Supporting Case-Based Student Writing and Logical Reasoning

Three Different Scaffolding Approaches and their Outcomes

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Why are we here?

- We've been making some changes over the past few years to a set of writing assignments in BIOL362.
- We wanted to see what the effects of these changes were, so we analyzed the data.
- We shared our findings at the CTLT 2016 summer institute, and thought Biology might find it useful as well.

- Biology 362:
  - 3rd Year, Cell Physiology course
  - 1 section, ~50-100 students, primarily BIOL majors
  - Focus on conceptual learning & skills development within the context of cell physiology

The Plan for Today

- What is logical reasoning?
- Why is it important for students to learn?
- How did we try to teach it?
- How can we best support student learning?

What is logical reasoning?

- What do you think?
- Logical Reasoning: Ability to draw a logical conclusion given a set of premises (ie. Ability to make and support an argument).
  Wikipedia
- Argument: "A series of premises and conclusions subject to the rules of science and of informal logic."
  Wisehart & Mandell (2008)
- Informal Logic: The logic used in everyday language to support claims and arguments.
  Stanford Encyclopedia of Philosophy

Be aware that different disciplines define arguments differently, which can confuse students (Lea & Street, 1998). This is a biologists definition.

Why should students learn logical reasoning?

- "The central point of education is to teach people to think, to use their rational powers, to become better problem solvers."
  Gagne (1980) p85
- Reasoning, critical thinking and problem solving are fundamental STEM skills which form the basis for acquiring more advanced skills.
  The Council of Canadian Academies (2015)

Learning Objective: Students will be able to formulate and defend an argument using logical reasoning, and experimental evidence.

How do we teach this?
The Case-Study Assignments

- The students work in groups to complete the assignment during class time (85 min)
- They are given 3 to 5 pieces of data and are asked to draw a connection between the data and a big-picture problem
- Each group writes a ‘hypothesis’ and a ‘rationale’
  - The Hypothesis: An argument, or model, that answers the question posed. 1-2 sentences.
  - The Rationale: A justification or defence of the hypothesis, using the data provided. 1-2 paragraphs.
- The students complete 4 case studies, with different data and questions, throughout the term

Handout Pg2: The First Case Study

"I liked the case studies. Both for the fact that we're learning to build a proper hypothesis and for the team bonding."

" [The case studies] didn't necessarily help too much with learning the material presented in class (although they did a little), but they were really useful in practicing the problem solving skills also needed in midterms and the final."

"I think that the emphasis on wording and logical flow was good because I think it's really important to be able to state all the steps you are taking to get to your conclusion (not just in this class of course)."

"[The case studies] made me think critically about what we learned in class and put the material from different lectures together."

*"The case studies were interesting but the criteria for what was expected was way too **vague**."*

*"Didn't like [the case studies]. Not sure if they are helpful for learning. Felt like an **arbitrary** way of thinking, didn't increase creativity."*

*"The case studies seemed to be more **difficult** than they should be, it was hard to know what to do to improve."*

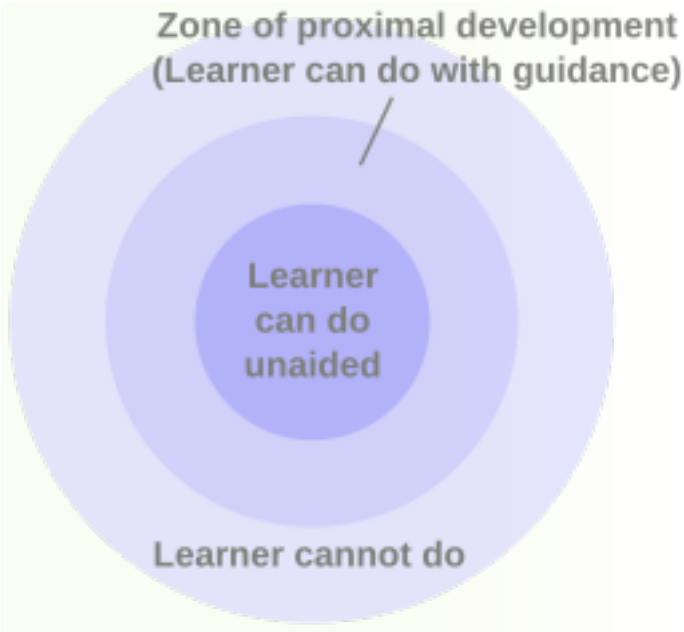
*"I did feel that the grades my group received did not accurately reflect our comprehension of the material … I believe we were **frustrated** because learning how to quickly and clearly communicate newly comprehended material takes much longer (years) than mentally or verbally forming rationales behind the data.*

How can we provide better support for this assignment?

Why do we provide support?

Zone of Proximal Development

Vygotsky (1978)



Wikipedia

Transformative Learning

Mezirow (1991)

Level of Challenge		Level of Support: Low	Level of Support: High
	High	**ANXIETY** frustration	**GROWTH** engagement
	Low	**STAGNATION** pointlessness boredom	**DEPENDENCY** busy work dumbed down

Modified from Wilson & Devereux (2014)

Types of Support

Built-In

- Designed into the assignment itself.
- Often designed to catch and correct misconceptions from the start.
- Helps motivate students to persevere with challenging tasks.

Contingent

- Support that is not planned, but offered as needed.
- Relies on in-the-moment interactions between teachers and students.
- Can address unexpected issues not covered by built-in scaffolding.
- Can be used to make connections to prior knowledge, draw concepts together, and highlight key points.

