Bladderwrack at Hudiksvall - A Teachers Guide

A common topic for many natural science subjects is how to use science to answer questions, and in a world of increasing amounts of information, such knowledge is of great importance. However, when it comes to experimental design, theory and practice can be two very different things and students need to get a grip on both in order to truly become familiar with the topic. In this ‘Teacher’s guide’ I am broadly outlining my thoughts on the subject while also presenting an example. I have intentionally made this guide general in order to accommodate more room for you to adapt to the circumstances in your class and the environment you have at your disposal.

Introduction

A suitable start when teaching students how science works, is asking the students questions which, in order to be answered, requires measuring variables with a large innate variation. Additionally, these variables should be easily measured by the students. Given these conditions, I find many questions stated in a biological framework ideal as there is often a natural variation in weight, age, color, size et cetera. Asking biological questions could also provide an opportunity to move the classroom outside and give the students a hands-on perspective as well.

When learning the process of answering a scientific question one often starts with small investigations focusing on one aspect of the scientific process: formulating a hypothesis, following a method, how to present results or how to write a discussion. Eventually more open-ended questions should be asked in order to discourage students from thinking that you always find a difference between treatments or that just because you have formulated a method the results are precise and accurate. However, questions where the results are determined will still have their place as when introducing new concepts, e.g. Student t-test or producing figures.

A warning: open-ended questions are difficult for students to work through as things are not served on a platter. They will probably struggle but along with that comes the potential for great learning. At the end of the project, if the student can explain how mean and variation interacts with the need for replicates, great progress has been made. In a longer perspective, if the student then can relate and discuss these statistics to the outcome of a statistical test (mainly Student’s t-test) they are miles ahead of their way to mastering the scientific method.

The example: Bladderwrack at Hudiksvall

The aim of this exercise was to present the students with an open-ended ‘start-to-finish’ project in order for them to develop a sense for how the different aspects of experimental design affects each other and how this is connected to actually being able to answer a question. In order to be able to do this, students should already have knowledge about concepts of mean and variation but not necessarily to e.g. replicates, accuracy and precision as these can be included into the introductory lectures. Depending on the question the students chose to ask or is presented with, different equipment is needed but that is up to the teacher to provide or mitigate. In this project we did not include the use of statistical testing.

As a background to this assignment the students were told that they worked at a company tasked with evaluating the possibility of harvesting macroalgae along the coast of Hälsingland (mid Sweden, Baltic sea). They were told examples of what could and what could not be done. After a discussion the students agreed that they should investigate the dry-fresh weight ratio of Bladderwrack (*Fucus vesiculosus*) in the area and compare it to surveys done further south and in more saline waters.

Planning

Given that this exercise is a 'start-to-finish' type of project, the idea is that the teacher should mainly guide the students along and help them overcome problems but not to tell them what to do - making mistakes is equally good as being correct. Although, the teacher should be cautious and make sure that the students will have some type of results that can be discussed and presented in the end. In this project, examples of questions that arose during the planning were:

- How do we choose where to sample?
- How many locations do you think we need?
- How do we know what to pick? Which part of the algae are we after?
- What if we don't find any Bladderwrack?

During this process it is important to point out that they should make a 'Plan A' but leave room and be ready and make adjustments in the field as necessary. After the project is done I often mention the concept of a pilot study to describe what they have just done. Before heading out to the field, students should have a clear understanding of what to do and where. For example, they might have

- a Google map over the area with transects or similar drawn
- a field protocol for making notes
- the means to randomly select areas to sample (e.g. if the need to select new areas arise)

In the field

Here I have just one piece of advice: as a teacher, make sure the students have contingency plans and then 'go with the flow' in the field. All in order to be sure they come home with some data to analyze and present while having a great time in the field.

Post-field and presenting

Measurements and data gathering should present no problems if the students are prepared but when it comes to presenting the findings there can be more questions depending on how experienced they are at making reports.

In this project the students were required to present their findings in the format of a scientific poster rather than a written paper. Later in their careers, students will find that scientific posters are a common way of presenting research and that the format is not limited to scientific meetings but also similar to leaflets, public information boards and such. In a poster, the mix between text and graphics will present the students with a challenge as they tend to think of movie posters or leaflets with just a punchline (e.g. 'Take the vaccine and combat covid-19!' or 'Vote on us to save the world!") making them produce posters with too much graphics and too little information.

My advice is to remind the students that a scientific poster is 'just' a paper except you get all information in one go. Introduction, method, results and discussion with a conclusion should be on there for it to be understandable and reproducible. The exception to a written paper is that the number of references are normally fewer.

There are a number of programs you can use in order to make your poster. The idea is to do a Microsoft Powerpoint or Google Presentation on just one slide. Canva is an online program my students like to use based on the fact that there are many nice layouts to choose from. When it comes to how to fill your poster with content there are a number of guides online one can choose from and many examples on how they can look if you do a picture search. Here are some guidelines I tell my students:

- Use as much of the poster as possible. Think ⅘ content and ⅕ empty space.
- Use a portrait orientation and have a title at the top.
- Readers of a poster tend to move their attention as if following a backwards drawn S.
- Use a max of three colors and make them match as well as not 'scream', i.e. no neon colors!
- Use pictures and figures that add something to the story not just because they are nice.
- Keywords can be made bold in order to stand out more.
- Print a A4 sized copy and hold it out at arm length to judge font size. If you can read it with no problem then it is not too small if the final size is A1. A smaller final size means you can go even smaller in font in order to get more information on the poster.
- Getting good at this often means you have a shot at winning prizes as conferences often have a "Best poster" competition.

Final thoughts

Open-ended questions can be difficult to answer but are rewarding and students will have the feeling of doing something "for real". In addition, presenting it as a scientific poster often sparks a flurry of creative ideas not often seen when they write a laboratory report. However, students also find it difficult to include information on the confined space of a poster. All combined will present a challenge for the students but hopefully they will come out having learnt something and what else can a teacher ask for?