Annotation as an active learning strategy to engage in statistical communication

An Bui

CCUT Requirement 3 (adapted from GRAD 210 final project)

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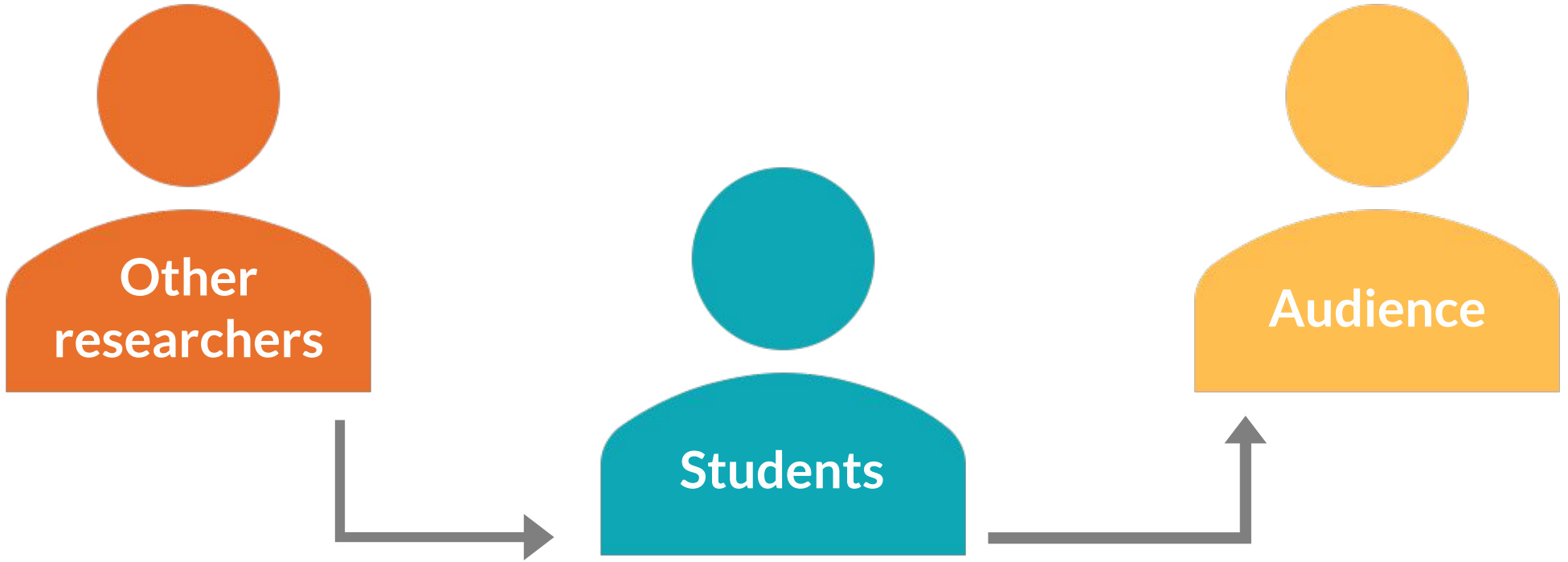
Fostering student participation in scientific dialogue is a core part of my teaching philosophy



What are **other researchers** communicating to **me** via primary literature?

How do **I** communicate to **an audience** about research (mine or anyone else's)?

