Environmental Systems and Societies Name:

*How to write a Discussion, Evaluation, and Conclusion*

The third section of the Internal Assessment (IA) is the Discussion, Evaluation, and Conclusion portion of your investigation. This is the portion of the investigation where you demonstrate an understanding of the concept you are investigating as well as the techniques you have chosen to employ.

**Discussion:**

The discussion section is really broken into two parts: the results and the discussion. The results section is where you explain in words what happened during your investigation. That doesn’t mean you explain your steps again, instead it means you explain what happened during your experiment and how you know. For example, if you were investigating osmosis, your raw data might look like this:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Size of Potato versus the Type of Water | | | | |
| Type of water | Mass of potato (g) | | Length of potato (cm) | |
| Before | After | Before | After |
| Deionized | 4.2 | 4.8 | 15 | 15.8 |
| Salt water | 4.1 | 3.5 | 15 | 13.9 |

Your processed data might look like this:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Size of Potato versus the Type of Water | | | | |
| Type of water | Mass of potato (g) | | Length of potato (cm) | |
| Change | % Change | Change | % Change |
| Deionized | 0.6 | 14.3 | 0.8 | 5.3 |
| Salt water | -0.6 | -14.6 | -1.1 | -7.3 |

Your results might look like this:

**Results:**

We placed two potato samples in water. The first sample was placed in deionized water and the second sample was placed in .05 M solution of Sodium chloride water. We let the samples rest in the water for 36 hours, here are the results:

*Mass:* The mass of the potato placed into the deionized water increased in mass 0.6 grams, this equates to a 14.3 percent increase in mass. The mass of the potato placed into the salt water decreased in mass 0.6 grams, this equates to a 14.6 decrease in mass.

*Length:* The length of the potato sample placed into the deionized water increased in length 0.8 cm or 5.3 percent. The potato sample placed into the salt water decreased 1.1 cm which is a 7.3 percent decrease in length.

*Notice that I did not report the raw data. I focused on the processed data and I included the SI units I used to measure the data—THIS IS IMPORTANT. This would be where you also described results from statistical tests such as mean, median, mode, standard deviation, correlation coefficient, t-test and margins of error (see me if confused about this part).*

Once you have established what the results of your investigation and statistical analysis were, you can continue on to the discussion portion of your write up.

The discussion is where you show the reader you understand the following:

* The concepts behind the investigation (what osmosis is and how it works).
* How your results compare with the established scientific literature (yes you need to find a similar study online and see what their results were—don’t forget to site their study as a source).

Here is an example:

Osmosis is the random movement of water from an area of higher concentration to an area of lower concentration across a membrane such as a phospholipid bi-layer. An easy way to gauge which side of the membrane has a lower concentration of water molecules is to look for the solute (such as salt) concentration. The side of the membrane, which has the higher amount of solute, corresponds to the side of the membrane with the lower concentration of water molecules. The expectation would then be that the water molecules would move from the higher concentration area to the lower concentration area in an attempt to reach equilibrium.

Our data was collaborated and contrasted by Theodore Sauyet’s investigation entititled *The Effects of Saltwater on Potato Cells*. Sauyet found a 0.7 gram decrease in the mass of his potato sample when placed in salt water. This equates to a reduction in mass of 20.6 percent compared to a 14.6 percent decrease in mass in our study. The difference in reduction between the study could be attributed to a different molar salt solution, Sauyet did not specify the molarity of his salt solution. A more significant difference was Sauyet found no change in length of his potato sample. We found a 7.3 percent decrease in the length of the sample. He did find an *increase* in the diameter of the potato, we did not measure the diameter of the potato, but we would have expected a decrease, based both on our length measurement and on the concept of osmosis itself. If water is leaving the cells of the potato and they are shrinking as a result we would expect the culmantion of the shrinking cells to equate to a smaller diameter of potato.

Sauyet’s report can be viewed at: [http://teddy.sauyet.com/homework/9thGrade/.../**Potato**%20lab%20report.doc](http://teddy.sauyet.com/homework/9thGrade/.../Potato%20lab%20report.doc)

‎**Evaluation:**

The evaluation portion of the Internal Assessment is probably the most difficult section of the paper to write. Part of this is because you don’t have very much experience in doing your own experiment and you also have not read very many studies. These two factors combine to make it very difficult to evaluate how well you did yours—it will seem at first like you did your investigation perfectly, but in reality there is always room for improvement. With that said you still have to do it, so here are my suggestions.