Modified from Wilson & Devereux (2014)

The 3 Approaches We Used

- **'Traditional'**
  - students are given instructions before each case study
  - instructor/TAs answer questions during the assignments
  - TAs mark and give individual and general written feedback on answers
- **'Step-by-Step'** (same as traditional plus…)
  - students are given a worksheet deconstructing the thought processes experts use when doing the assignment
  - the whole worksheet is marked in the first case study, but only the final hypothesis and rationale are marked subsequently
- **'Student Marking'** (same as traditional plus…)
  - in the first case study only, students try writing a hypothesis, but this is not collected or marked
  - instead, students are shown example hypotheses and rationales, and given a rubric for marking them

Handout Pg3: Scaffolding Examples

Types of Scaffolding

Built-In

- Students do the assignment four times
- Pre-assignment resources explain hypotheses
- Assignment instructions and background provided
- Students work in groups
- Big picture problem highlights importance
- Step-by-step worksheet breaks down the process
- Student marking worksheet

Contingent

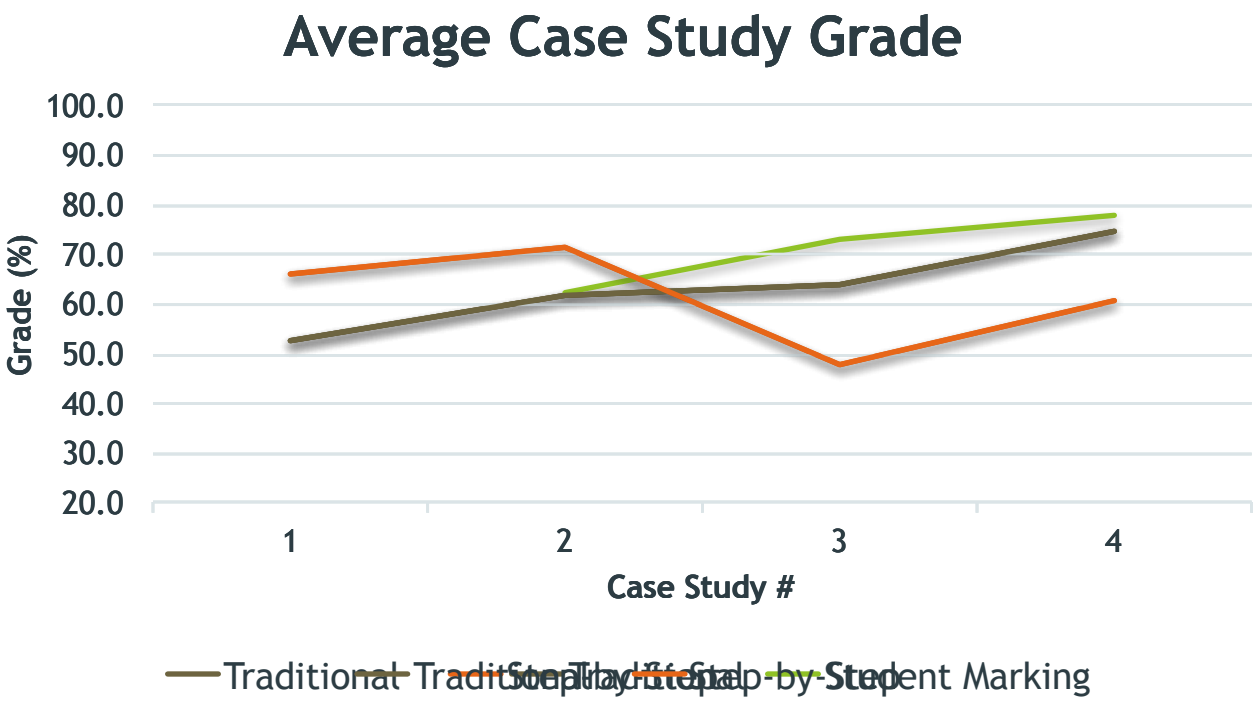
- Answer questions during class
- Provide detailed individual feedback
- Provide general feedback on common issues
- Share examples of good answers with comments
- One-on-one feedback with groups when requested

What do you think happened?

- Which type of scaffolding resulted in the biggest improvement in student performance?
- Which approach did students like best, and why?

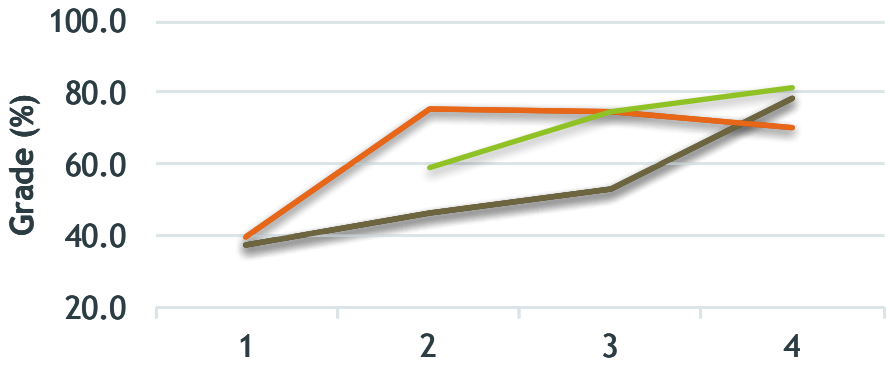
Traditional Step-by-Step Student Marking

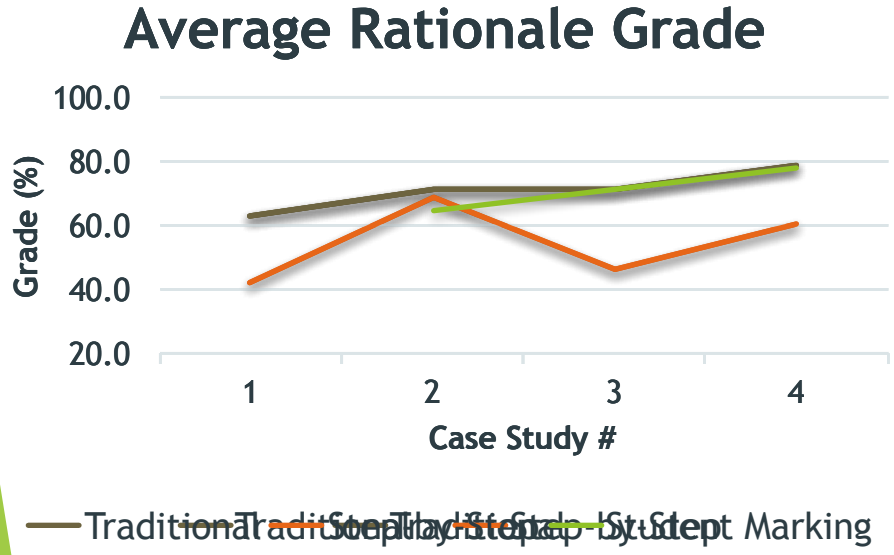
Part 1: Grades



Step-by-Step: Students did better on the first case study, but could not sustain this when support was removed.

Student Marking: Students improved faster than with the 'Traditional' approach, and did as well on the second case study, despite not writing the first case study.