Scaffolding student engagement with primary literature using CREATE framework

Consider

Read

Elucidate hypotheses

Analyze & interpret data

Think of the next Experiment

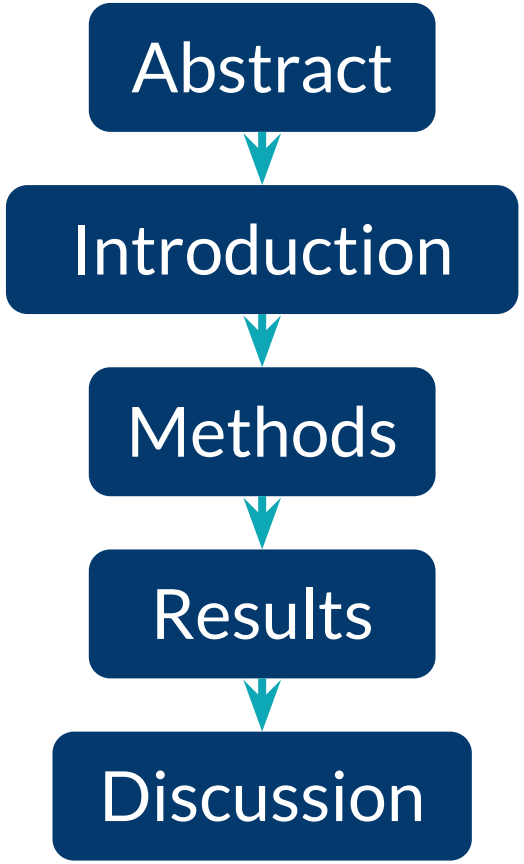
Hoskins et al. 2007,
Hoskins 2010

Adopting the CREATE framework in biology courses leads to gains in critical thinking:
thinking like a scientist and **interpreting data**

Kenyon et al. 2019
Gottesman and Hoskins 2013

Reading styles differ between “novice” and “expert” readers

Narrative-centric



Hubbard et al. 2022

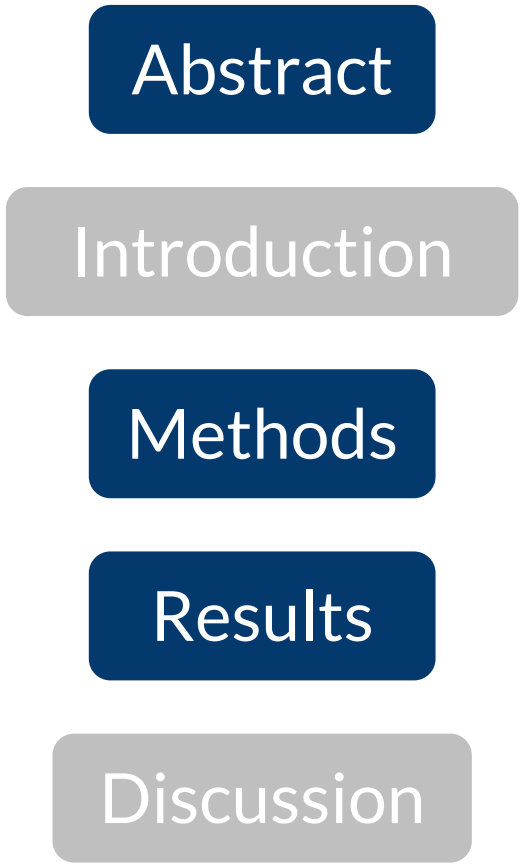
Students tend to view “Methods” and “Results” sections as less important for understanding than other paper sections

“Methods” and “Results” were perceived to be difficult because of lack of technical skill

Lennox et al. 2020

Reading styles differ between “novice” and “expert” readers

Data-centric



Expert reading is characterized by critical evaluation of evidence

How do we bring students into the “experienced reader” (and therefore, experienced communicator) realm?

Hubbard et al. 2022

Scientific skepticism is a teachable skill

I don’t know what a p-value is but I know it’s supposed to be less than 0.05.

Student reflection, Spring 2024

In many statistics courses, students learn about p-values as a metric by which a researcher assesses statistical significance. Unfortunately, students can also come away with the understanding that statistical significance equates to importance or usefulness of a study, as indicated by this student’s reflection of p-values as “supposed” to being less than 0.05, the typical significance threshold in biological sciences.

In my teaching, I want students to unlearn this notion that p-values are supposed to be less than 0.05. I guide them to understand that *thorough* communication about statistical analysis means reporting more than a p-value to provide context for the calculation of the statistic. Additionally, I show them that interpreting statistics in the context of the biological system is more informative than relying solely on a p-value.

Scientific skepticism is a teachable skill

I don’t know what a p-value is but I know it’s supposed to be less than 0.05.

