Standards-based Grading With Voice: Listening For Students' Understanding

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Abstract. Standards-based grading is gaining popularity at the high school level, including physics courses. The basic notion is to give your students a list of objectives upfront that they need to master. Students can reassess often and their final grade is determined solely by their last reassessment on each standard. It is the instructor's job to help students find ways of showing their mastery to you. I implemented this in a junior-level mechanics course where the small numbers allowed me to introduce a novel twist: all assessments had to include the student's voice. This meant that students turned in pencasts, screencasts, and in-person assessments. Several days were also set aside for collaborative oral assessments, where students offered up honest advice and scores were mutually determined. In this paper, I'll share my experience trying out this pedagogical experiment and try to convey how it has improved my own understanding of my students' understanding.

INTRODUCTION

Imagine teaching someone how to pack a parachute[1]. Over the course of the instruction period, you assess the student's ability several times. If there are, say, five assessments in a situation like this, you would like to see mastery towards the end that is sustained. This is not the typical way we assign grades in physics classes. Instead, we average the five assessment results to come up with a final grade. If the student does well early and slacks off, the grade could be the same as it is for someone who takes a while to "get it" but shows sustained mastery by the end.

The approach of Standards-Based Grading (SBG) is to try to find a way to give a final grade that takes into account retention and is flexible to deal with students who take that extra time to learn something. Students are encouraged to submit work as evidence of understanding the standards and resubmission is encouraged. The most recent submission determines the current score for a given standard.

In this work, I will describe how I implemented a novel SBG implementation that enabled me to have a much better picture of where my students' understanding of the material was. The course was a junior-level Theoretical (or Classical) Mechanics course taught to nine students in the spring of 2011.

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[1] This analogy is borrowed from an excellent High School physics teacher named Frank Noschese.

MY STANDARDS

To produce the standards for this course, I looked carefully at the chapters I intended to cover in Thornton and Marion's *Classical Dynamics of Particles and Systems*. In each chapter, I found what I considered to be the core material, which I defined to be the material a student should have mastery over by the end of the course. I structured each standard as an "I can . . . " statement.

Here are some examples:
- I can derive the Euler's equation.
- I can use Mathematica to find a path that minimizes something.
- I can show that the Lagrange method is equivalent to Newton's laws for a simple system.
- I can use Mathematica to model an interesting system.
- I can use Mathematica to model a system with viscous friction (also applies to chapter 2)

Some standards (like the first and third in the example above) ask students to demonstrate understanding of an important result, like a derivation. Others ask students to demonstrate mastery of a particular application, like the Lagrangian formalism. Some require the use of particular tools, like Mathematica, while others are connected to standards from different portions of the course, like the viscous friction example above.

The students helped me refine the list as the course went on. Sometimes we would collectively decide to combine several standards or split one into several. We would also have discussions centering on the notion of

what is a core piece of material. The full list of standards by the end of the semester can be found at http://tinyurl.com/TMStandards.

MY SCALE

For each standard assessment, I applied the following four-point scale that I borrowed from Frank Noschese:
1. Doesn't meet expectations
2. Approaches expectations
3. Meets expectations
4. Exceeds expectations

If a student essentially "answers the question," he would receive a three. Note that this amounts to a 75% score in the grade book and hence a 'C.' The easiest way I found to communicate to the students what it takes to get a four, was to point out that I always brag about fours to either my colleagues or my wife. It turned out this 'bragging' concept really helped focus the course.

ADDING VOICE

The novel twist that I brought to SBG for this course was my insistence that every standard assessment turned in must be accompanied, in some way, by the student's voice. There were three major ways students accomplished this: Oral assessments in class, screencasts, and pencasts.

