

Aligning Learning Objectives, Activities, and Assignments to Promote Enduring Understandings in a Cell Biology Laboratory



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Background

Our goal was to revise and update the curricular materials of an intermediate cell biology laboratory course to provide a stronger foundation for our students. To begin, course faculty defined a set of “Enduring Understandings¹” that students should take away from the course, including the ability to:

- compare/contrast experiments with published results and propose new experiments
- communicate scientific findings in written, visual, and oral forms
- use bioinformatics in support of traditional experiments

In this revision, we focused on three major changes to improve students’ educational and attitudinal outcomes:

- Creating clear learning objectives** to align assignments with the three enduring understandings and to make the relevance of assignments more transparent to students,
- Altering the content** of particular assignments to align better with the enduring understandings,
- Changing assignment scaffolding**, and incorporating more **practice and peer review opportunities**.

We assessed success of our changes by analyzing feedback from students pre and post-revision.

Methods

- The course had 5 laboratory sections, with 48 students in Spring 2017 and 46 students in Spring 2018
- All laboratory course materials were reviewed by instructors in Summer 2017, and learning objectives were defined for each lab session
- Corresponding weekly pre-lab lectures, quizzes, and assignments were modified or redesigned and used in Spring 2018
- Effects of changes were evaluated via an anonymous electronic survey to students, and by qualitative analysis of responses to end-of-semester course evaluations

Table 1: Summary of Modifications to the Cell Biology Laboratory Curriculum

Year	Assignments	Other Activities	Experiments (unchanged from 2017 to 2018)
2017 (pre-revision)	<ul style="list-style-type: none"> Weekly assignments analyzing data Final unit assignments - full scientific papers (both units 1 + 2) 	<ul style="list-style-type: none"> 30 min prelab lectures focused on key terms and methods 	Unit 1: Protein Expression and Enzyme Kinetics <ul style="list-style-type: none"> Purification of β-galactosidase Michaelis-Menten Kinetics Student-designed inhibition assay
2018 (post-revision)	<ul style="list-style-type: none"> First assignment of each unit focused on overview and experimental question Weekly assignments analyzing data and comparing to literature Final unit assignment – results and discussion (unit 1); small group poster/individual discussion (unit 2) 	<ul style="list-style-type: none"> Pre-lab lectures incorporating active learning techniques Activities to introduce enzyme kinetics, interpret data, and peer review 	Unit 2: Cell Culture and Apoptosis <ul style="list-style-type: none"> Treatment of mammalian cells with chemotherapeutics Examination of cells using protein, DNA, and microscopy assays

Figure 1: Student ratings of selected curricular materials as “effective for building the skills and knowledge [they] needed for the final unit assignments.” (2018 only, n=36)

