

# Explaining the scientific method to first year biology students in an accessible manner

## Abstract & Background Information

The scientific method paired with the practice of statistics is widely implemented to analyze, interpret and derive conclusions regarding a dataset. This laboratory exercise introduced first year biology students to the scientific method, applying it to evaluate how brown planaria (*Dugesia tigrina*) responds to light. In the laboratory setting, students were required to formulate a research question and hypothesis, design a study, record observations, gather data and perform statistical calculations (mean, median, standard deviation, t-tests), receiving feedback from their peers and teaching assistants. We produced multiple videos enabling students to review the content.

### Why videos and what makes them effective?

The world students currently live in has changed due to the presence of technology (Rackaway, 2012) and students are now shifting towards videos as a resource for information (Prensky, 2010). Richard Mayer (2001) developed the Multimedia Principle which helped educators understand the effectiveness of videos as pedagogical tools. A student can either learn from the visuals posed in the video, or listen to the narration explaining the concept, or read in-text words/definitions to enhance their learning. Videos also improve learning quality by reducing cognitive load and increasing student attention (Ljubojevic et. al., 2014). If done effectively, engaging video production can draw more attention from students which in turn will decrease the mental process of understanding the concept (Ljubojevic et. al., 2014).

### Objective

- Measure the effectiveness of an animated video being used as a pedagogical tool by analyzing the differences in grade between a video versus the standard laboratory manual.

### Hypotheses

#### Video Effectiveness

It is expected that a statistically significant difference in grade for the laboratory report will conclude that videos are effective in reinforcing knowledge in science laboratories.

#### Knowledge Retention

It is expected that a statistically significant difference in grade for multiple laboratory reports will conclude that the video was effective and as a result, students retained knowledge from the video played on the first day of laboratory.

### Experimental Design

This experiment was conducted in two Ryerson University science laboratories:

- General Biology I (BLG143)
- Botany (BLG230)