Student reflection, Spring 2024

Showing that published science is still open to analysis, criticism, and debate invites students to **hone their analytical skills**. As students “think like scientists,” they learn that **scientific findings are open to evaluation from diverse viewpoints and should not be accepted passively.**

Hoskins 2010

Scientific skepticism is a teachable skill

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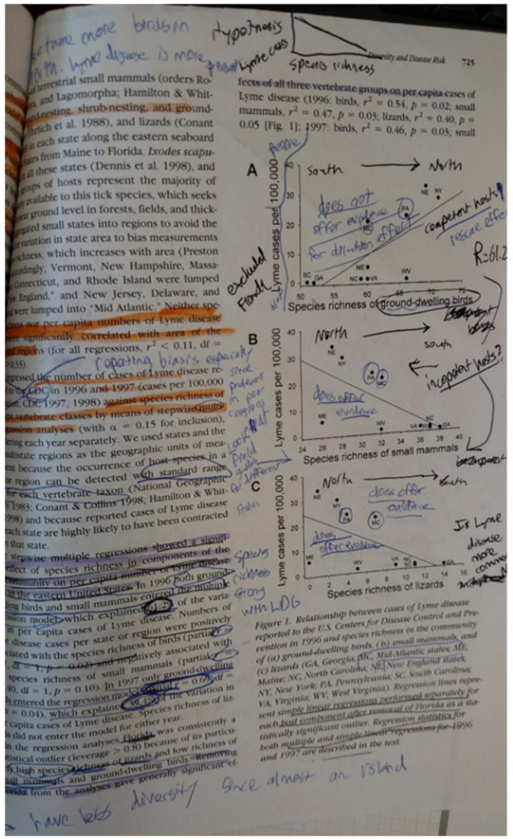
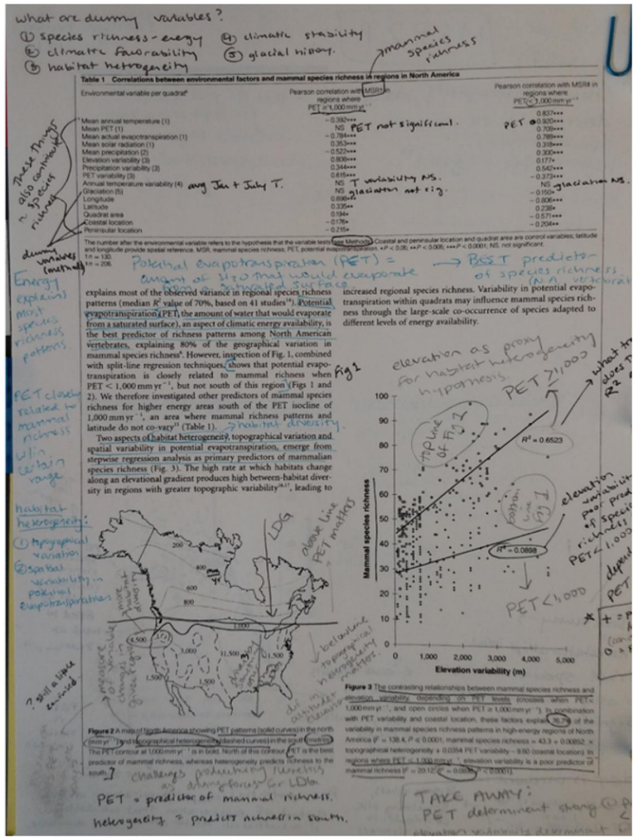
Hoskins 2010

To unlearn their experiences with statistical significance, I want my students to learn scientific skepticism by thinking like a scientist. By the end of the course, they should have the confidence to approach any written or visual report of statistical results and assess the accuracy and effectiveness of such a report. Before, if they were to see a written statement that included ($p < 0.05$), they may have accepted the statistical interpretation as useful, informative, or good. After this exercise, which is built into a larger class following this framework of "thinking like a scientist", students will be able to say that such a statement is incomplete, *and* suggest ways of making it more thorough.

Annotation activities can promote critical thinking



Smith and Paradise 2022



Annotation can guide students towards:

- drawing meaning from scientific literature and **"high level of reading engagement"**