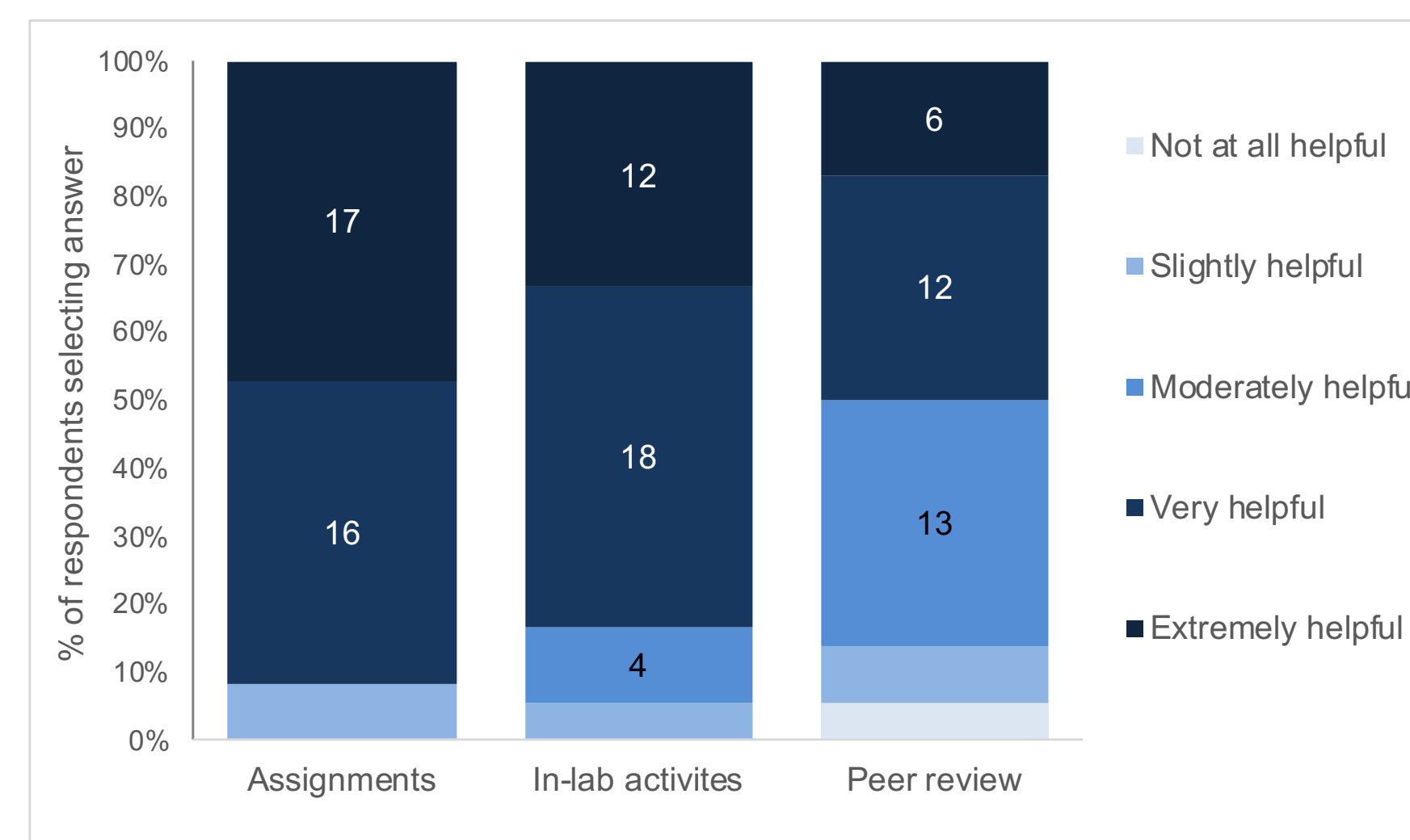


Figure 3: Analysis of course evaluations mentioning keyword in response to open ended questions about which features of the course were most valuable or could be improved. * represents p<0.05 by Fisher’s exact test.

Coded Themes:	Valuable Features		Features to Improve	
	2017 N=38	2018 N=35	2017 N=38	2018 N=35
Active Learning	4	5	0	0
Alignment	12	14	7	2
Assignments	14	5*	22	15
Autonomy	1	1	1	0
Collaboration	2	0	0	0
Communication	1	0	2	6
Confidence	1	0	0	0
Course Content	4	3	2	3
Course Organization and Planning	3	3	6	8
Course-related Resource	1	7*	1	2
Enjoyment	1	1	0	1
Frustration, Stress, or Anxiety	1	0	3	3
Grading and Feedback	0	0	2	9*
Instructor Support	1	0	0	0
No Changes	0	0	6	6
Pacing	0	0	5	0
Quizzes	1	0	1	4
Skill or Knowledge Development	23	20	2	1
Workload	0	1	11	6

Figure 2: Qualitative analysis of student answers to: “Which component of the lab assignments was most helpful for preparing you with the skills and knowledge you needed to complete the final unit assignments?” (2017: n=43, 2018: n=36) * represents p<0.05 by Fisher’s exact test.