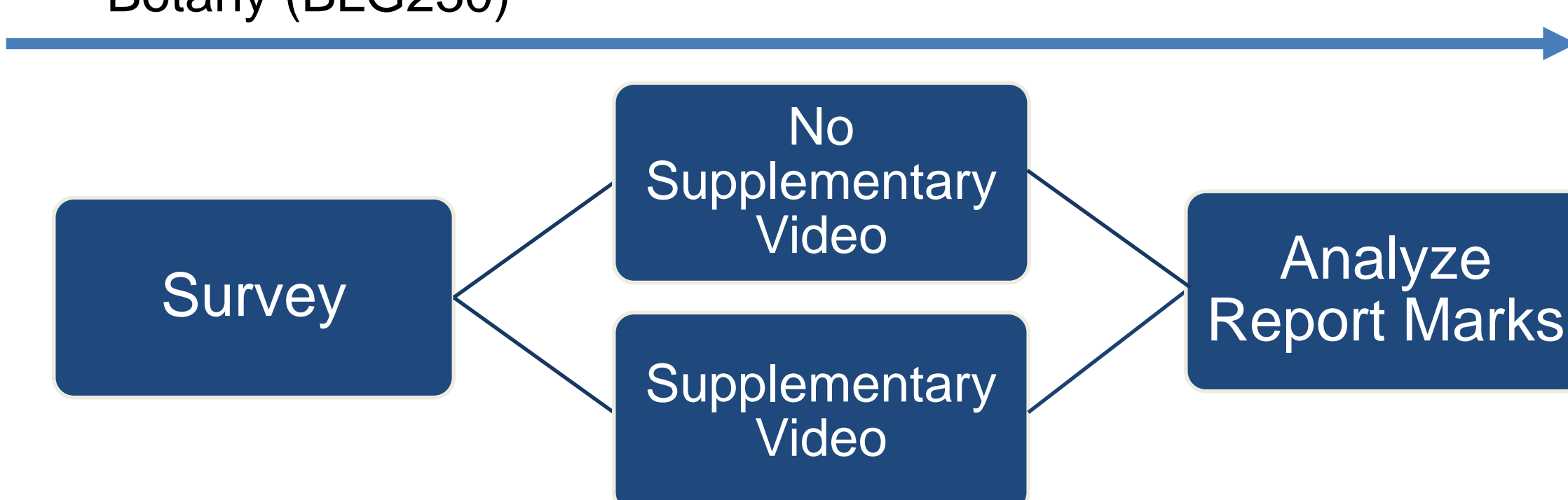


Figure 1. Simplified Experiment Process

## Video Composition

### Importance of Statistics

- Connecting the applications of statistics to the field of biology to understand its importance

### Statistical Terms

- Quantitative & qualitative data, independent and dependent samples, population & samples
- Provides foundation for knowledge and literacy in laboratory material<sup>1</sup>

### Central Tendency

- Mean and median
- Importance of understanding how data is distributed

### Organizing Data

- Use of histograms
- What information we can derive from histograms

Figure 2. Main Components of Video

The composition of the video was influenced by the study performed by Dr. Wilson, 'The Flipped Class: A Method to Address the Challenges of an Undergraduate Statistics Course'. It first starts with building a small foundation in the subject (Wilson, 2013) by discussing the importance of statistics in sciences and by introducing basic terms that will be commonly used in laboratory. Following is approaching the application portion of statistics (Wilson, 2013), which in the video is the description and example of application for central tendency. Methods of organizing data is also an applied process, specifically understanding histograms. This was chosen because histograms are introduced in the first laboratory and are relevant to the lab material.

