

Using peer ranking to enhance student writing

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Abstract

What do we want our students to get out of the introductory physics course? Often these goals include improved conceptual understanding, improved critical thinking and improved writing and communication. These can be difficult goals to accomplish. One possible way to address these goals is through the use of peer ranking of student writing. In a peer ranking assignment, students not only answer a conceptual question but they also evaluate other students' answers. With a normal writing assignment, once students answer a question the students' involvement has ended. With a peer ranking assignment, students actively focus on both writing and physics.

Student writing in introductory physics

Writing assignments have long been used in introductory physics classes, at both the university and pre-university level. In a typical assignment, a student writes a response to an end-of-chapter conceptual question. The instructor collects and grades the assignments, providing feedback on writing and conceptual understanding. The instructor may even post a solution to the question or discuss the question in class but at that point the assignment is complete. There have been several variations on the standard writing assignment that are designed to further engage the students [1–6] and we will offer another method here.

The goal of a writing assignment is to explore the conceptual understanding of students and to give the students practice in communicating and writing by posing thought-provoking questions to the students. Are these general goals being met with a standard writing assignment? Is it possible to make the assignment even more worthwhile?

Imagine assigning the following question to your introductory physics class:

A truck and a motorcycle both have the same rocket engine attached to them. These rockets provide a thrust of 1000 N for 10 seconds. If both vehicles start from rest, which vehicle will have the greater momentum after the rockets stop firing?

A typical student response may look like one of the following answers:

Student 1:

The larger truck will have more momentum. It has more mass and would be harder to stop than the smaller motorcycle. The harder it is to stop, the more momentum an object has. The truck may take longer to get going than the motorcycle, but after it starts it will be the harder one to stop.

Or:

Student 2:

I think the motorcycle will have the greater

momentum because in the equation Force \times change in time = mass \times velocity, the mass of the motorcycle is less so his velocity will be greater. The same amount of force and time is applied to both but the masses and the velocities will be different.

From reading these responses, it is easy to get a sense of students' conceptual difficulties with impulse and momentum. But is there a way to encourage the students to critically examine these difficulties? By reading and evaluating the work of their peers, students are confronted with exactly that task.

Peer evaluation

Questions can be created that address several cognitive levels of reasoning. These levels can be described by Bloom's taxonomy [7], which lists the levels as: knowledge, comprehension, application, analysis, synthesis and evaluation. Many of the typical end-of-chapter questions fall in either the 'knowledge', 'comprehension' or 'application' categories. Having a student look at other students' responses with the goal of determining what is both correct and wrong about them rates at the top of Bloom's taxonomy, 'evaluation'. Some other benefits of peer ranking could possibly be:

- Students can see how other students in the class are thinking. This gives them the opportunity to see both good and poor thinking and writing styles. Seeing that other students have similar ideas may also reduce anxiety about being wrong.
- If students know that their peers will review their work, they tend to be much more careful with their writing and spend more time thinking about it.
- Students are likely to have reduced levels of spelling and grammatical errors because they can see what it looks like when other students make these mistakes.
- Students have the opportunity to critically think about the conceptual material being addressed. Even students who wrote a correct response must reflect in order to determine why an incorrect response is wrong.

- Subtle problems with student responses can be revealed (such as incomplete logic, inconsistent application of concepts and improper use of physics language).
- Being able to explain a concept is an indication of a deeper understanding than just answering conceptual questions.

There are three common methods for this evaluation: rating, ranking or review. In peer rating the students would assign a score to each answer they review. This is often ineffective, because students typically assign uniform scores to all the work they review. In a peer ranking assignment, the students have to choose which response is the best and which is the worst. For a peer review assignment, the students would critique each response and give detailed comments on each answer. We decided to focus on peer ranking because it is relatively easy to implement yet forces the students to make decisions concerning the quality of writing samples they are examining. Peer review can be useful in many circumstances but can require a large amount of time on the part of the student (and the teachers!).

The peer ranking process

There are several means by which an instructor could implement a peer ranking assignment in a class. Below are the basic steps we used in creating a peer ranking assignment. We have attempted to be as general in our description as possible to allow for variations in different implementations.

Step 1

Make a writing assignment. You can skip this step by providing the writing samples, but students won't get the writing practice. If possible, collect student responses electronically to save yourself the pain of transcribing or photocopying. For our implementation of peer ranking, we used WebAssign [8], but most likely any electronic homework collection method (including e-mail) should save you considerable time.

When choosing a question for use in a peer ranking assignment, it is important to realize that not all questions produce responses suitable for ranking. We found that simple questions, requiring a single response using a single concept,

worked best. The following is a conceptual question that works well for peer ranking:

Two students are discussing the motion of a ball thrown straight up that lands. One student says that the acceleration at the highest point must be zero, the other students says that it is not zero. Which student is correct?

Questions that require multiple responses or the application of more than one concept create responses that are difficult to compare. The following question has multiple dimensions on which a student could rank it.

When a player kicks a football, is he doing any work on the ball while his toe is in contact with it? Is he doing any work on the ball after it loses contact with his toe? Are any forces doing work on the ball while it is in flight?

How does a student (or a teacher, for that matter) compare the quality of a response that answers the part about the work done by the foot correctly, but answers incorrectly about the forces on the ball? Such questions might be better suited for peer evaluation than peer ranking.

Step 2

Select student writing samples for the students to rank. We choose three to six of the answers submitted from the class for each student or group of students to rank. We found that giving more than six writings makes ranking difficult. In our implementation using WebAssign, we typically sorted all the writing samples from the class into four bins, according to quality. Each student would then get a set of anonymous writings with one randomly drawn from each bin. In this manner, all the submitted answers would be ranked by other students.

Ideally, the sample of responses should run the gamut of quality, from excellent to poor. If necessary, the instructor can 'spike' the pool of writing samples with their own writings. We did this if there were no outstanding student examples, or if student writings failed to address relevant concepts. For example, in the rocket question above, it is possible that no student considers the role of impulse and momentum. If this is the case, the instructor creates a writing sample and puts it into a bin with no other responses (to ensure that all students see the instructor's sample).

Step 3

The students receive their answers from other students and rank them from best to worst. Students can also be asked to explain the criteria they used to rank the responses. A student ranking score can be generated based on the correlation between that particular student's ranking of answers and the instructor's ranking. This correlation can be used to generate a grade for the student. In our implementation, we found that grading the students' rankings of answers encouraged the students to fully participate in the ranking exercise. The grade was not a direct correlation with the ranking, but padded greatly such that the lowest grade a student could achieve was 60%. 

Step 4

The final and most important step of the peer ranking process is to incorporate this process in class. A discussion of what makes a good answer and what makes a poor answer can be very productive. This could be a series of ongoing discussions that have the goal of building students' abilities to write and analyse writing as the term progresses. One option is to have students explain their criteria as part of the ranking process. These criteria can then be compiled and shared with the class. By doing this, the students take ownership of the ranking process. It turns out that the general consensus of the class criteria correlates quite well with expert opinions. Some students may rank primarily on length of writing or number of spelling mistakes, but other students realize that these criteria do not always give an appropriate ranking. Many institutional goals include the development of critical thinking and writing ability—this is a step in that direction.

Conclusion

Peer ranking is an attractive alternative to teacher's grading of student writings. Students submit their own writing to peer review and participate in the evaluation process. By reading and critically examining the writings of their peers, students can improve both their writing skill and their understanding of physics. The ranking task, in contrast to rating or reviewing, is relatively easy for teachers to manage, but still forces students to make choices when reviewing the work of others.

References

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- [8] Information on WebAssign can be found at webassign.net

