AC 2008-2777: ACTIVELY MODIFYING THE CLASSROOM APPROACH USING PRE-TESTS AND RECURRING PROBLEMS

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Actively Modifying the Classroom Approach Using Pre-Tests and Recurring Problems

Abstract

Finding the right level of instruction is an exceptionally difficult task for new faculty. The gap between the podium and the seats is large. Student insecurity and reticence to offer honest and immediate feedback about their understanding coupled with faculty focus on content goals and course objectives can often lead to a disconnect between what is being presented and what the audience is capable of acquiring. As a result, students often contend that faculty members have forgotten what it is like to be learning something for the first time.

Pre-tests and recurring problems are examples of tools that can be used to assess client (student) levels so as to tailor instruction to meet student needs. Samples of both skill and content pre-test results as well as examples of how classes were altered to adjust the level of instruction in response will be presented. As a follow-up to the pre-tests, results from the use of recurring problems in a class will be presented to demonstrate how these tools allow for continual re-evaluation of the difficulty level and course pacing. These tools can also be used to help students identify their own areas of difficulty and to promote individual addressing of key concerns.

Introduction

Finding the right level of instruction is an exceptionally difficult task for new faculty. The gap between the podium and the seats is large. Student insecurity and reticence to offer honest and immediate feedback about their understanding coupled with faculty focus on content goals and course objectives can often lead to adisconnect between what is being presented and what the audience is capable of acquiring. As a result, students often contend that faculty members have forgotten what it is like to be learning something for the first time.

New faculty is faced with many challenges in their first terms of teaching. Developing lecture notes, acquiring sense of campus culture, creating evaluation tools and the grading and assessing students are just a few of these challenges. However, one of the most difficult challenges facing the new faculty member is remaining responsive to their students. With all of the demands on an instructor’s time and attention, it is hard to hear and make time to understand student frustrations. It is even harder to make midstream adjustments to one’s instructional plan. For the students, however, the mismatch between the instructor and student, such as instruction that is above their level of ability, can lead to disastrous levels of frustration and conflict in the classroom.

Reform in education[1-5] and studies in cognition[6,7] reinforce the idea that an adaptive and flexible approach to instruction is essential to efforts to improve student understanding. Recognizing that Students entering a class not only bring the gaps in their background and a set of preconceived notions, but also that their knowledge “consists of loosely interrelated knowledge fragments.... difficult to remember, difficult to regenerate if partially forgotten and prone to inconsistencies.”[1]

Therefore, one goal of a new instructor should be that of active instruction: an approach where the instructor is attuned to the needs and abilities of the students that are physically
present in the classroom. An approach that adjusts to level of students, responds to student
difficulties with material as they arise, and keeps a finger on the pulse of the class. Two helpful
and easy to implement tools that can be used to assist in this process are pre-tests and recurring
problems (themes).

**Pre-Test: Moment of Inertia**

While a great deal of research has been done to examine how pre-tests effect student
learning\(^9\) less research is available on how the use of pre-tests can be used as a tool for
instructors to adjust their teaching of content. Pre-tests serve students by increasing "students
sensitivity to a learning situation, it can alert them to issues, problems, or events that they
ordinarily may not have noticed, it can lead them to evaluate the task its apparent relevancy or
meaning, and it can serve as a categorization of the actual learning task so some generalization is
possible" \(^{10}\). A more important use of pre-tests, however, is to understand students’ existing
knowledge so that the instructor can adjust content to build on prior knowledge and to ensure
that instruction is not to advanced or too elementary for the particular group of students. \(^{[8,9]}\)

Pre-Tests, assessing either mathematical skills or prior content recall, are a useful tool for
dissecting an audience’s level of understanding upon entering a class. This is an especially
useful tool to employ since, if used properly, the pre-test can help an instructor to tailor the
classroom instruction to support or improve student abilities before the lecture notes have been
written. While any early implementation of a pre-test opens the possibility of the results being
skewed by the slow start to a term that is often experienced as student shake off their vacations,
it is a situation where any information about one’s audience is good information.

An example to motivate the usefulness of pre-tests in modifying classroom instruction is
the concept of the moment of inertia as it relates to forces on submerged surfaces. One of the
earliest major content areas in Fluid Mechanics is the concept of pressure and hydrostatics. This
unit often ends with a section on the determination of the forces acting on submerged surfaces
and the equilibrium conditions of underwater structures such as gates. While this topic is
primarily an application of the previously taught unit, and as such could be omitted from the
course, it is often useful to include because it is one of the few opportunities for content
trajectories from Statics classes to terminate. Students, re-exposed to content from previous
classes, will have the opportunity to reinforce their understanding of these concepts and they will
be able to explicitly observe the connection between subjects in the field of Engineering.

The forces on submerged surfaces topic is generally motivated by a review of the concept
of an equivalent force system as taken from a standard Statics class. This review is then
connected to the current content by identifying the distributed force as being the pressure force
as a function of depth. Through a series of derivations using slant coordinate systems and
integration to find the magnitude and location of the equivalent force system, students are able to
assess quantities such as the force needed to hold a submerged gate closed for a given depth of
water. From a process education perspective, the solution to problems can be reduced to a three-
step procedure: determine the pressure at the centroid (magnitude of the resultant force)
determine the location of the center of pressure (locate the position of the equivalent force),
assess the conditions for equilibrium.

During the summer of 2006, the author’s first term at a new institution, student
performance in this area was abysmal. Error modes for this topic ranged from improper
integration in finding the moment of inertia to the complete omission of the conditions for
rotational equilibrium, yet homework performance on textbook problems was outstanding. A mathematics skills pre-test given at the beginning of the term (Figure 1) showed that roughly two-thirds of the class population (80 students) were proficient in their basic calculus skills (perfect, minor math error and failure to distribute multiplier) and the source of the difficulty was unclear. Clearly something was interfering with the students’ ability to connect to the subject, but it would end up taking a lot of work to sort out.