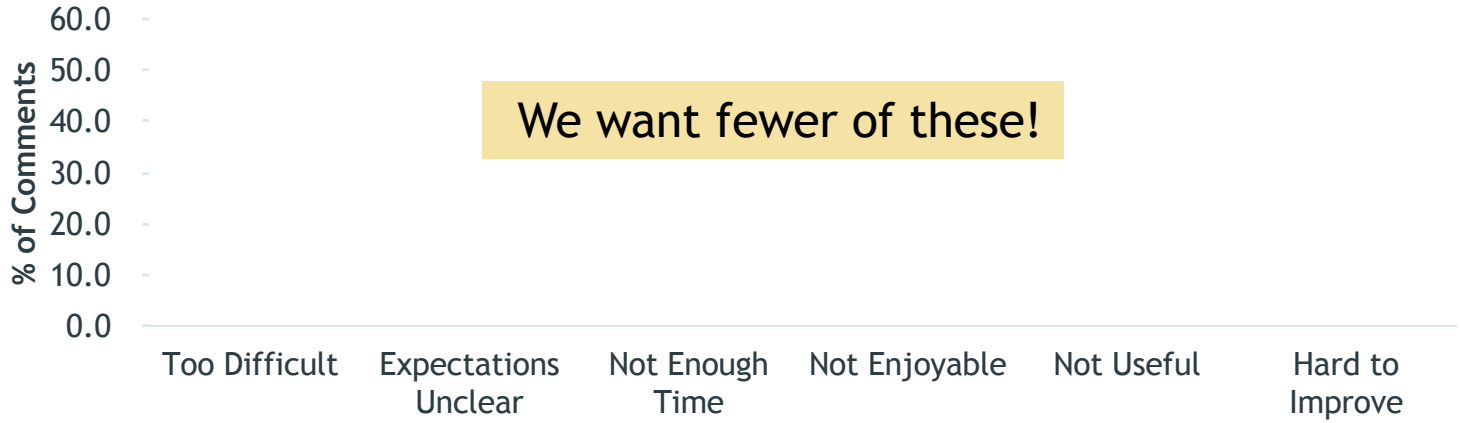


Step-By-Step: Student hypotheses improved faster when the steps were broken down, but the rationales were disjointed and did not improve in quality

Student Marking: Student hypotheses improved faster, despite not completing the first assignment.

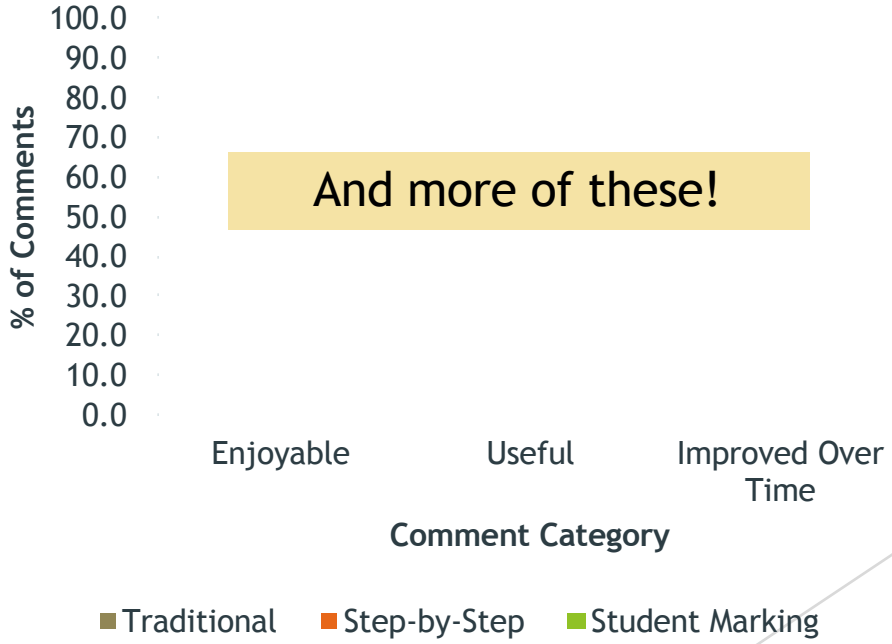
Part 2: Student Feedback

Negative Comments



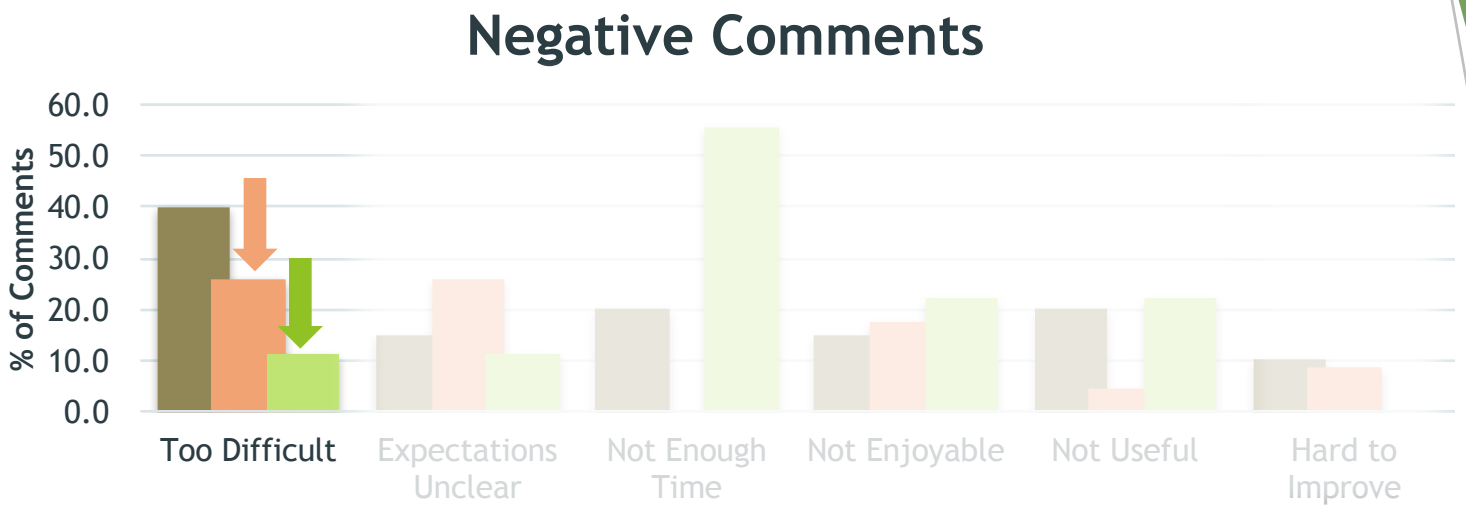
We want fewer of these!

