Use of Microthemes to Increase Writing Content for Introductory Science Laboratory

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INTRODUCTION

Writing is a learning activity, as well as a communication skill. Many instructors recognize the value of writing as a learning tool but struggle to develop effective writing assignments. Instructors are generally pressed for time during lecture due to the necessity to deliver content and, therefore, cannot dedicate time necessary to teach science writing skills effectively. Traditional term papers assigned to a class with varying writing skills may not accomplish the desired goal of teaching both technical writing skills and critical thinking skills. Students that are already struggling with content may be at a disadvantage in terms of conveying complex ideas. An answer to this problem is the microtheme paper (1) which we employ in an Introductory Botany laboratory setting.

Microthemes are short writing assignments that are based on the concept of leverage where a small amount of writing is preceded by a great deal of thinking. Bean et al. (1) describes four types of microthemes, each designed with a different focus for use in the classroom. Briefly, a summary-writing microtheme has the student discuss the structure of assigned material and condense it, while retaining hierarchy and eliminating fill. A common example in a science course would be writing the abstract to a scientific paper. A thesis-support microtheme has the student take a stand on a topic, while developing the ability to discover, state, and defend an issue. As the name implies, a data-provided microtheme provides students with data in the form of tables or factual statements. The student is asked to discover a thesis or general statement that gives meaning to the data. Students progress from merely listing facts to making assertions, much like the discussion section of a scientific paper. Finally, cognitive puzzles are presented in a quandary-posing microtheme. Students must explain the underlying scientific principles in clear terms and pose solutions.

Often, these microthemes can be presented to students as “Explain to a friend who has no or limited scientific background . . . .” For our lab exercises, we used adaptations of data-provided microthemes and cognitive puzzle microthemes,
which are completed by the students at different times. Data-provided microthemes are completed in class and are designed to help the student process the data generated in lab. Cognitive puzzle microthemes are completed outside of class, and are designed to reinforce concepts taught in lab and to encourage the student to make broader generalizations about results. The immediate goal of the microtheme assignment is to increase time spent writing, but the overall goal is to increase the quality of writing in the more formal lab reports (i.e., concept, grammar, syntax).

PROCEDURE

The Introductory Botany course is one of the first courses Biology majors take as part of the biology curriculum at our university. Typical lab size is about 25 students and is often taught by graduate teaching assistants. Many of our incoming freshman Biology majors do not have strong backgrounds in either biology or writing. Our department has made a commitment to increase writing content in all courses, but especially freshman-level courses.

One of the first laboratory exercises given in the Introductory Botany lab is a comparison of the density of stomata in young and old leaves as an illustration of the nature of scientific investigation. The goals of the lab are to introduce students to the use of the microscope, as well as formulation of a hypothesis. Figure 1 shows an excerpt from the laboratory manual detailing the laboratory procedure. In the experiment, students are asked the question “Does a small, young leaf have all the stomata (small pores in the epidermis that allow gas exchange) that a mature leaf will have, all compressed into a smaller area? Or, as a developing leaf expands in size, does it also produce more stomata?” (2) Students are then asked to form a hypothesis, test it in lab by comparing stomatal densities of young and old leaves, analyze the data to see if there is a significant difference between the two leaves, and form a conclusion about the validity of the hypothesis.

**Complete in class:** (2 1/2 hours)
- Read the lab procedure in your lab manual as well as the attached handouts. Perform the
  - lab experiment, as directed in the above pages, as a group. Complete the lab report (15
  - points - group).

- (Last 30 minutes):
  - **Complete microtheme 1:** What do my results really imply? (5 points – group). Neatly write, by hand, only
    on the front of one 8 X 5 index card

- **Complete outside of class:** (1 week, due at the beginning of next lab session.)
- **Complete microtheme 2:** Why did I do this experiment? (5 points – individual). Neatly write, by hand,
  only on the front of one 8 X 5 index card.

**Experiment:**
For both a young and old leaf: Paint a thin layer of clear fingernail polish on the underside of a leaf, use a piece of
tape to make an impression of the underside of the leaf, apply the piece of tape directly to a slide, view the slide
on the high power objective lens, count the number of stomata that appear in 10 fields of view, enter the data into
the statistics software, and record the associated t-statistic and p-value.

**Important information that should be mastered:**

- **Description:** Stomata are small pores in the epidermis that allow gas exchange in the interior of a leaf.
  Carbon dioxide enters the leaf and is used to make carbohydrates during photosynthesis. Transpiration
  allows water vapor to escape out of these same pores. Both processes are occurring when the stomata
  are open; thus, 90% of water is lost when carbon dioxide is allowed to enter the open pore.

- **Question:** Does a small, young leaf have all the stomata that the mature leaf will have, all compressed
  into the smaller surface area?
  - Null hypothesis: Young and old leaves of the same plant species do not have different stomatal
densities.
  - Claim/alternative hypothesis: Young and old leaves of the same plant species have different
stomatal densities.

- Statistical test used to determine if the data SUPPORTS the hypothesis: T-test: To test if two groups are
  statistically different from each other by comparing their corresponding means (averages).

**FIGURE 1** Handout provided to students with instructions. Adapted from
Evert, R. F., S. E. Eichhorn, and J. B. Perry (2), as used by Sam Houston State University.