The purpose of this section is to evaluate your work and identify any weaknesses, limitations or errors in your experiment. To do this you need to reflect on what you wanted to find out. Did this experiment help you to answer your research question? If the answer is yes then ask, is there any part that I rushed or that I didn’t explore fully? Most likely there will be something that comes to mind—this is where you can focus. Another question you might ask is does this give me enough evidence to predict what will happen in another similar circumstance? If the answer is “no” then that is an area where the investigation is limited. Once you do identify the weaknesses, limitations or errors you will need to make recommendations as to how to improve the process the next time you do the experiment. Here are some prompts to use when trying to evaluate your investigation:

* Were the variables appropriate?
  + Independent variable:
    - Was the independent variable the right variable to study? Did it answer my research question?
    - Did I use the correct SI unit of measure when measuring the change in the independent variable?
    - Was I specific enough when I designed my independent variable? For example, did I explain what molarity of solution I would use with the potato?
  + Dependent variable:
    - Was this the correct dependent variable to measure—did it work for answering my research question? Should I have focused on density instead of volume?
    - Did I use the correct SI unit of measure when measuring the change in the dependent variable?
    - Did I use the correct calculations when determining change in the dependent variable?
    - Did I explain and account for the margin of error inherit in the methods I used to measure my dependent variable?
  + Controlled variables:
    - Did I create an exhaustive list of variables that I needed to pay attention to?
    - Did I explain what level I would set the controlled variables?
    - Did I explain how I would keep the controlled variables at the levels I set?
    - Were there variables which possibly affected my investigation, which I had not accounted for?
    - How do I think these variables affected the results of my investigation?
* Were there problems with the equipment?
  + Did you caliberate the equipment? Why not? How certain are you of the accuracy of the measurements?
  + Did you have an alternate way of measuring the dependent variable?
* How good was the method you designed for testing the independent variable’s effect on the dependent variable?
  + Did your design allow enough time to see how the independent variable affected the dependent variable?
  + Did your design generate enough data to be statistically confident of your findings?
  + Did your design lead to unexpected results? Was this due to random error, miscalculations or poor execution?
* How well did you use your time? This is not the place for a confession about wasting time, instead it is a discussion about how to organize the investigation to be more efficient with time and with materials.
* Other investigations that you could do which would be related to this one.

It may be helpful to organize the bulk of this section as a table—with the areas of concern on the left and how you would account for them on the right. The following is a checklist found online to double check you have fully evaluated your work:

* I have commented on the design and method of the investigation
* I have commented on the quality of the data
* I have listed the weaknesses of the study
* I have assessed the importance of each of these weaknesses
* I have commented on the precision and accuracy of the measurements
* In evaluating the procedure, I have specifically looked at the variables, the processes, the use of equipment and the management of time
* My suggestions for improvements are based on the weaknesses and limitations identified
* As appropriate, I address modifications to the experimental technique and the data range
* The modifications that I propose are realistic and clearly specified

Remember: ***This section is not a confessional about how you could have measured more carefully and managed your time better!*** It is supposed to be a thoughtful reflection of your work which demonstrates an understanding, by you, of the techniques used to explore your research question. If you are not sure about one of the questions above—I suggest googling the question and reading, until you have a good understanding of the criteria—then evaluate your work. This is the section that has the potential to help you stand out from other people’s work. Give this section thought and it will pay off.

**Conclusion:**

Time to pull it all together. Writing a good conclusion illustrates to the reader that you understand the implications and the significance of the work you have done. Like the other sections of this report there is a format that is expected. The general steps are as follows: State your claim, back up your claim with evidence, explain why your evidence is valid, explain other possible interpretations and an explanation for why you do not agree with those interpretations.

*Stating your claim*: To begin, restate your research question and your hypothesis (which should be your predicted answer to the research question). Next you must either accept or reject your hypothesis. It is important to remember there is absolutely nothing wrong with rejecting your hypothesis (unless the evidence is to the contrary), the point of the hypothesis is to guide your investigation, not to determine the quality of the study.

*Evidence:* The importance of this part of the conclusion cannot be overstated. There are countless examples of someone accepting their hypothesis and then failing to support the acceptance with ample evidence. Even worse many students accept the hypothesis when the data actually tells them something else. When discussing the evidence it is crucial you use NUMBERS. You have already done the work of applying statistical techniques, now you must demonstrate you know what those numbers illustrate. If you fail to use numbers and the proper units of measure, you have essentially failed to provide any evidence for your claim.

*Explaining the significance of the evidence:* The numbers are useful only if you know what they mean. In this section you must explain why you chose the statistical tests you did and why you interpret the results the way you did. If you decided to focus on the mode of a data set instead of the median, there should be a reason and you should fully explain the reason here. Often it will be necessary to revisit some of the underlying concepts so the reader understands how you came to your conclusion.

*Other possible interpretations:* Usually there is more than one way to look at a problem and there is multiple ways of interpreting data. I would argue there is a best way, but it depends upon the circumstances of your investigation. In this section, you acknowledge other possibilities and explain why you did not choose those paths of inquiry.

*Summarize:* The final paragraph should be a succinct summary of the research question, hypothesis, evidence and acceptance or rejection of the hypothesis.

*Sources:* It is not actually in the conclusion, but it is important to remember a works cited page. The examiners see works from all over the world. It is very likely they will recognize a source and if you do not cite that source you could be accused of plagerism. When in doubt cite it as a source.