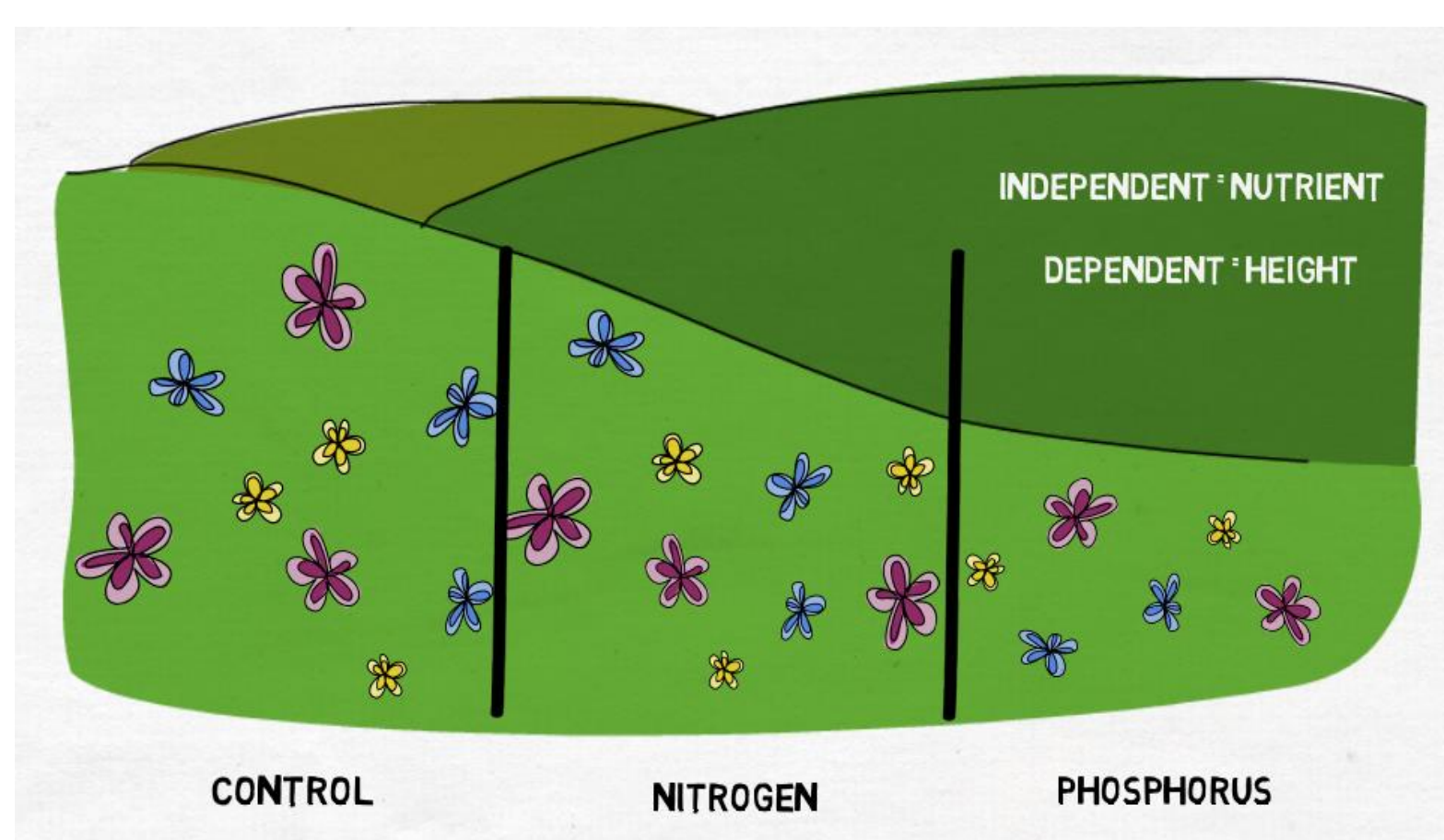


Figure 3. Statistical Terms Screenshot

A screenshot from the video displaying how statistical terms were approached. Terms were introduced in a storyline example of a botanist studying plant nutrients and growth. Terms were used in relation to the example.

### Why is statistics important in biology?

Biology is a natural science that deals with understanding aspects of life. Many stochastic events occur in nature and the need for statistical applications in biological experiments are necessary to fully comprehend and estimate results of an experiment being applied (Colquhoun, 1971). There are always random, uncontrolled variables in natural sciences that must be accounted for; hence the need for statistics and fields such as biostatistics (Colquhoun, 1971). Applying statistics to biological research allows biologists to paint a bigger picture on what their findings truly entail and helps them predict outcomes of their treatments.

## Results & Conclusions

### Laboratory Report 1: The Scientific Method

Students who viewed the video performed 5% better than students who did not view the video.

### Laboratory Skills 1: The Scientific Method

Students who viewed the video performed 3.5% better than students who did not view the video.

### Laboratory Reports 1, 2 & 4 Combined (Knowledge Retention)

Students who viewed the video performed 3.2% higher compared to students who did not.