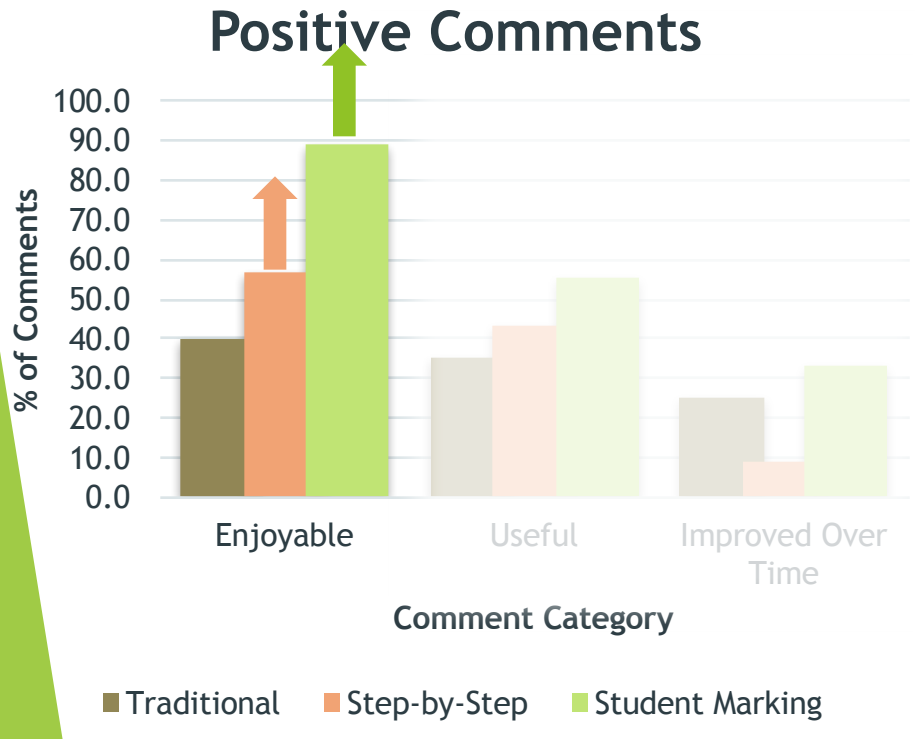
Positive Comments



And more of these!

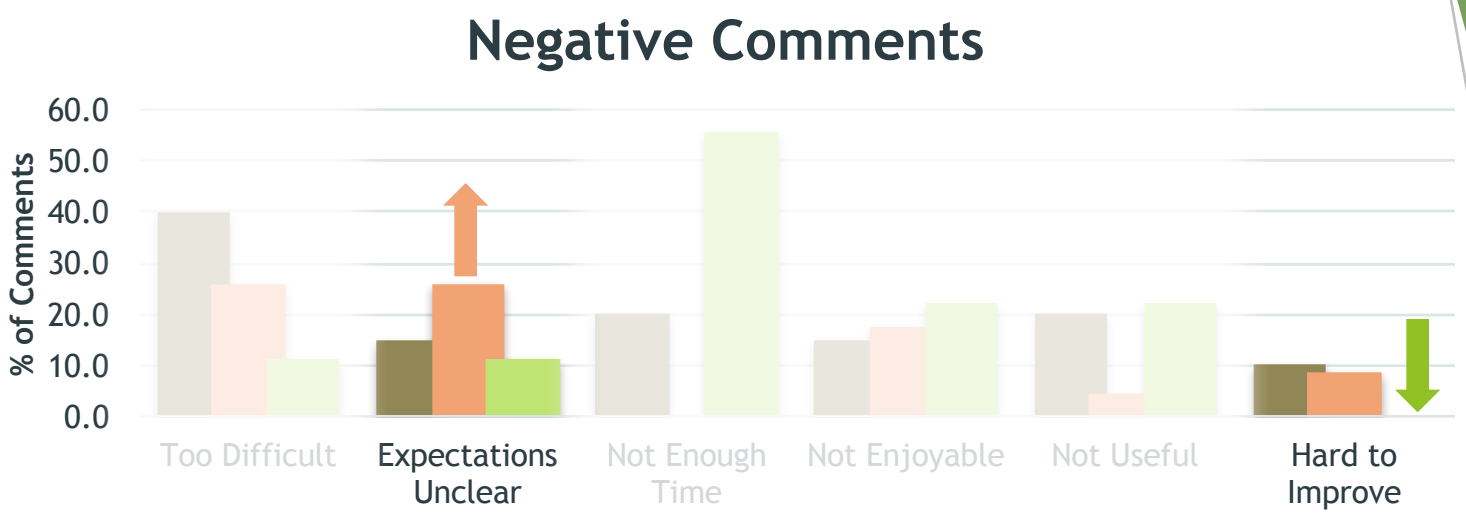
Difficulty and Enjoyment

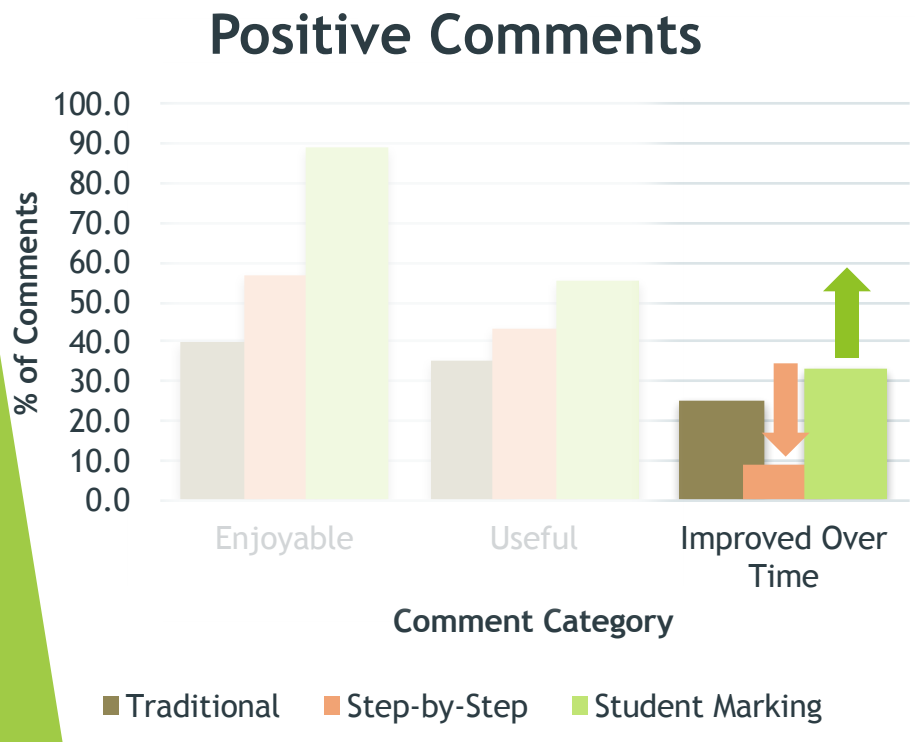




Students found the assignments less difficult and more enjoyable with both the Step-by-Step and Student Marking scaffolding.

