Do well-developed hypotheses correlate with improved scientific writing?

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Undergraduate Learning Outcomes Assessment: Pedagogy and Program Planning

- Semester long certificate program
- Pre-semester workshops
- Weekly meetings
Motivation
Spring 2013 teaching evaluation:

“Don't expect too much from the students, we are doing the best we can but he set such a high bar for us.”

“Lower expectations a bit for how students will do.”

“Lower difficulty in grading.”

“Less harsh grading will lead to less frightening atmosphere.”

“Grading system should be easier.”
BIO 141: Evolution
Spring 2013

- Students generally score their work higher than instructors.
Students who were better able to assess their own work achieved higher scores.
Needs assessment, Spring 2015:

In terms of your scientific writing, list two things you need to improve most.
Needs assessment, Spring 2015:

In terms of your scientific writing, list two things you need to improve most.
Biology Program Learning Outcomes:

**PLO 2.** An ability to develop and critique hypotheses and to design experiments, models, and/or calculations to address these hypotheses.

**PLO 4.** The ability to read, evaluate, interpret, and apply numerical and general scientific information.
Testable hypothesis as a threshold concept

- Requires integration of multiple ideas and articulation of these ideas in explaining the system being investigated (Taylor and Meyer 2010)

- Transition to understanding threshold concepts generally troublesome, but understanding the concept leads to a transformed way of thinking in the discipline, without which the learner cannot move forward successfully (Meyer and Land 2003)

- **Goal:** help students construct good (i.e. concise, clear, testable, understandable, and meaningful) hypotheses to help improve their reports.
Likert scale rubric to help students assess level of proficiency achieved

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<tr>
<th>UNACCEPTABLE</th>
<th>ACCEPTABLE</th>
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<tbody>
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<tr>
<td>Abstract</td>
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<tr>
<td>Topic/issue, Question, Hypothesis</td>
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<tr>
<td>Method</td>
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<td>Major Result</td>
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<td>Conclusion/Discusion</td>
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<tr>
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<tr>
<td>Discussion</td>
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<tr>
<td>Interpretation of results</td>
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Descriptive rubric to help students assess level of proficiency achieved

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<tr>
<th>SECTION</th>
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<th>Excellent Full points</th>
<th>EVALUATION</th>
<th>Poor Minimal points</th>
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<td>Engaging and descriptive</td>
<td>Appropriate</td>
<td>Not enough content information or too much</td>
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<tr>
<td>Authors</td>
<td>To recognize the sole author of the research paper</td>
<td>Named in appropriate place &amp; way</td>
<td>n/a</td>
<td>Not named.</td>
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| Abstract          | To concisely summarize the context and question, general methods, major findings, and implications of the observations or experiments in relation to what is known or expected | Key information included:  
  o Problem statement  
  o Description of methods  
  o Major results  
  o Implications  
  Presented clearly & concisely  
  All information is correct  
  Organization is logical  
  Captures any reader’s interest | Sufficient information is presented in proper format  
  Would benefit from some reorganization  
  Understandable with some prior knowledge of experiment or observations | Some key information is omitted or tangential information is included  
  Some information is misrepresented  
  Some implications are omitted  
  Incorrect format is used |
| Introduction      | To provide major context, identify central questions, and appropriate background information. To present an answerable and matching plausible hypothesis | Relevant background information is presented in balanced, engaging way  
  Your question and hypothesis match and are a logical extension of existing knowledge  
  Clear statements of the study’s goal (question), hypothesis, and predictions if relevant.  
  Writing is easy to read  
  All background information is correctly referenced | Relevant background information is presented but could benefit from reorganization  
  A plausible hypothesis is given  
  With some effort, reader can connect your study to background information  
  Writing is understandable  
  Background information is correctly referenced | Background information is too general, too specific, missing and/or misrepresented  
  Study question is incorrectly or not identified; a plausible hypothesis is not given  
  Writing style is not clear, correct or concise  
  References are missing, insufficient, or inappropriate |
| Materials and methods | To describe procedures correctly, clearly, and succinctly. Included one correctly formatted citation of the lab manual, and other citations as relevant. | Sufficient for another researcher to repeat your experiment  
  o May include informative, labeled diagram if/as needed  
  o Neither too broad nor too specific  
  (i.e. not a rewrite of the manual)  
  Lab manual cited | Procedures could be pieced together with some effort  
  Lab manual cited | Procedures incorrectly or unclearly described or omitted  
  Lab manual not cited |
Needs assessment and Mid-semester assessment:

Proficiency in writing hypotheses

How difficult is writing a hypotheses

Proportion of responses

Proficiency

Proportion of responses

Difficulty
Iterative hypothesis development for final report

- Students participating in all iterations of hypothesis development:
  - mean score = 78% \( (n = 29; \text{s.d.} = \pm 19) \)
  - average normalized gain = 61%

- Students forgoing one or more iterations:
  - mean score = 50% \( (n = 12, \text{s.d.} = \pm 31) \)
  - average normalized gain = 21%.
Final Hypothesis & Report

- Relationship is weak, but ...

- 89% of students with a perfect hypothesis score earned at least a proficient grade on final report.

- Only 24% of students earning less than 2/3 points on their hypothesis earned a proficient grade.

\[ R^2 = 0.23 \]
What skill(s) have you learned or improved in Evolution, if anything, that you think will help you be successful in your other courses and/or career in the future?

“Guiding my own learning has been a fundamental skill I have been taught in this class. I think it was acquired with the greatest skill in writing my own hypotheses and directed what my lab reports explored.”

“... I have learned a multitude of skills and knowledge not only about evolution, but scientific skills and reasoning as well. I went from not knowing the importance of, and how to write reports, to being able to identify mine, and others strong and weak points of a paper.”

“... writing an effective hypothesis. This semester, the fact that I knew what an effective hypothesis looked like helped me write better papers in my Writing 116 ... class.”
What I learned:

- Using assessment throughout the semester allowed me to adjust/add activities for students to practice skills before large assignments.

- Students who actively engaged with these practice assignments performed better in general than students who skipped them.

- Focusing on learning outcomes and establishing goals at the start of the class allowed for clear planning throughout the semester.
Questions?