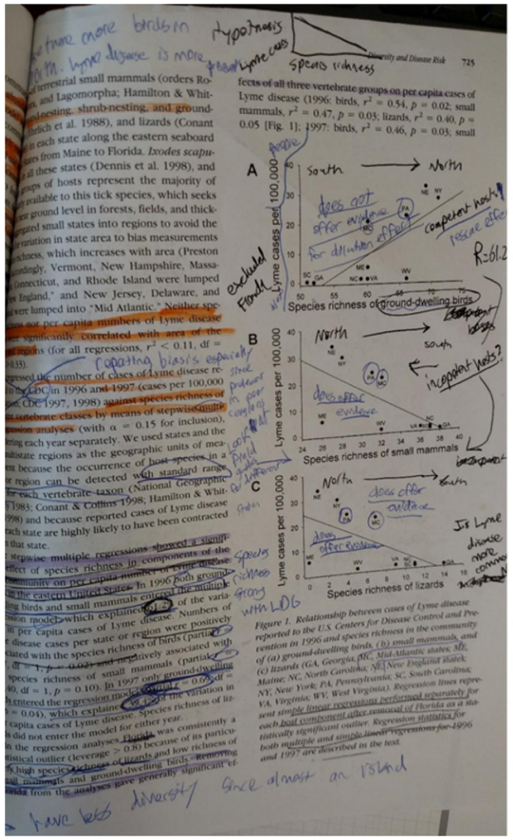
Smith and Paradise 2022

- **improved reading comprehension**

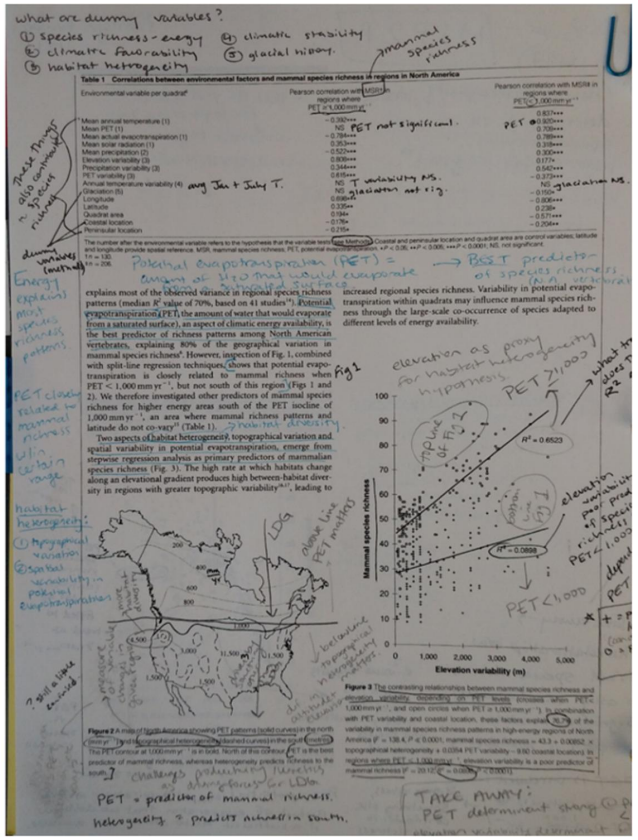
Zywica and Gomez 2008

This suggests that annotations can promote critical thinking (thinking skeptically) by leading students to engage with words and ideas through physically marking up the text.

Annotation activities can promote critical thinking



Smith and Paradise 2022



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In the biology classroom:

- **active learning → critical thinking** in evaluating how data can support a hypothesis

Styvers et al. 2018

Case study: Statistics for Environmental Studies (ENVS 193DS), Spring 2024

Department: Environmental Studies

Class size: 51 students

Format: 2 lectures/week, 1 discussion/week

Application of specific technique: once (but looking forward to building this out further!)

Slides 11 - 13 show examples of slides from my lecture on the topic of communicating “beyond p-values”.

Classroom dialogue to improve written statistical communication

Approach results statements with healthy skepticism

Framework: If you don't understand what is going on, you might have more to learn...
but the authors also might have more to write about (that they ultimately didn't)

Classroom dialogue to improve written statistical communication

Approach results statements with healthy skepticism

Using a t-test, we found a significant difference in lobster carapace sizes between marine protected areas and non-protected areas ($p = 0.02$).