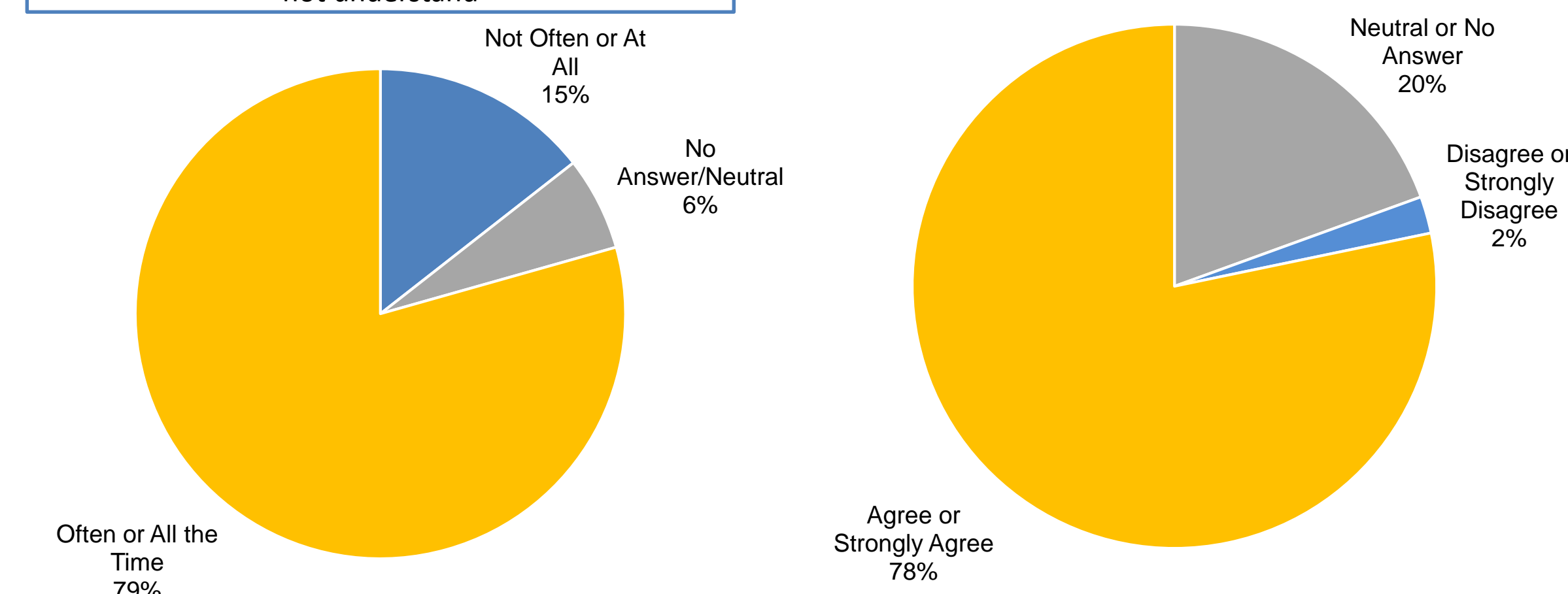
### Laboratory Skills 1, 2 & 4 Combined (Knowledge Retention)

Students who viewed the video also performed 2.4% higher on LS124 than students who did not.

Despite these grade differences (*with the exception of Laboratory Report 1*) being determined insignificant according to a Kruskal-Wallis test, there is still a slight increase in grade between sections who viewed the video and sections who did not. According to survey data, students currently use videos to learn and there is a need for instructors to implement videos in their classrooms. Future work must continue to incorporate more videos in laboratory and continue to analyze the grade differences.

I use online video formats (i.e. YouTube) to recall knowledge, skills, or to learn more about concepts I do not understand

I feel it would be beneficial to me if a professor provided more supplementary tools, like videos, to me more often



## Acknowledgements

This project was funded by the Ryerson Learning and Teaching Grant.

Thanks to Biology I students (2018), Botany students (2018) and teaching assistants for their support.

## Works Cited

- Colquhoun, D. (1971). Lectures on Biostatistics. Oxford University Press, London, England.
- Ljubojevic, M., Vaskovic, V., Stankovic, S., & Vaskovic, J. (2014). Using a Supplementary Video in Multimedia Instruction as a Teaching Tool to Increase Efficiency of Learning and Quality of Experience. *IRR OD, 15*(3): 275-291.
- Mayer, R. E. (2001). *Multimedia Learning*. Cambridge University Press, New York.
- Mayer, R. E. & Johnson, C. I. (2008). Revising the Redundancy Principle in Multimedia Learning. *Journal of Educational Psychology, 100*(2): 380-386.
- Prensky, M. (2010). Why YouTube matters. Why is it so important, why we should all be using it and why blocking it blocks our kids' education. *Emerald Group Publishing Limited, 18*(2): 124-131. doi: 10.1108/10748121011050469
- Rackaway, C. (2012). Video killed the textbook star?: Use of multimedia supplements to enhance student learning. *Journal of Political Science Education, 8*(2), 189-200. doi:10.1080/15512169.2012.667684
- Wilson, S. G. (2013). The Flipped Class: A Method to Address Challenges of an Undergraduate Statistics Course. *Society for the Teaching of Psychology, 00*(0): 1-7.