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Department of Physics

Introductory Physics for the Life Sciences

Change of students' attitudes in a redesigned lecture

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Project motivation

Students with non-physics majors often lack a motivational incentive in studying physics, and they struggle in viewing physics as a valuable subject for their own discipline. To overcome these motivational issues, we have reformed [1] a compulsory calculus-based first year introductory physics lecture which is offered to students in biology together with students in pharmaceutical sciences (Tab. 1).

By making physics more accessible, we hope that students also change their attitudes and beliefs of learning physics. To that end, we are relying on CLASS, the "Colorado Learning Attitudes about Science Survey" (Tab. 2).

Instructors	1 full Professor + 11 TAs
Students	200/year
Period	14 weeks (Feb – May)
Assessment	final exam (Aug)

Lecture	5h/week
Rec. class	2h/week
Study hall	2h/week

Table 1: Key figures of the lecture.

Method

We offered the CLASS as an online survey for two student cohorts as a pretest in week 1 and as a posttest in week 13. The presented results are based on the combination of both cohorts (Tab. 3).

CLASS (Colorado Learning Attitudes about Science Survey) consists of 42 statements for which students are asked to agree or disagree using a five-point Likert scale. Of these 42 statements, 36 are scored by comparing a student's response to the expert's response [2].

CLASS category	Example question (expert response)
Personal Interest	I think about the physics I experience in everyday life. (Agree)
Real World Connection	Learning physics changes my ideas about how the world works. (Agree)
Problem-Solving (PS) General	If I get stuck on a physics problem on my first try, I usually try to figure out a different way that works. (Disagree)
Problem-Solving (PS) Confidence	Nearly everyone is capable of understanding physics if they work at it. (Agree)
Problem-Solving (PS) Sophistication	If I want to apply a method used for solving one physics problem to another problem, the problems must involve very similar situations. (Disagree)
Sense Making or Effort	I am not satisfied until I understand why something works the way it does. (Agree)
Conceptual understanding	Knowledge in physics consists of many disconnected topics. (Disagree)
Applied Conceptual understanding	When I solve a physics problem, I locate an equation that uses the variables given in the problem and plug in the values. (Disagree)

Table 1: CLASS categories.

	Students	Female	Male	Bio	Pharma
Cohort 2018	76	51	25	39	37
Cohort 2019	60	42	18	18	29
Total	**136**	**93**	**43**	**70**	**66**

Table 3: Participants (only matched responses are considered).

[Q1] Improvement in expert-like attitudes? (Fig. 1)

- Shifts between pre- and posttest are either non-significant or negative.
- All negative shifts, however, have small effect sizes (d ≤ 0.3).

[Q2] Differences between the study programs?

- Similar results for students with a major in biology and in pharmaceutical studies.

[Q3] Gender differences? (Fig. 2)

- Female scores are less expert-like in the categories *Personal Interest* and *Real World Connection*.
- Only for the category *Real World connection* the gender difference has a medium effect size (d = 0.56).

[Q4] Shifts linked to the exam performance? (Fig. 3)

- There isn't any relevant correlation between individual shifts and the achieved grade in the final exam.