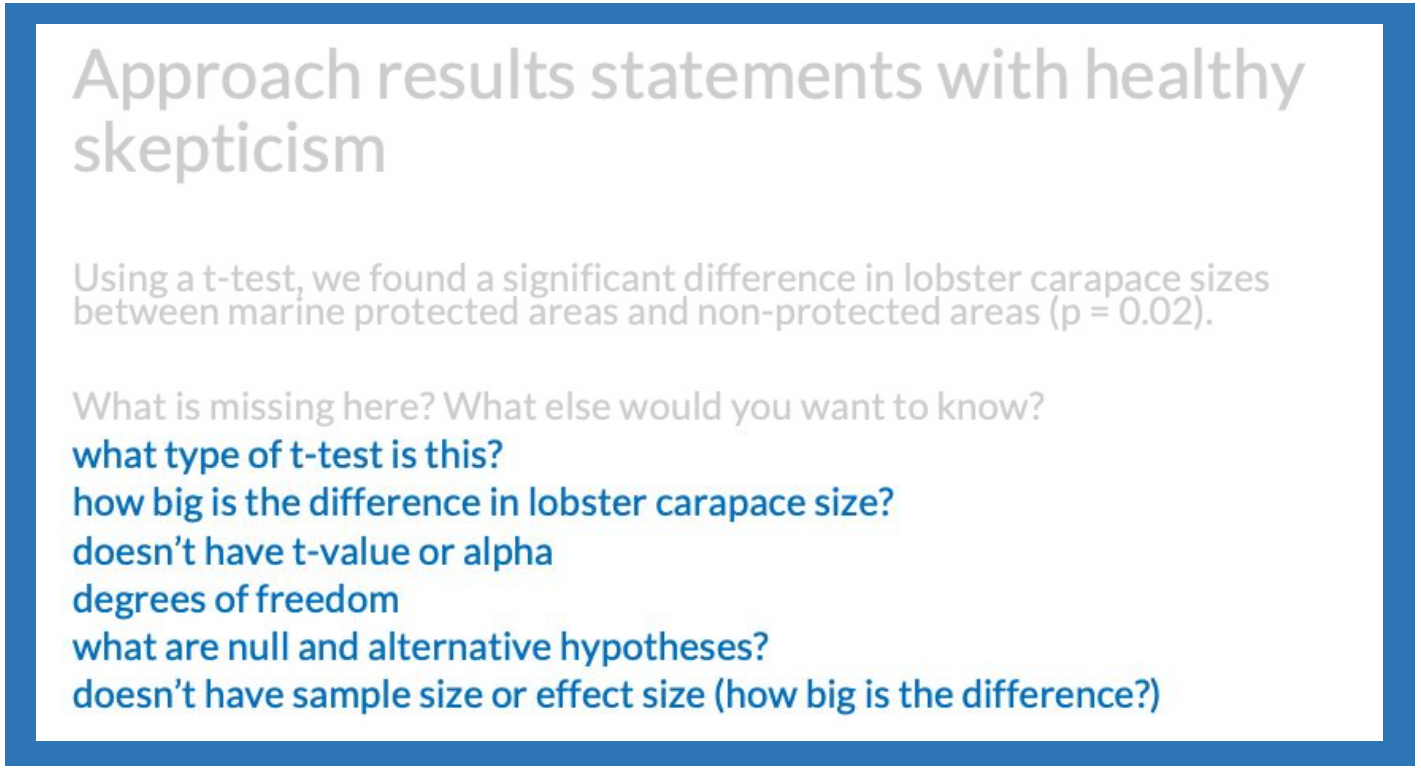
What is missing here? What else would you want to know?

Activity: present students with an "incomplete" research statement

Give time to annotate and discuss with peers

Guiding questions to encourage thinking about what is "missing"

