +/- error (uncertainty)
4. Add appropriate statistic that describes the range of the data e.g. max/min, standard deviation, confidence limits. Justify choice.
5. Calculated descriptive and/or inferential stats collected together in a table of processed data. This can be added to the raw data table as an extra column or row.
6. Correct units/ error for processed data/ decimal places
7. If anomalous data is to be left out of the analysis this must be justified. (like wrong measurements or strange results which cannot be right and would influence the outcome.
8. Decide if the data can be graphed
9. Justify the choice of graph
10. Organise qualitative data into useful format allowing for improved interpretation

DCP (3) Presenting Processed Data

<u>Tables</u>

1. Make a clear reference in the table to the independent variable and dependent variable, organisms, molecules or other biological material.

2. Processed data table must have the same standards as the raw data table as described in DCP(1).
3. It may be that the processed data is placed in an extension of the original raw data table.
4. Column headings with correct headings, units and errors are required.

Graphs

1. Your graph will need a meaningful title which can be interpreted at a glance. This means that an intelligent reader can tell what the graph is about without having to read the whole investigation. The title would include a reference to the independent variable, dependent variable, locations, organisms, molecules etc.
   e.g. The effect of increasing temperature on the rate of reaction of alpha amylase enzyme digesting its substrate amylase to maltose.
2. Choice of graph style justified with reference to the type of data you are presenting. Try to avoid simple bar graphs or histograms and move onto the scatter graphs showing the mean with data points and the SD with error bars.
3. Make good use of the graph scale (In Excel do not just accept default graphs, revise the scales carefully). Use e-notation if the scale is large or very small e.g. x 10^{-2} mm.
4. Add axis labels with the correct Independent variable (x-axis) and dependent variable (y-axis)
5. Add axis units
6. Add uncertainty to axis title(+/- error)
7. Accurately plot the points (probably mean values)
8. Add error bars such as range or Standard deviation,
9. Type of error bars are labelled on or very close to the graph, not just mentioned in the text. They can be added below the title in smaller letter or in italic.
10. Add a trend line/ curve as appropriate. In a line graph the independent variable is continuously manipulated and therefore a line should be drawn. This is a line of best fit taking in as many points or as close to the points as possible. A good graph will have plotted error bars in which case the line of best fit should base between the outer limits of the error bars to give the line of best fit.
11. Identify anomalies which you later discuss in the conclusion.

Conclusion and Evaluation (1)

Your conclusion must not overstate the reliability of your data. This means that small or slight trends cannot be used as conclusive evidence of a difference or relationship in the data. Try to avoid grant claims for your data analysis.

Conclusions based on a statistical test

1. State the outcome of your statistical test or calculation of an index.
2. This is based only on the stats without reference to the hypothesis or research question *e.g. Comparison of the two data sets by t-test finds that P=0.07*
   Using the above statistic state if you are adopting or rejecting the hypothesis on the basis of the stats test.
   e.g. Since P=0.07 (7%) is greater than $P_{critical}$ = 0.05 (5%), so 7 % chance of there being no real difference exceeds the critical 5 % change allowed.
3. Then move to a more descriptive statement of this adoption or rejection of the hypothesis.
   e.g. There is no real difference between the two sets of data
4. At this point refer to the experimental hypothesis or research question and the degree to which they agree of disagree with the statistical analysis.
   e.g. Null hypothesis is adopted and the directional hypothesis is rejected with P=0.07 .
5. The trend or Pattern in the data should be stated.
   e.g. Region A is shown to be more diverse than region B (specific values need to be included)
6. A reference is then made at this point to the experimental hypothesis or research question and the degree to which the index agrees or disagrees with the hypothesis.
7. The pattern of the graph should be described with clearly reference to both the IV and the DV. However since no statistical measure of difference or correlation (also indices) have been used then you must be very careful not to overstate their case.
8. The degree to which the plotted data fit the established pattern (reliability) has to be named, this will be very difficult without a statistical test.
9. Anomalies need to be identified
10. The pattern in the graph should then be compared to the hypothesis or research question and a statement should be made about the extent to which they agree or disagree.

You are not finished with CE as all investigations should now continue with the following sections:

1. There should be a discussion on the reliability of data with specific reference to the graph or data for support. If possible refer to the SD as a measure of the reliability of the mean OR Error bars using SE can be used as a graphic signal of difference (see Error bars in experimental biology).
2. Reference to the qualitative data that you have collected and how this impacts on the conclusion drawn from the analysis.
3. You might mention if the background biological variation is relevant to the investigation and illustrate an awareness of the nature of biological investigations. You really need to try to carry out this section as this is why you do not have to propagate error as in other GP4 sciences.
4. You should now compare your investigation with other published values that are in the textbooks or research papers you might have accessed in your research. Try to find a link between your work and what has been published noting how it does or does not agree.
5. At this stage you will want make the a suggestion for further investigation, the idea is to suggest new productive direction for the investigation not the specific measures to address the weaknesses in method.
6. You must reference all of the sources (APA) that you have cited in this section using a formal referencing system.

CE (2) Evaluation

1. You must link all of the weaknesses to an improvement.
2. You should suggest how this has affected the data increasing or decreasing the reliability.
3. Use the error bars as a measure of the evaluating the reliability of the data. Wide error bars would suggest the data at some point is not as reliable and would benefit from a method change that would make it more reliable.
4. Increasing the sampling points of the independent variable, if you did have the correct range, could maybe be improved.
5. Did you have the right number of repetitions? Increasing the sampling points of the independent variable might have to be done.
6. Anomalous results should be identified with possible explanations. Try to avoid statements like “my data was wrong”.
7. Have there been any genetic or environmental variation in the population that has affected the sample statistics or raw data. What effect is it estimated to have had?
8. What are the effects of the associated qualitative data (observations) on the reliability of the mean, try not to be vague, estimate a qualitative effect.
9. Consider any issues that have arisen from the control experiment, if performed.
10. Problems arising from the method that had not been anticipated should be identified, just as their effects on the collection of raw data. Note; human error is not a method error but a lack of manipulative skills.
11. Assess any other limitations that have influenced the data collection

CE(3) Improvements

1. Ideally this should be in column three of the table and linked to a specific identified weakness.
2. Each limitation should have a suggested improvement.
3. Suggestions must be realistic for a school laboratory and within a realistic time limit
4. Improvements have to rectify the associated limitation and produce more reliable data.
5. Citation of the literature is needed for the improved method if available (cannot be a novel suggestion).