Oral Assessments In Class

Several class days were set aside for oral assessments. Students were selected randomly to do an assessment of a random active[2] standard on the front white board. When the student finished, we would hold a whole-class discussion about what score to give. The other students participated in this in ways that were more honest and useful than in my past experience; in part because the students understood every assessment to be low-stakes. Students knew that a re-assessment could always be submitted later to change the grade. Some examples of the whole-class discussion are available at http://tinyurl.com/collabassess[3]

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[2] Standards became active on the day that material was covered in class.
[3] The url takes you to my blog where I've written extensively on the class in question.

Screencasts

The bulk of the assessments turned in by the students were done via screencasts. To do this, a student typically wrote out her solution to a particular problem or standard, scanned the paper document, and recorded her screen showing the pdf along with her voice using Jing, a free program for screen recording. She could then use her mouse to point out each step of the solution. Some students would use tablet computers or pen mice to record the original creation of the document along with their voice.

For the standards that involved Mathematica, screencasts were essential. To ensure that the students were creating their own code, I required that the recordings showed the creation of every character in the syntax. This was tedious at first, but after I was sure they had mastery of the syntax needed, I would let them start the recording after typing in all the relevant code. In those latter cases, students were still required to walk me through the logic involved.

Sample screencasts can be seen at http://www.screencast.com/t/NiI5GO6OPH, http://www.screencast.com/t/ocvKwYlqs, and http://www.screencast.com/t/qyaWzurLOuJ.

Pencasts

Another technology the students could use for the non-Mathematica standards was a LiveScribe SmartPen and tablet. These allow students to record their voice while writing on paper. The result is a web-viewable interactive document that allows me to skip ahead to the points I care most about. Students could write up the whole thing and simply add arrows for me to navigate (http://tinyurl.com/sbgpencast1), or they could leave the recorder on during the whole creation process (http://tinyurl.com/sbgpencast2).

My department has purchased several of these ($100 each) and I would check them out overnight to any students who wanted them.

DISCUSSION

Authentic assessment is very difficult to do. As instructors, we want to use tools that help us better understand how well students understand the core concepts of a given course. Typically, one-on-one face-to-face situations allow us to do this best, but it has scaling problems. My attempts to implement SBG with voice in this class was aimed at trying to get a better feel for how well my students were learning, especially as compared to written homework and exams in the past. Here, I discuss four points of interest to me: assessing derivations, collective

standard creation, lack of extra credit, and re-assessment issues.

Derivations

In the past, I have asked students to do derivations on exams. I would not do so in a homework assignment, however, because I knew that all the correct steps were given in either the text and/or the lecture notes. Having a student recreate those notes on an exam is one thing, but asking for it in homework seemed fruitless. I recognized that this kept me from assessing something that I held to be quite at the core level in many of the courses I teach.

In this course, students showed me derivations all the time. Of course, what they had written in both the screencasts and pencasts was nearly always correct. However, listening to them explain all the steps was where I focused my assessment efforts.

Consider the derivation of the Euler equation in the calculus of variations:

$$\frac{\partial f}{\partial x} - \frac{\partial}{\partial x}\frac{\partial f}{\partial x} = 0 \quad (1)$$

Typically, two lines above that very important result is this equation:

$$\frac{\partial J}{\partial \alpha} = \int_{x_{\text{int}}}^{x_{final}} \left(\frac{\partial f}{\partial x}\alpha(x) + \frac{\partial f}{\partial x}\alpha'(x) \right) dx \quad (2)$$

where J is the action (the integral of the functional, f) and $\alpha(x)$ is the function that represents deviations from the minimal path. To get to Equation 1, students need to recognize that, since α is arbitrary, if they can factor it out of the integrand, whatever is left must be zero to achieve the minimization that is sought. In order to accomplish this, students need to use integration by parts on the second term of the integral in Equation 2. Doing this takes the derivative off of the α term and puts it on the other term. This leads directly to Equation 1.

What I would watch for is that the students said more than "now you integrate by parts." Instead I wanted to hear "I need to get α to factor out, so I need to … so something to this $\alpha_o(x)$ term. Hmmm, maybe integration by parts!" That would tend to make the difference between a three and a four on the assessment.