Classroom dialogue to improve written statistical communication



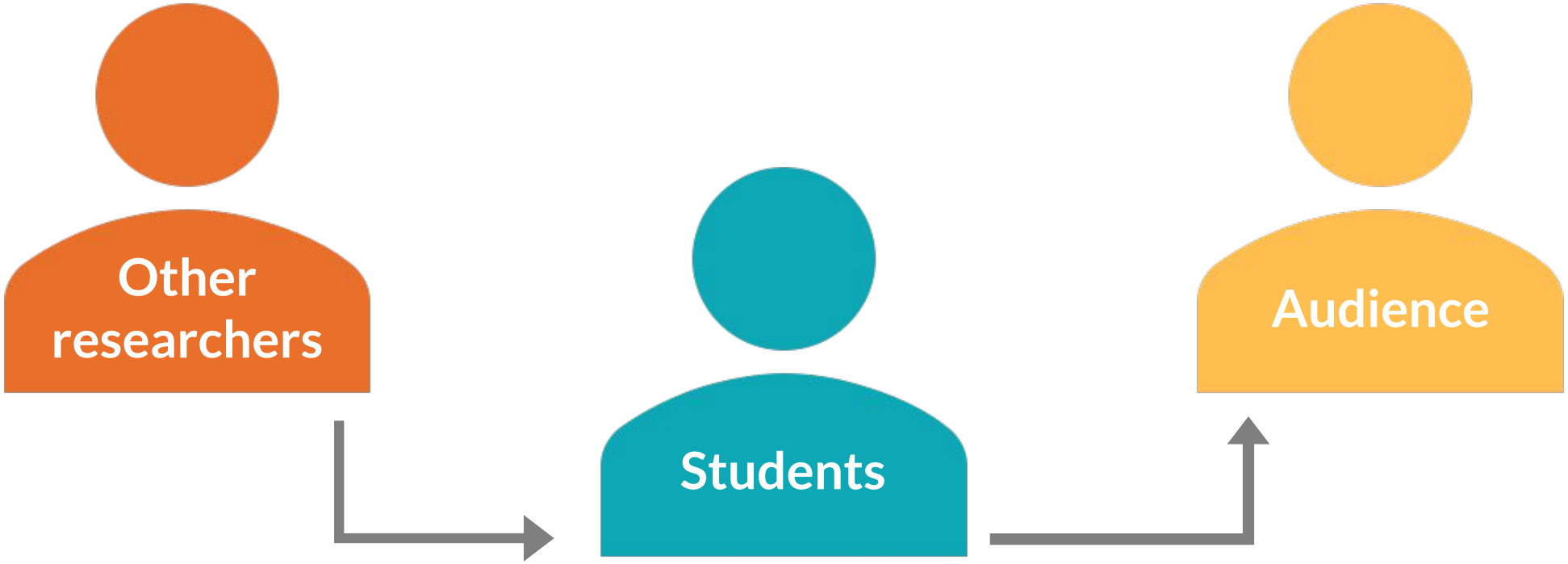
Whole group discussion:

made a list in class of student responses
connected each response to an aspect of the **biology of the system**

Future iterations should involve more demonstration, integration, and student feedback

- do an actual demonstration of annotation
- more annotation activities as course continues → more sophistication
- student assessment
  - students will be presented with an incomplete statement
  - task: list what is missing and define *why* those components are crucial for understanding the biology of the study system
- student reflection
  - Was this exercise useful for your understanding when you read scientific literature?
  - What would you suggest to researchers to make their statistical reporting more thorough, and why?

Ultimate goal: bring biology to statistics and statistics to biology



Students will ground and interpret their findings in the context of ecology, granting a more nuanced understanding of statistical results.

Citations

Gottesman, Alan J. and Sally G. Hoskins. (2013). CREATE Cornerstone: Introduction to Scientific Thinking, a New Course for STEM-Interested Freshmen, Demystifies Scientific Thinking through Analysis of Scientific Literature. CBE – Life Sciences Education 12 (1). https://doi.org/10.1187/cbe.12-11-0201

Hoskins, Sally G., Leslie M Stevens, Ross H Nehm. (2007). Selective Use of the Primary Literature Transforms the Classroom Into a Virtual Laboratory. Genetics 176 (3), 1381–1389. https://doi.org/10.1534/genetics.107.071183

Hoskins, Sally G. (2010). “But if It's in the Newspaper, Doesn't That Mean It's True?” Developing Critical Reading & Analysis Skills by Evaluating Newspaper Science with CREATE. The American Biology Teacher 72 (7): 415–420. https://doi.org/10.1525/abt.2010.72.7.5