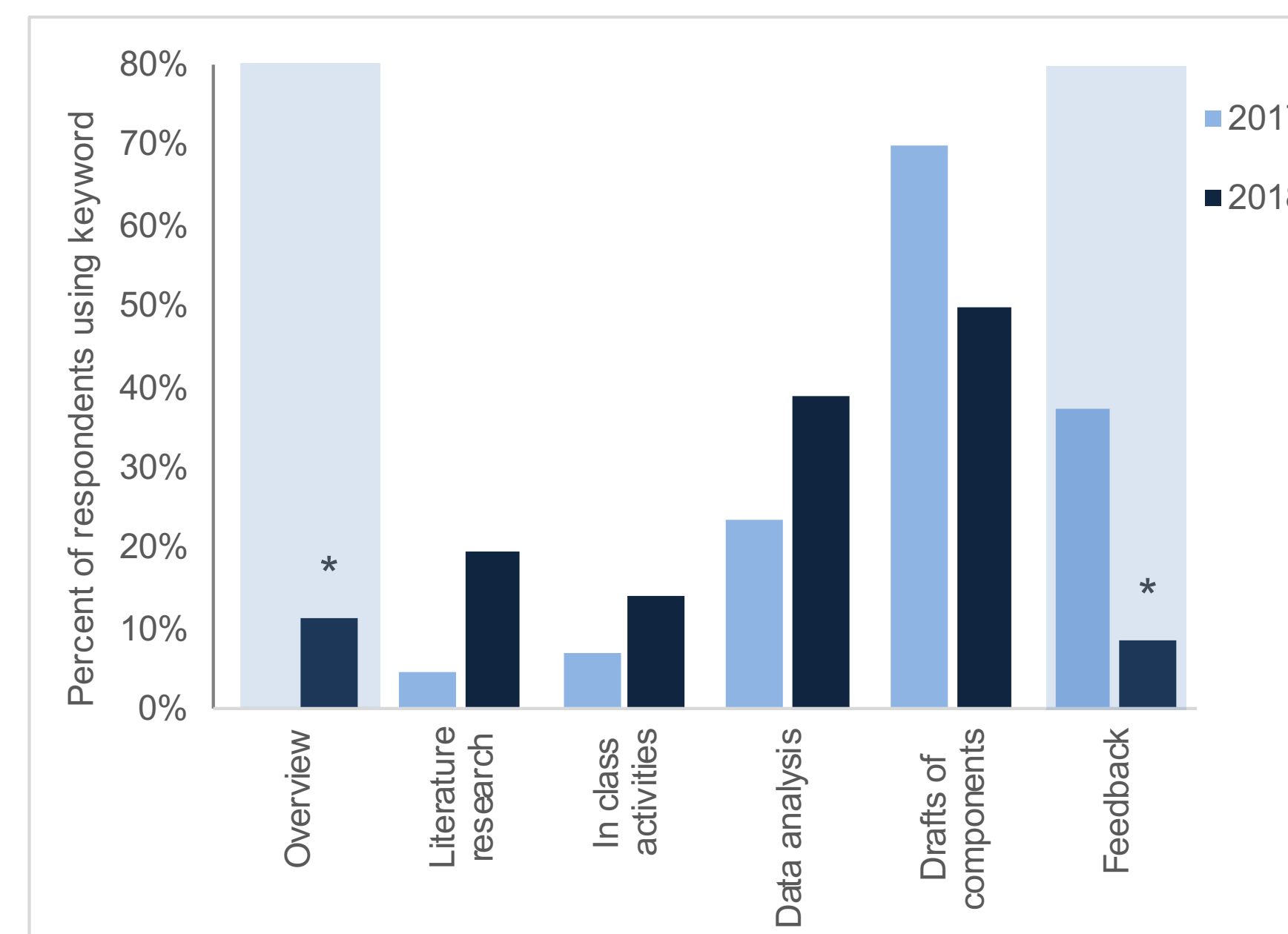
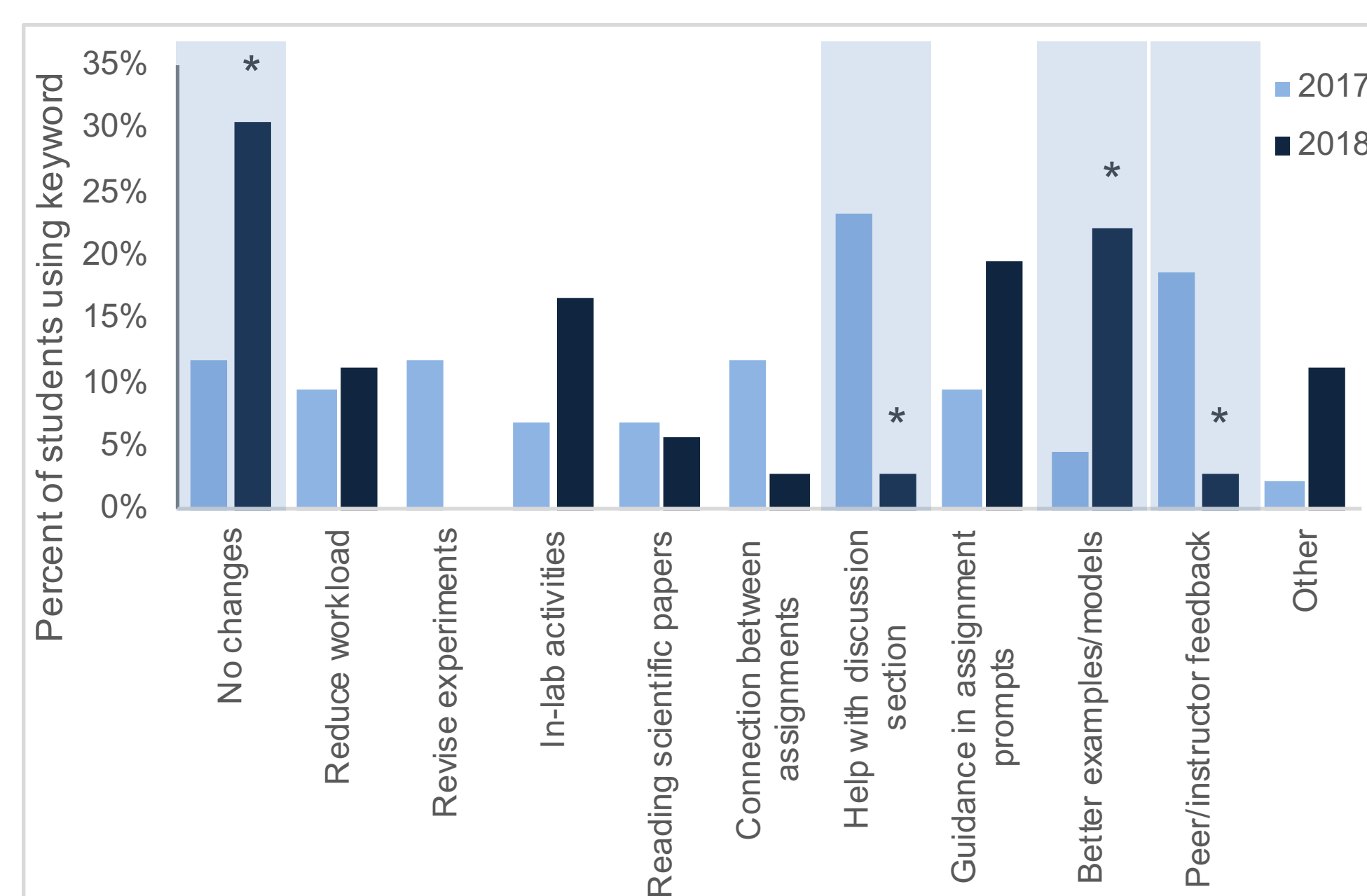