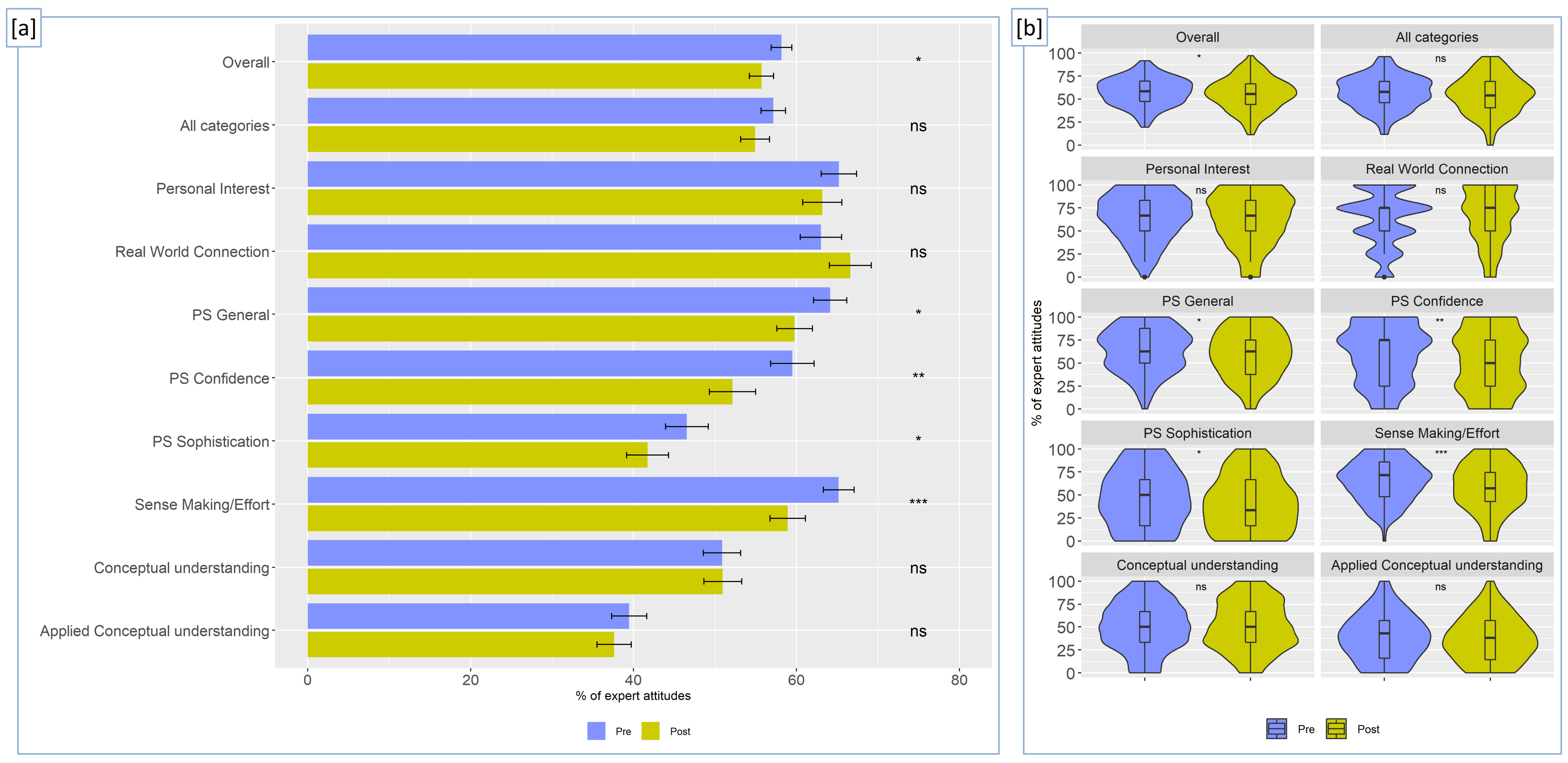

Figure 1: Expert-like scores on pre-CLASS and post-CLASS tests. [a] mean values, [b] score distributions. Error bars = SE. Difference between pre- and posttest: *p<0.05, **p<0.01, ***p<0.001, ns = not significant.