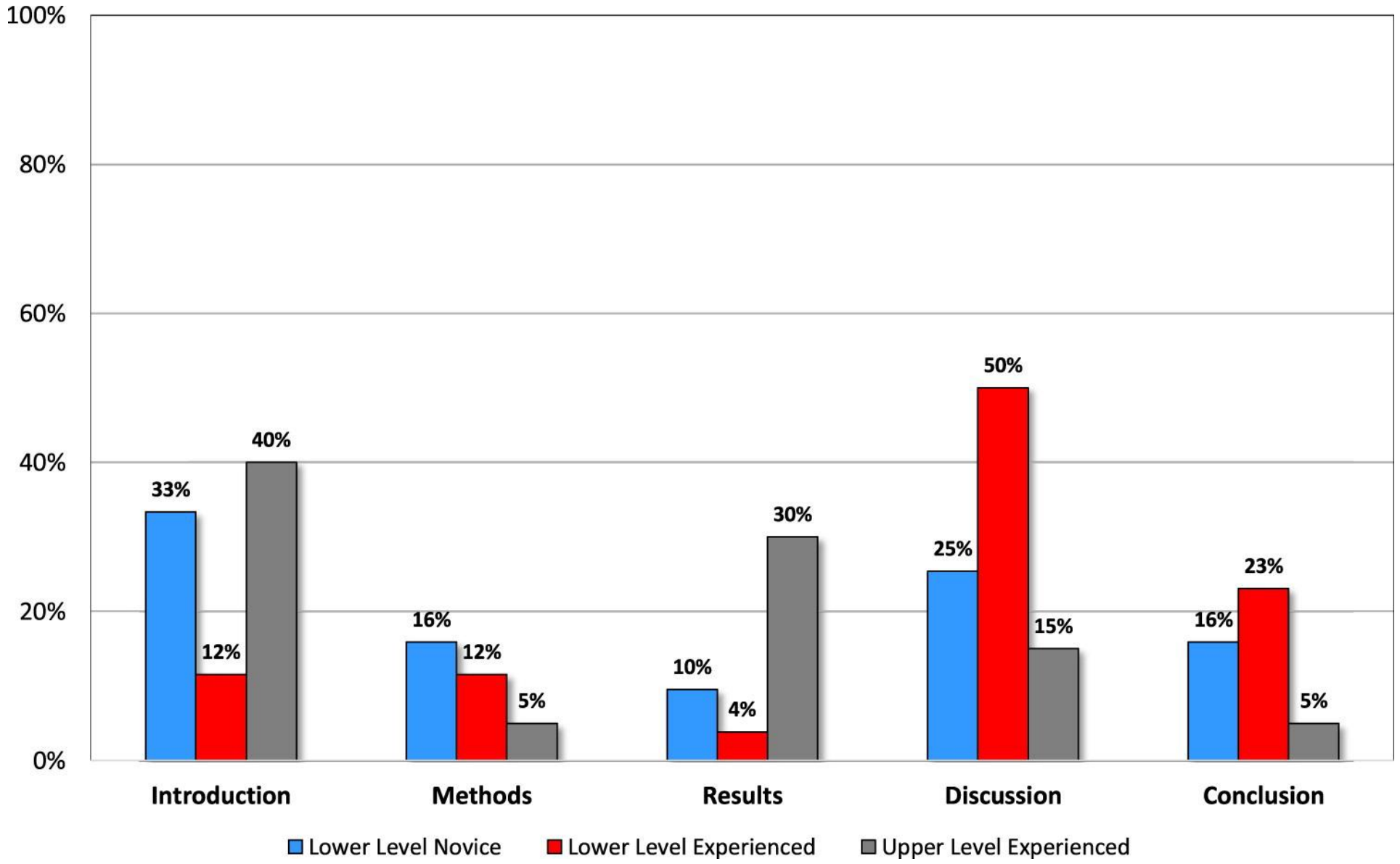
Hubbard, K. E., Dunbar, S. D., Peasland, E. L., Poon, J., & Solly, J. E. (2022). How do readers at different career stages approach reading a scientific research paper? A case study in the biological sciences. International Journal of Science Education, Part B, 12(4), 328–344. https://doi.org/10.1080/21548455.2022.2078010

Kenyon, Kristy L., Bradley J Cosentino, Alan J Gottesman, Morgan E Onorato, Jamila Hoque, Sally G Hoskins. (2019). From CREATE Workshop to Course Implementation: Examining Downstream Impacts on Teaching Practices and Student Learning at 4-Year Institutions. BioScience, 69 (1), 47- 58, https://doi.org/10.1093/biosci/biy145

Lennox, R., Hepburn, K., Leaman, E., & van Houten, N. (2020). ‘I’m probably just gonna skim’: an assessment of undergraduate students’ primary scientific literature reading approaches. International Journal of Science Education, 42(9), 1409–1429. https://doi.org/10.1080/09500693.2020.1765044

Smith, K. G., & Paradise, C. J. (2022). Teaching the process of science with primary literature: Using the CREATE pedagogy in ecological courses. Ecology and Evolution, 12, e9644. https://doi.org/10.1002/ece3.9644