Figure 4: Qualitative analysis of student answers to: “What suggestions do you have for improving the assignments so that they better support students’ learning?” (2017: n=43, 2018: n=36) * represents p<0.05 by Fisher’s exact test.



Conclusions

After the revision, students in 2018:

- found assignments and activities and activities helpful (Figure 1), but scores for individual assignments did not change significantly (data not shown)
- were more likely to find overview and scientific literature assignments helpful to their learning, and were able to connect their work to broader contexts (Figure 2)
- were significantly more likely to think assignments did not need to be improved (Figure 4)
- had fewer comments about improving workload, pacing, and alignment, demonstrating improved student perceptions of the course (Figure 3)
- found course-related resources more valuable, showing they recognized improvements to pre-lab material and enhanced lab/lecture integration (Figure 3)
- wanted more feedback and peer review (Figure 3,4) –this is likely partially because instructors’ efforts were focused on creation and implementation of new material rather than returning submitted assignments

Future Directions

From these data, key features to improve in the next iteration of the course include:

- Creation of model answers/examples to provide students with guidance on instructor expectations
- Stronger emphasis on providing, receiving, and incorporating peer review and instructor feedback into final unit assignments

References

- Wiggins, G. and McTighe, M. *Understanding by Design*, 2nd edition. Pearson/Merrill Prentice Hall, 2005.

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