Expectations and Improvement

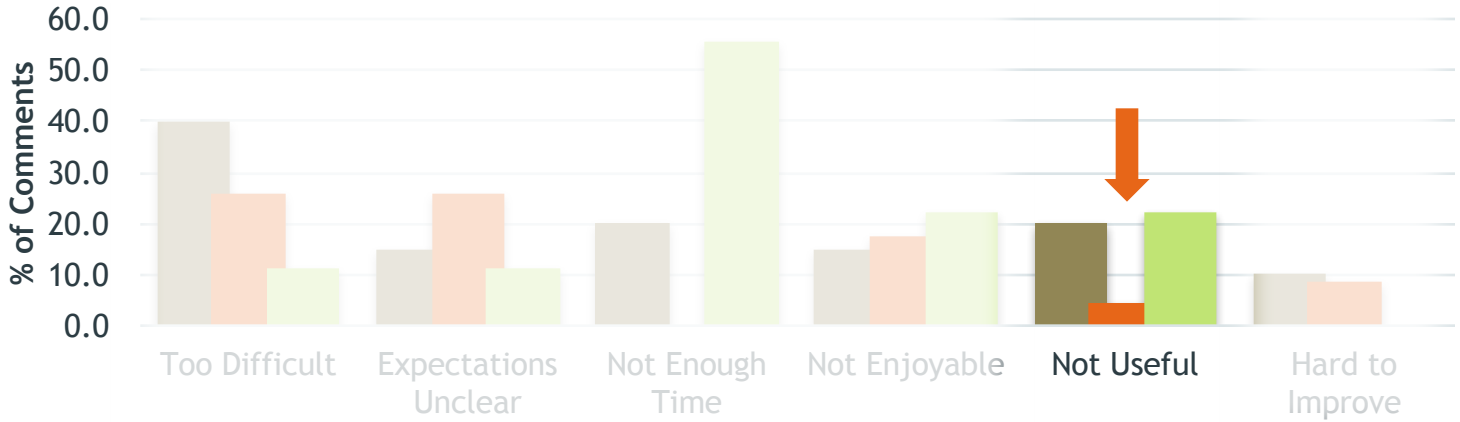




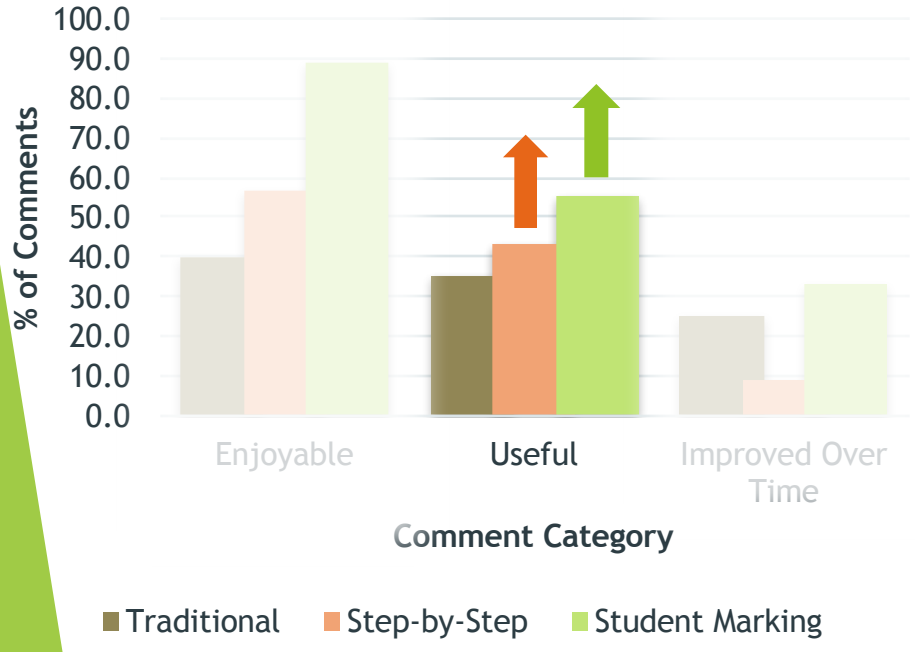
Students seem to have found it harder to improve over time with the Traditional and Step-by-Step approaches, compared to the Student Marking scaffolding. This agrees with the trend in grades.

