The Biophysicist

Response to Comment by Shlyonsky

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Dr. Shlyonsky makes some important points in his comment on my paper but perhaps misunderstands the discussion of assessments because of cultural differences. In the United States, the use of standardized assessments, or concept inventories, is quite common in introductory physics courses to measure learning gains by students (and effectiveness of teaching by instructors) through the use of pretests and posttests (1). These concept inventories are research based and standardized to allow comparison between different modes of courses in the same university or universities across the country. Their usefulness is based on a consensus among physicists of what should be included in these inventories, a consensus that is challenged by this new curriculum to make the topics more relevant to life science students. Therefore, a new concept inventory must be developed for this new curriculum.

More generally, I agree with the commenter's discussion of assessments within the course itself. Physics is the primary course in which life science students learn valuable analytical skills and stands in contrast to typical modes of teaching in biology, where memorization is emphasized. At Michigan State we have continued to use written problem-based exams that utilize analytical skills, but many of the problems used in our traditional courses are no longer useful because they cover topics not included in this curriculum. It is my hope that a new library of problems will be created by instructors teaching this course here and at other universities that focus on the new topics covered, such as diffusion and entropy.

As Shlyonsky has demonstrated in his own work (2), showing students how physics is integrated into real-world life science problems is a great motivator, and I wholeheartedly agree with this approach, but this curriculum demonstrates that molecular and cellular biology (MCB) topics can be even more tightly integrated into the curriculum rather than as a qualitative follow-on to a "real" physics question. For example, Shlyonsky (2) has an example of how muscle fibers are modeled by springs, including a calculation of energy produced by shivering in cold weather. We also include a similar set of problems to calculate the force in one myofibril, but we further integrate a discussion of the myosin molecule itself and the basic mechanism of the power stroke that provides the force. The terminology is presented within the problem so students are not expected to bring much prior knowledge of MCB; nor do we test their vocabulary. This deep dive requires 1–2 h of class time and demonstrates to the students that physics is not just relevant, but underlies biological phenomena they consider important.

In response to the author's surprise at the elimination of certain topics, I will give a longer rationale than was feasible in the paper. First, rotation is an integral component of adenosine triphosphate (ATP) synthase function, but the topic of rotation in a traditional curriculum focuses on conservation of angular momentum. Because the ATP synthase motor operates in water, angular momentum is completely damped by the solvent, and it is difficult to see the principles of rotation in play in this example. In fact, it is difficult to observe conservation of momentum of any type in an aqueous environment (i.e., dynamics at low Reynolds number) except at the level of molecular collisions, which we cover in the discussion of diffusion. Second, the topics of electromagnetic induction and advanced circuits (direct or alternating current) have their use in biophysical methods such as electroencephalography and patch clamp techniques, but they are not intrinsic physics concepts in MCB in the same way that the potential across a membrane is. Michigan State offers advanced courses that cover such methods in detail, and I believe that the grounding the students receive in the basic ideas of electric potential and Ohm's law serves them well in mastering the methods later.

REFERENCES

1. Madsen, A., S. B. McKagan, and E. C. Sayre. 2017. Best practices for administering concept inventories. *Phys Teach* 55:530–536.
2. Shlyonsky, V. 2021. Motivating premedical students to get interested in physics. *Phys Teach* 59:288–290.