Collective Standard Creation

It was exciting to me to see how invested my students were into this process. We had many conversations in and out of class about the fairness, importance, and difficulty of various standards. We made many changes to the first draft of standards and being open to those changes helped me and the students take better ownership of all our learning.

The best example is listed above regarding an "interesting" example to be modeled in the Lagrangian formalism. In the first draft I had specified how many dynamic variables the problem needed to have. However, students would ask about lots of interesting applications that didn't meet that and other similar specifications. So we landed on the word "interesting." We spent a large portion of a class period coming to a working, communal definition of that word and we decided that we could change the standard to reflect that. I'm very happy we did as I believe it lead to much more "interesting" screencasts for me to watch and assess.

No Extra Credit

With the exception of a final worth 5% of the grade where students made and discussed a mind map of the material, the bulk of their grade for this course was based on the standards (re)assessments. There was no homework, no exams, and no extra credit. I made my standards clear, got the students on board with why they were important, and they had to spend their time convincing me they understood and could communicate the standards. The "bragging" aspect of my scale took the place of extra credit work and I found myself satisfied with how the students' scores represented their understanding. In other courses, I have made the mistake of letting students do extra credit projects on material they already understood to make up for low scores on material they did not. I like this new way better.

Reassessment

Students seemed to like the notion that they could always reassess a lower score. However, the oral assessment days sometimes forced students to reassess standards for which they already had fours. Sometimes this meant that their grade went down, but I liked how this helped reinforce the notions of mastery and retention. One particular standard stands out for me in showing the amount of retention in this course. The very first chapter standard is to derive Equation 1. We covered this on the first day of class and students (re)assessed it many times throughout the semester. It was quite gratifying to hear students get excited to reassess that standard months after we had covered it. They knew they had it down and they were not worried about their grade suffering.

PITFALLS

This method of assessment and teaching was very different from what my students were used to. It took quite a bit of discussion early on to explain the system, and, more importantly, to get the student to buy into this method as being something that can aid their learning. I am excited to teach advanced electricity and magnetism in the fall of 2011 because many of the same students are enrolled and those that were not in the past class have heard how it works from those that were.

With only nine students doing (and re-doing) thirty standards, each with usually five minutes of video to watch, my time spent grading was substantial. The extreme procrastination that some students adopted, which is discussed below, lowered the amount of time I had to spend assessing, but for larger classes this is definitely an issue. For a class load above twenty, I would consider using some peer review to aid in providing formative feedback but it is an open issue that perhaps the PER community could help me research.

At the beginning of the term, the standards and the policies were made clear. With the exception of the forced assessments on the oral days, students could turn in materials whenever they wished. For some, they considered their schedule carefully and tried to average out their workload. This meant they received a lot of feedback from me, often in the form of a screencast, and they could use that feedback for reassessment improvements. Some students, on the other hand, miscalculated how much work they could get done towards the end of the semester. In the student evaluations for the course and in informal discussions I have had with students who were in the course, a lot of attention has been placed on how to "force" more assessments.

My current idea, which I will try in my fall course, is to require a submitted assessment within two weeks of when the standard becomes active. This can be a '1,' but it must be submitted or else the student must take a zero for that standard for the rest of the course. What I am most excited about for this policy is the ability to go into class, review what had become active two weeks prior, and discuss the common problems I have seen in the assessments I have received on that material.

CONCLUSIONS

I have used this Standards-based approach only once but I am very excited to use it in most of my courses in the future. Telling the students what I think they should learn on the first day and then giving them plenty of opportunities to show their understanding has been a big change to my teaching technique. The notion of having the students always use their voice has allowed me a much deeper insight into their understanding of material. I am excited to incorporate ideas I brainstormed with the PER community at the conference and I look forward to reporting back on my progress.

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