Usefulness

Negative Comments



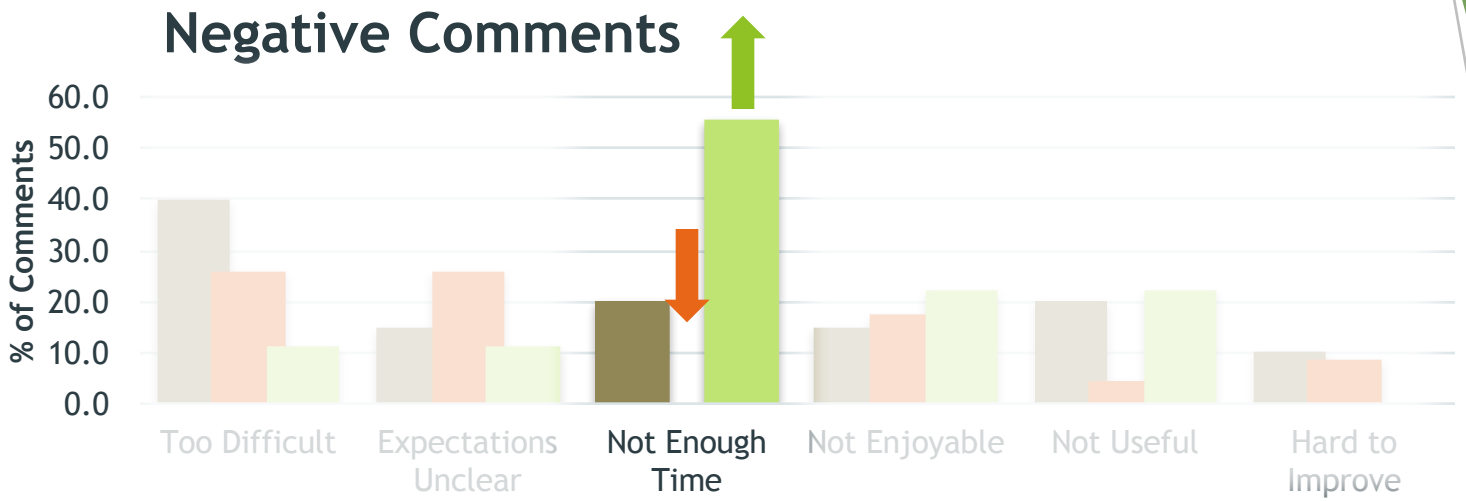
Positive Comments

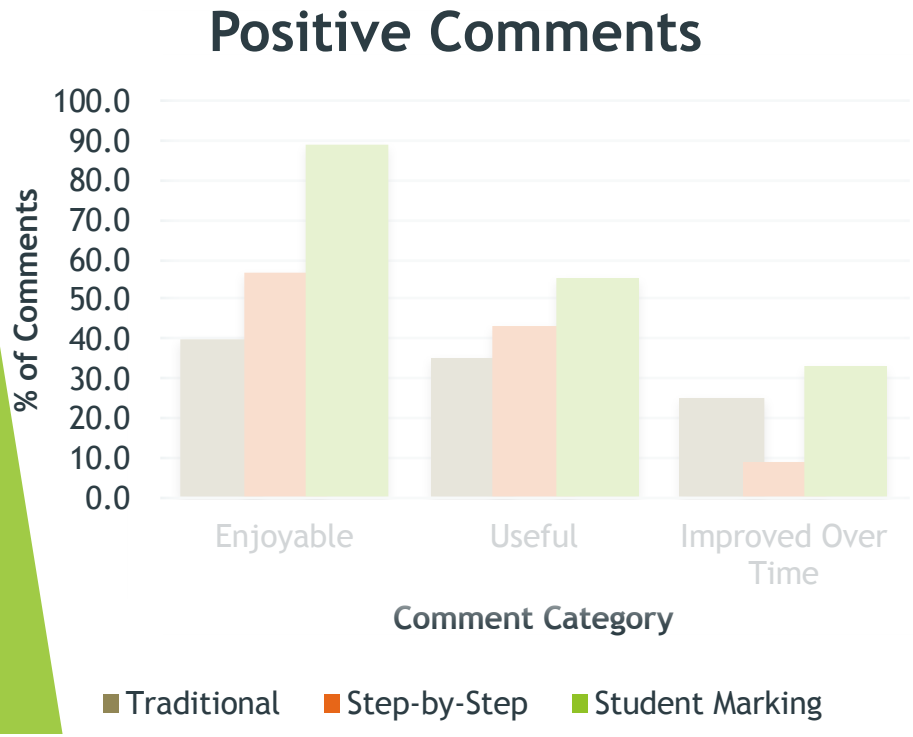


Comments about lack of‘usefulness’ tended to center around the assignment’s focus on communication/writing.

This may indicate a misunderstanding of the learning objective and/or its importance for their education.

Time Constraints





Students asked for more time only for the Traditional and Student Marking approaches.

This likely reflects less time spent working on constructing and organizing their arguments, as the Step-by-Step approach tended to provoke lower quality responses.

Conclusions from the Data

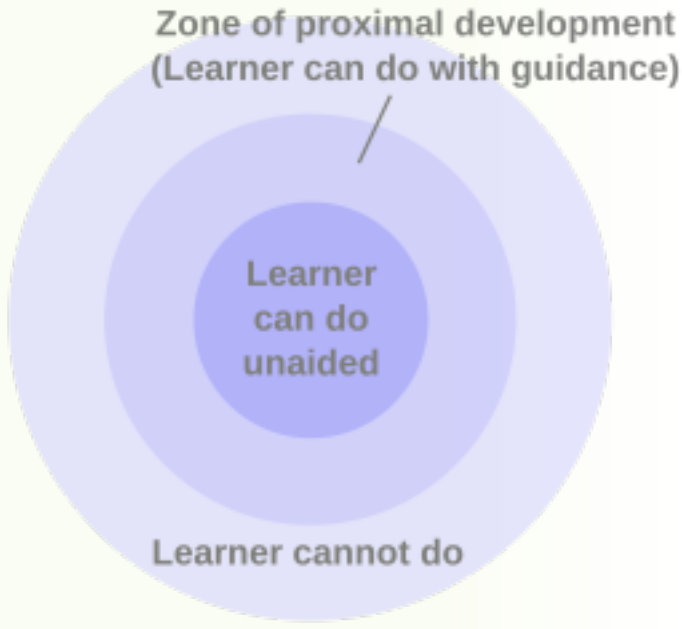
- **Step-by-Step:** Hurt student learning more than it helped. While we think that students felt more supported initially, students did not feel this way by the end of term.
  - Student Learning: Worsened
  - Student Attitudes: Worsened
- **Student Marking:** Students performed just as well with the scaffolding, but seemed to feel better supported than with the **Traditional** approach.
  - Student Learning: Stayed the Same
  - Student Attitudes: Improved

What are the take-home messages?

1. Students learn best when pushed out of their comfort zones, but well supported

- Assignments should be challenging enough that students need to work at it.
- But you need to provide support, to avoid student frustration and maximize learning.

Vygotsky (1978)



Mezirow (1991)

Level of Challenge		Low Support	High Support
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Level of Support

Modified from Wilson & Devereux (2014)

2. Providing examples of writing is more powerful than trying to explain what 'good' writing is

- Identifying 'good' writing is easier for students than trying to explain why it's 'good'.
- One way to help student do this is to provide specific examples of what we consider good writing.
- This can also reduce student anxiety by demystifying the assignment and clarifying the meaning of the terminology used
  - eg. critique, evaluate, synthesize, hypothesize, demonstrate, argue, rationalize, conclude, justify, explain, summarize …

Student Feedback on Case Studies

"The marking of the hypotheses and rationale in the first case study was useful in figuring out how to write hypotheses and rationales. What was perhaps more useful in determining how to write the hypotheses and rationales, though, was the feedback and examples of good and bad hypotheses and rationales."