The handout given to the students at the beginning of class details the estimated
student’s time for progression through the lab, including an experiment, lab report,
and title of an in-class microtheme and a homework microtheme that will be given
to the students after the completion of the lab experiment (Fig. 2 and 3). Figure 2
shows our adaptation of the data-provided microthemes, completed in class, which helps students understand data generated in lab. Figure 3 shows our adaptation of the cognitive puzzle microthemes, completed outside of class, which encourages students to make broader generalizations about their results.

**Microtheme 1: What do my results really imply?**

Two groups in a botany lab, “Group A” and “Group B”, received different results for an experiment comparing the densities of stomata on young versus old leaves. Group A received a significant p-value of .04 and Group B received a nonsignificant p-value of .06. Group A told Group B that they must have done the experiment wrong since they did not get significant results. Group B pointed out that Group A used maple leaves instead of oak leaves for the experiment. Group A said that didn’t matter and that they did more replicates. They also said that their data was better and proves their hypothesis that young leaves have different stomatal densities than old leaves. Please clarify, to these two groups of students, the real meaning of the results of their data. Be sure to address the following terms in your answer: p-value, prove versus support, ways to decrease error, and other hidden factors that may be relevant to the obtained results.

**FIGURE 2** Microtheme 1 given at end of laboratory session and to be completed in class.

**Microtheme 2: Why did I do this experiment?**

Stomatal density is influenced by different factors such as humidity, light intensity, and temperature. A fully submerged underwater plant may have no stomata yet a floating plant may have only upper stomata. In addition, studies support that mature leaves signal to younger leaves and that the number of stomata of the younger leaves is adjusted due to environmental conditions that surround the mature leaves. The CO₂ level and stomatal index are inversely related. For example fossil leaves of ginkgo (and relatives) have high stomatal density during ice ages (when CO₂ levels were low). The reverse was shown during periods of warmer climates. Knowing that CO₂ is a greenhouse gas, explain to your friend, who is a nonscience major, how the above information could be important in the role of global warming (climate change)? Be sure to address the following questions in your answer: what is climate change, how does climate change affect the CO₂ level, how would this adjusted CO₂ level affect stomatal density, and what broader predictive implications could this have on the environment.

**FIGURE 3** Microtheme 2 given at end of laboratory session and to be completed as homework.
These writing assignments are five to ten sentences in length, and should not exceed the front side of a five-by-eight index card. Students are also provided with guidelines for writing the microtheme (shown as the last bolded sentence of the microtheme description, Fig. 2), as well as the grading rubric (Fig. 4) intended to guide teaching assistants in their grading efforts. Microthemes are quickly graded by placing them into one of three general categories (5–4, 3–2, 1–0) based on the student’s understanding of the material. Within the general categories, the work is ranked better or worse (for example, a score of 5 or 4).

**Microtheme grading criteria (5 points each):**

5-4 Microthemes in the category will show a confident understanding of the science concepts and will explain those concepts clearly to the intended audience. 3-2 Microthemes in this category will reveal to the instructor that the writer probably understands the science concepts, but lack of clarity in the writing or lack of fully developed explanations means that the microtheme would not teach the concept to new learners. 1-0 These microthemes will be unsuccessful either because the writer fails to understand the science concepts, because the number of errors is so high that the instructor cannot determine how much the writer understands, or because the explanations lack even minimum development.

**FIGURE 4** Grading rubric provided to students*. Adapted from Bean, J. C., D. Drenk, and F. D. Lee (1).

DISCUSSION & CONCLUSION

Microthemes are effective in providing multiple opportunities for student writing, allow for a rapid turnaround in instructor feedback, and can be designed to require the student to apply concepts learned in lecture and lab. The microthemes described here help the students not only to understand how to perform an experiment, but also why they performed the experiment. In addition, the students increase their knowledge of the usefulness and application of science as well as statistics, while incorporating broader implications and concepts that otherwise may have been lost or underdeveloped. For example, this particular assignment focuses on the important concept that students should learn early on, that
experiments and statistical tests used in science do not prove a hypothesis, but rather that the data either support or do not support a hypothesis. The microtheme process also increases interaction and group discussion through the sharing of ideas and by providing instant clarification of vague concepts that the student may experience during a botany lab. The brevity forces the student to write concise answers and allows for rapid feedback, thereby reinforcing concepts. The instructor can increase the writing content of the course without the burden of excessive grading that usually follows writing assignments.

We have found that using an in-class microtheme followed by a follow-up microtheme format was very helpful at keeping students on task in the lab during the experiment. Students seemed to take more of an active process in understanding the material being covered so that they could properly answer the questions being posed in the microthemes. Not only can microthemes be used in other biology lab settings, but they can also be used in lecture classes, and are a good way to get the students to review important concepts before an exam.

Microthemes are versatile and can be used as a quick writing assignment that can be done in-class without taking up too much class time, or as homework assignments that allow for an extended amount of thinking time. They also can train students to limit the amount of words used to summarize a great deal of material while focusing on key concepts. Microthemes also provide an increase in the amount of writing opportunities, and can be used to summarize a concept or procedure, as well as allow for the broadened application of the material to new ideas that encourage critical thinking.
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References