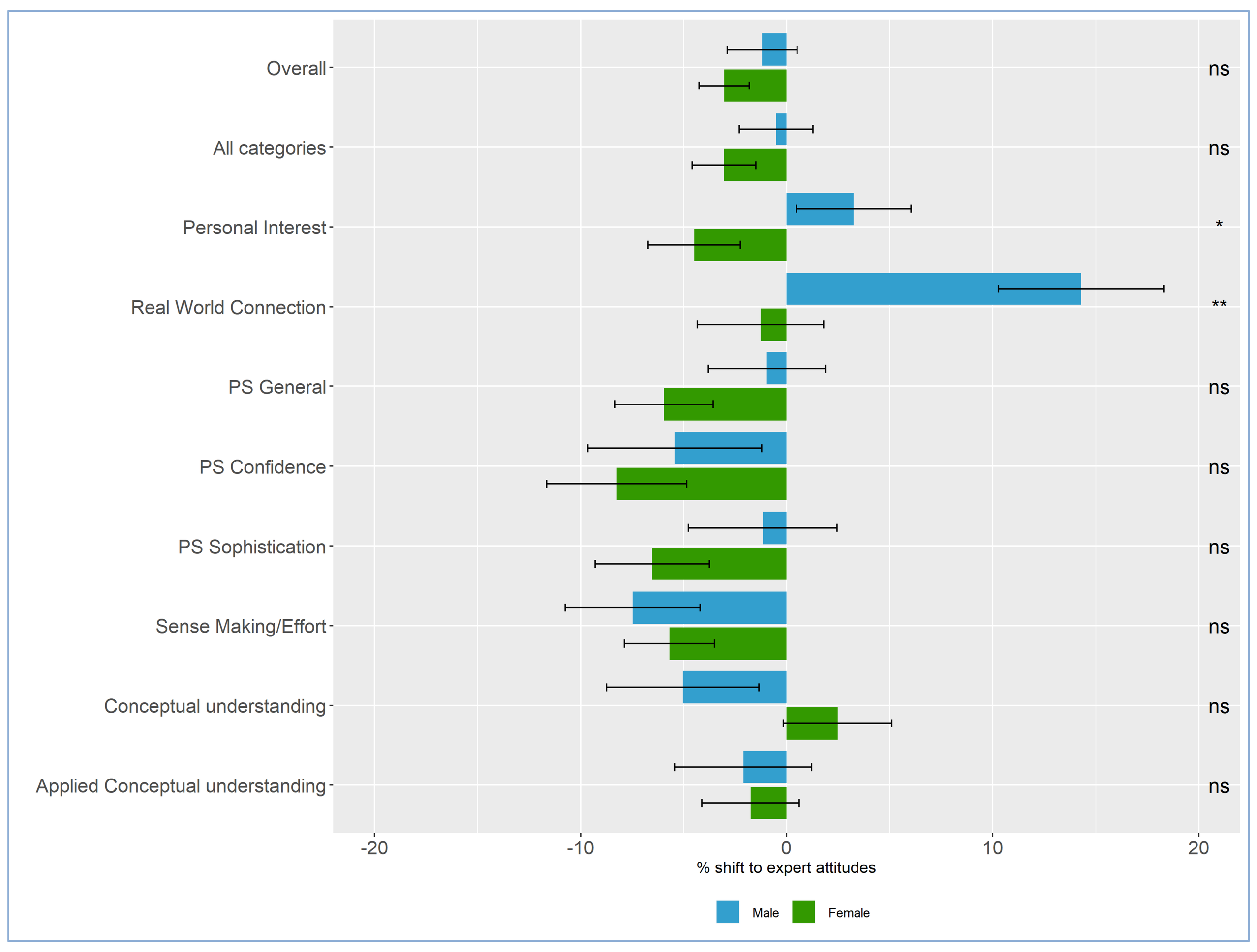

Figure 2: Expert-like shifts from pre- to posttest for male and female students. Error bars = SE. Gender difference: *p<0.05, **p<0.01, ns = not significant.

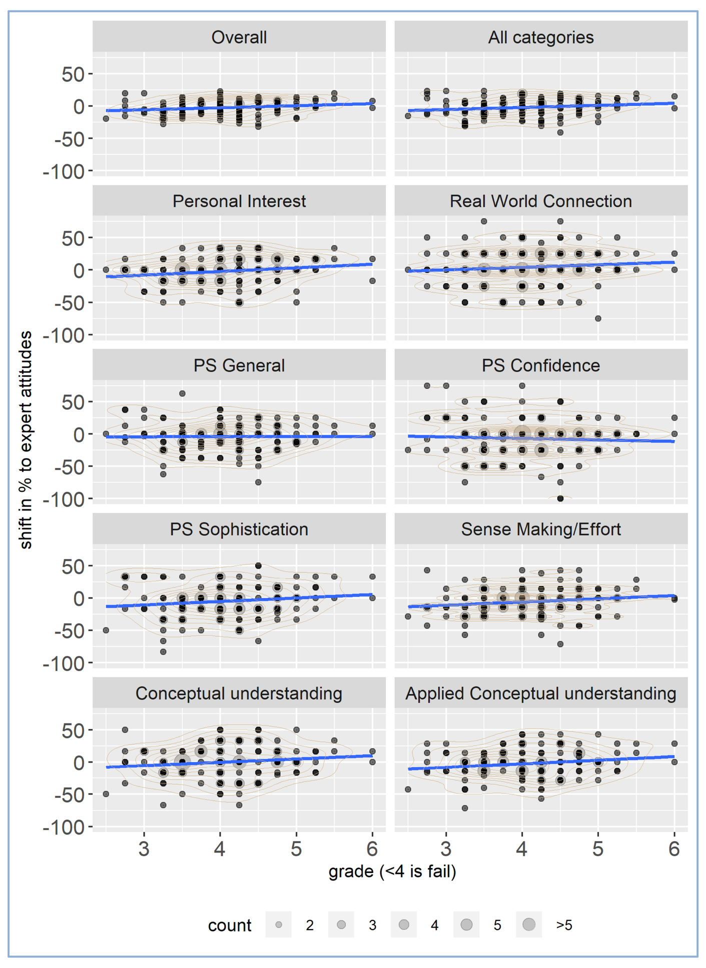

Figure 3: Individual expert-like shifts linked to the achieved grades in the final exam.

Conclusion

Based on results from the literature [3], the supportive feedback from the student evaluations and on students' active engagement, we had expected positive results. However, former studies already showed that, especially in large classes and with non-physics majors, the initial scores in CLASS tend to deteriorate considerably [2,4]. In our case, with more or less unchanged attitudes, we could not replicate these findings. The transition period of only 12 weeks might have been too short for gaining more conclusive results.

References

[1] Meredith, D. & Redish, E. (2013). Reinventing physics for life-sciences majors. *Physics Today*, ***66****(7)*, 38-43.

[2] Adams, W.K., et al. (2006). New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey, *Phys. Rev. ST Phys. Educ. Res.* **2**, 010101.

[3] Crouch, C.H., et al. (2018). Life science students' attitudes, interest, and performance in introductory physics for life sciences (IPLS): An exploratory study, *Phys. Rev. ST Phys. Educ. Res.* **14**, 010111.

[4] Madsen, A., et al. (2015). How physics instruction impacts students' beliefs about learning physics: A meta-analysis of 24 studies, *Phys. Rev. ST Phys. Educ. Res.* **11**, 010115.