3. Better support is more powerful than more support

- How can you give better built-in support?
  - Make your expectations clear and explicit
  - Give multiple opportunities to practice
  - Encourage students to work together
  - Provide example answers
  - Build-in check points for sub-tasks
  - Don’t deconstruct the thought process too much

Annotated References
(Key Literature)

- Hattie & Timperley (2007) The Power of Feedback. Rev. Ed. Research 77(1):81-112
  Very thorough summary of the literature around feedback and how to give it effectively.
- Kim, Prevost, Lemons (2015) Students' usability evaluation of a Web-based tutorial program for college biology problem solving. J. Computer Assisted Learning 31:362-377
  Outlines the theoretical framework behind different types of scaffolding (i.e. conceptual, strategic, procedural, metacognitive) and tests their implementation in an online biology problem-solving tutorial.
- Lea & Street (1998) Student Writing in Higher Education: an academic literacies approach. Studies in Higher Ed. 23(2):157-172
  Contrasts instructor and student perspectives of writing requirements. Identifies inconsistencies in what different instructors mean when talking about 'structure' and 'argument'.
- Mezirow (1991) Transformative Dimensions of Adult Learning. San Francisco, CA: Jossey-Bass.
  Describes the dichotomies of high and low levels of challenge and support and how they interact and affect the learning experience of students.
- Vygotsky (1978) Mind in Society: The development of higher psychological processes. Cambridge MA: Harvard University Press
  Introduces the theory behind the zone of proximal development.
- Wilson & Devereux (2014) Scaffolding theory: High challenge, high support in Academic Language and Learning (ALL) contexts. J. Acad. Lang. & Learn. 8(3):A91-A100
  Excellent introduction to the theory behind scaffolding and how to use it to support student writing.
- Wisehart & Mandell (2008) Problem Solving in Biology: A Methodology. J. College Sci. Teaching. 2:24-29
  Outlines a procedure biology students can use to construct an argument based on data.

Handout Pg5: Annotated Bibliography

References
(Other - Quotes and Definitions)

- Informal Logic (2011) Stanford Encyclopedia of Philosophy http://plato.stanford.edu/entries/logic-informal/#Two
- Council of Canadian Academies (2015) Some Assembly Required: STEM Skills and Canada's Economic Productivity. Ottawa (ON): The Expert panel on STEM Skills for the Future, Council of Canadian Academies.
- Gagne (1980) The conditions of learning (3rd ed.) New York: Hold, Rinehart & Winston.
- Wikipedia (2016) Logical Reasoning

The End!

Are there any questions?

The End!

Part 3: Instructor Feedback

How did the feedback change?

First Year

Hyper-phosphorylation of the microtubule-associated protein Tau results in the inability of Tau to stabilize microtubule networks in the cell (how?), and causes abnormal neurofibrillary tangles in the brain cells (why?) of patients with Alzheimer's disease. **The microtubule networks are essential for normal cell functioning. Without the stabilization of these networks in the cell, these cells undergo massive death in Alzheimer's disease patients, resulting in shrinkage of the brain.** (I'm not sure what this adds to the hypothesis)

This hypothesis is too general and needs to contain more specific information.

Second Year

The hyper-phosphorylation of Tau results in fewer correctly aligned microtubules (how are these connected?), causing neurofibrillary tangles (are you saying the incorrectly aligned microtubules cause the tangles? This is incorrect) which leads (are you saying the tangles themselves lead to the neurodegeneration?) to the neurodegeneration characteristic of AD and CTE.

Third Year

The pathogenic plant bacterium *Pseudomonas sp.* is able to avoid detection by plant cells by secreting the protein AprA, which degrades flagellin monomers, preventing the~~m~~ monomers (it wasn't clear to me if you were talking about flagellin or AprA binding to FLS2) from binding the FLS2 receptor on the plant cell and ~~as a result~~ which would (as written it implied that LACK of flagellin binding triggered immunity, rather than binding) activate~~ing~~ the plant's immune response. By degrading these monomers before they can bind to this receptor, the bacterium evades detection. (I'm not sure this last sentence is necessary as it seems to be repeating part of the first sentence.)

Your hypothesis contains all the important pieces of information, and I find it pretty easy to follow. I've included some wording suggestions to improve clarity. These may seem minor, but as written it's not always clear to me exactly what you mean.

7 Ways to Improve Feedback

1. **Use in-text Feedback**
   Tell students exactly where they can improve
   "A changes B (how?)."
2. **Use "I" Statements**
   Avoid absolutes, but give an expert's opinion
   "I find…"
3. **Focus on the Logic**
   Feedback should focus on the learning objective
   "I find it hard to follow your logic"
4. **Explain Why**
   Help students decipher your feedback
   "I find it hard to follow your logic because the way you've worded this the relationship between A and B is ambiguous (ie. A changes B)"

7 Ways to Improve Feedback

5. **Give a Better Alternative**

   Provide specific ways to improve

   "I find it hard to follow your logic because the way you've worded this the relationship between A and B is ambiguous (ie. A changes B), it would be clearer if you said A causes the loss of B."

6. **Provide Summary Feedback**

   Highlight the key points

   "Overall, you are describing the data well, but your connecting logic is a bit too vague (see in-text comments)."