Zywica, J. and Gomez, K. (2008), Annotating to Support Learning in the Content Areas: Teaching and Learning Science. Journal of Adolescent & Adult Literacy, 52: 155-165. https://doi.org/10.1598/JAAL.52.2.6



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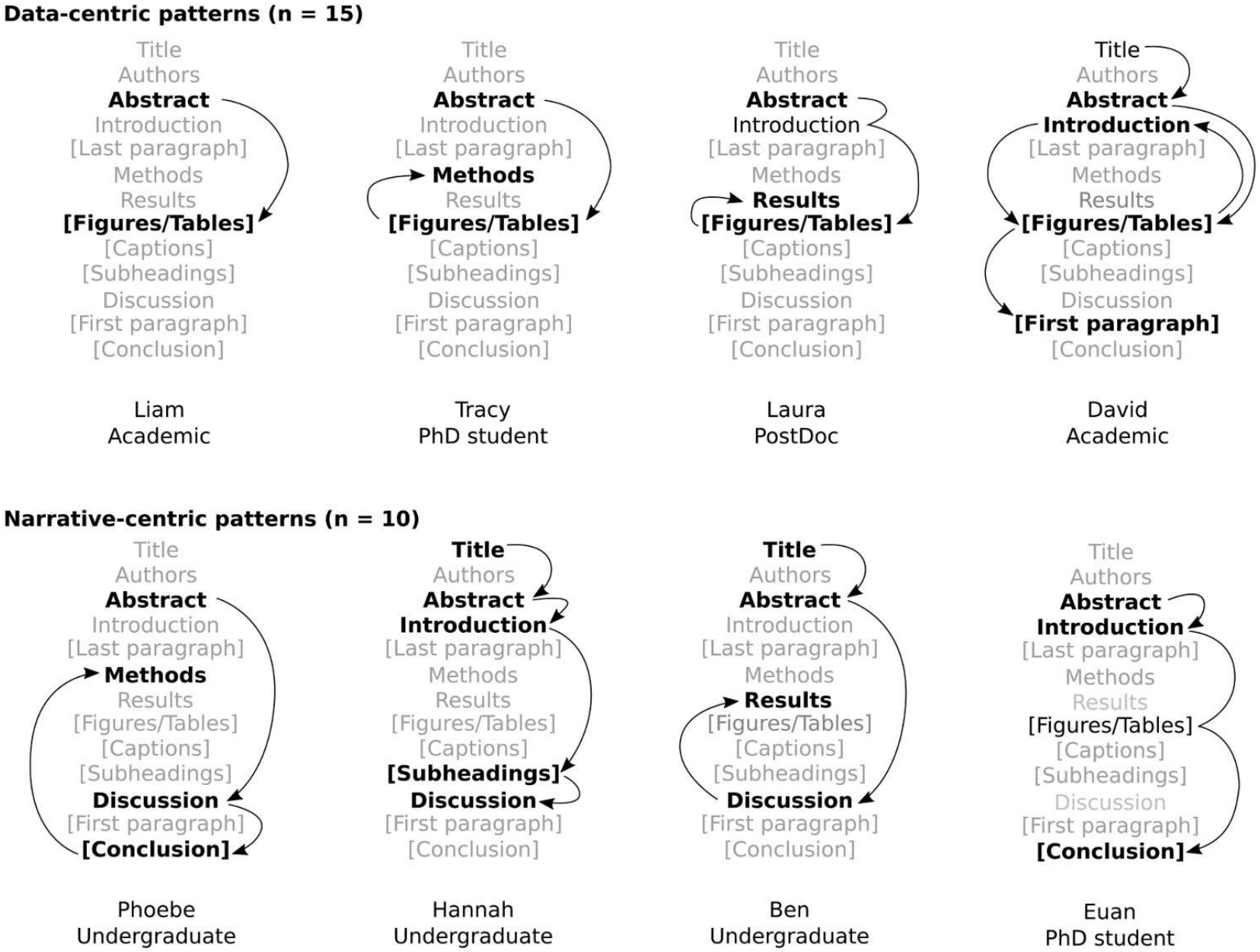

Hubbard, K. E., Dunbar, S. D., Peasland, E. L., Poon, J., & Solly, J. E. (2022). How do readers at different career stages approach reading a scientific research paper? A case study in the biological sciences. International Journal of Science Education, Part B, 12(4), 328–344. https://doi.org/10.1080/21548455.2022.2078010