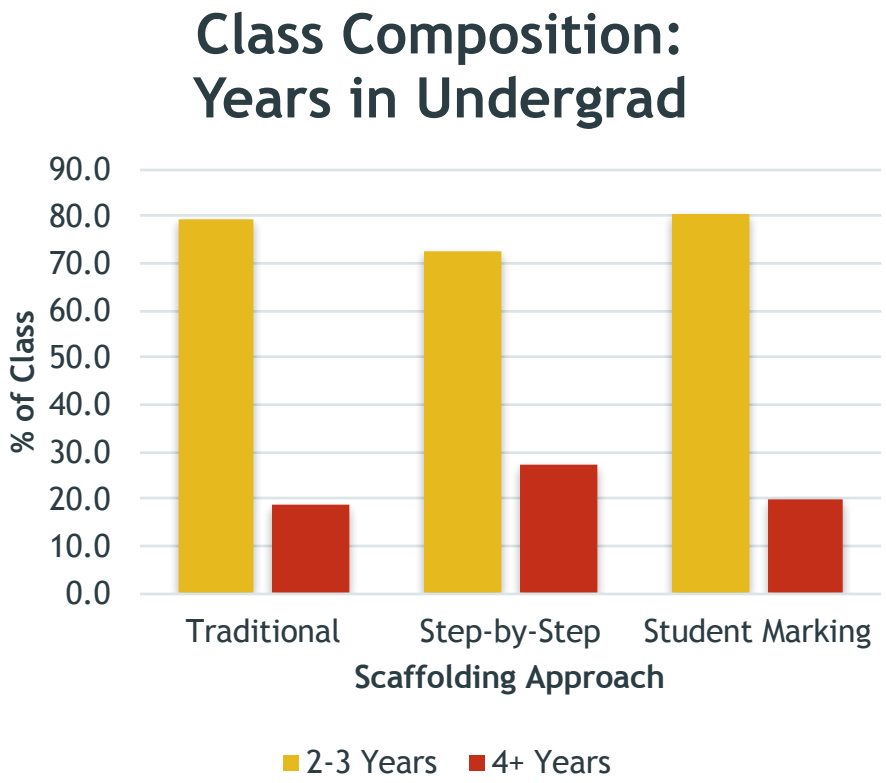
7. **Explain What is Done Well**

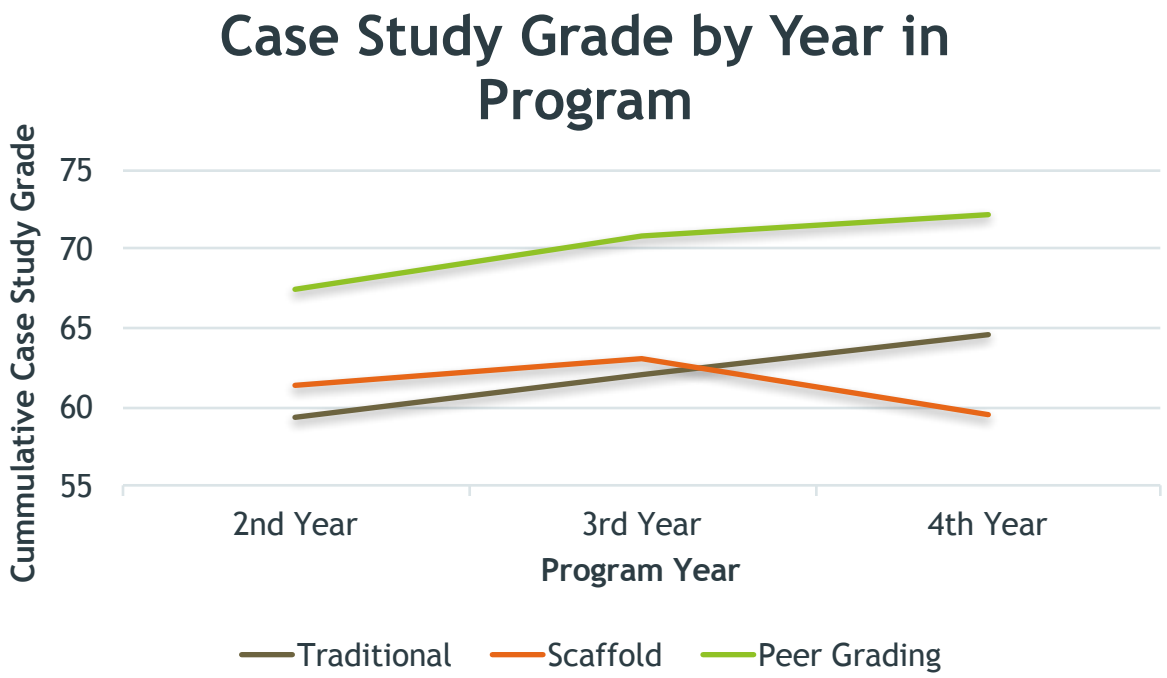
   Encourage them to continue good practices

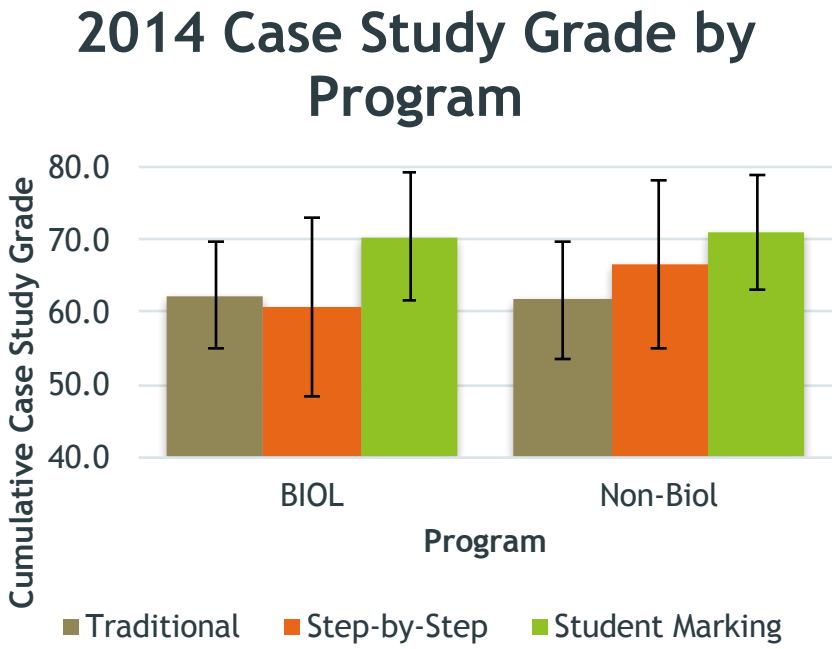
   "I liked how you incorporated the background information at the beginning, it gives a good context, and helps me understand how the data supports your argument."

Dealing with Time Constraints

- But! This kind of detailed feedback is a big time commitment.
- How can you get good feedback with a time limit?


Class Composition:
Years in Undergrad
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
% of Class
Traditional
Step-by-Step
Student Marking
Scaffolding Approach
2-3 Years
4+ Years


Case Study Grade by Year in Program
Cummulative Case Study Grade
75
70
65
60
55
2nd Year
3rd Year
4th Year
Program Year
Traditional
Scaffold
Peer Grading


2014 Case Study Grade by Program
Cumulative Case Study Grade
80.0
70.0
60.0
50.0
40.0
BIOL
Non-Biol
Program
Traditional
Step-by-Step
Student Marking