![Problem #4 - Integration](image)

**Figure 1**: Mathematical Pre-Test Results – Integration (Summer 2006)

During a later term (Spring 2007) the pre-test was modified to include a basic problem of double integration which could also be identified as determining the moment of inertia for a shape (Figure 2). With this question it was hoped that students could rely upon either their recollection of the material from Statics or their double integration skill from Calculus to correctly solve the problem. Student results from this question on the pre-test were illuminating (Figure 3). None of the students in the two sections were able to determine the correct value for the moment of inertia of the shape and a sizable percentage of the students avoided attempting the question all together. Many of the student responses seemed confused and were classified as “grasping at straws”. The one reoccurring issue in all of the modes of failure, however, was the inability to recognize that the integrand is not a constant of integration and that the variable of integration (dA) can be decomposed into a product of the differentials dx and dy.

![Figure 2: Question from Spring 2006 Pre-Test relating](image)

6) \[ I = \int y^2 dA \]

**solve for I**
The discussions that followed from this pre-test narrowed in on the cause of the problems and identified new directions for teaching the topic. First, it was discovered in reviewing the pre-test with the class that students had not previously seen the integral form for the moment of inertia. Instead, the students stated that their Statics classes focused on using tables to identify the moments of inertia for several standard and simple shapes. More complex geometries were addressed using the method of composite shapes. Having taught Statics previously at a different institution, the assumption had been that the depth of instruction on the topic was standard.

The second major outcome from these discussions was that the students were able to voice their frustrations over using double integration skills like method of strips since they had not seen the material since their Calculus II classes. This, for the majority of the students, was during the second semester of their freshman year and in the intervening time they would have had 13 other classes and 4 co-op work terms. Without regular practice at the skills and ideas behind the process these students felt ‘rusty’, but at the same time they felt confident that with review they could be quickly brought up to the level required by the class.

In this case, the pre-test was a useful tool for the instructor to probe the skill sets present in the target audience and, through discussions centered on the data exposed by the pre-tests, the instructor was able to determine the underlying reasons for the students’ inability to connect with the content material. After all of this information about the class was uncovered, students from previous terms were contacted in an attempt to understand why it had taken several terms for this information to be made clear. These students indicated that they had been reluctant to announce their confusion on the subject when they had been in the class since the content was somewhat familiar. They had felt foolish for not knowing something that the instructor had assumed that they had known.

As a result of these discussions, the lecture notes that were in place for the spring term of 2007 were revised to include a targeted Calculus review and explicit instruction in the method of strips for accomplishing double integration. In later terms, this reformation was taken a step further by developing analogies and triggers to memory along with process education oriented aides to help students get through and understand the material.
Recurring Theme: Couette Flow

The use of a recurring theme to gradually introduce sophisticated content material, a piece in scaffolding knowledge\textsuperscript{[11-13]}, is an additional tool available to instructors as an aid in modifying class structure and content exposure. By repeating a type problem over and over throughout the term, an instructor is able to revisit the material supporting the problem, develop extensions to the topic and introduce increasing levels of difficulty. In addition, students who repeatedly fail these quizzes have something tangible that acts as a warning light to their progress and the posting of class profiles can help them see that they have issues that need addressing. In addition, repeated highlights in a gradebook indicating lack of progress on these recurring problems are easy to identify and students can be contacted to get the help they need.

An example of the usefulness of this approach can be found in Fluid Mechanics with Couette flow. The concepts of viscosity and shear stress are typically covered in the first week of a Fluid Mechanics class, but the proper motivation of Couette flow is not possible until late in the term when the reduction and simplification of the Navier-Stokes equations is covered. As such, this makes the Couette flow concept ideal for use as a recurring theme.

Early in the term students are exposed to both the problem statement and geometry of the Couette flow problem with the velocity profile between the plates as being given (Figure 4). In this in-class exercise, the student’s task is to assess the coefficients in the profile from physical parameters and determine the velocity or shear stress at a given location between the plates. Student responses to these questions are used as indicators of student Calculus ability, functional evaluation skills and, logical reasoning. This exercise can then repeated as a quiz and the level of difficulty for the quiz can be increased or decreased depending on the feedback received from the in-class exercise: i.e. if the students have done well during the in-class exercise, the question can be transformed into one where the students are tasked with finding the height at which the shear stress is zero. Since the students have seen the geometry and structure of the problem in a previous environment, those factors are removed from the evaluation.

![Figure 4: Screen-shot of Lecture Slide Introducing the Recurring Theme of Couette Flow](image-url)

Glycerin at 20°C flows through two narrowly separated parallel plates. The plates are separated by only 5 cm and the pressure drops from left to right (see picture) at a rate of 1.6 kN/m per meter.

Unlike the picture, the top plate is moving to the right at 6 cm/s (+s direction). The pressure drop is calculated as:

\[
\frac{\Delta P}{\Delta S} = \pm \frac{1}{4} \frac{kN}{m^3}
\]

Describe the shape of the velocity profile and determine the velocity and shear stress in the fluid at a height of 12 mm from the lower (stationary) surface.
Later in the term, students can build upon their familiarity with the problem statement to focus their efforts on the reduction of the Navier-Stokes equations or the process of integrating the resulting equations. In these later problems, the emphasis is instead on the determination of the constants of integration rather than the geometry of the problem. In addition, since the students have already been exposed to the solution for this problem they will have tools, resources, and (most importantly) expectations to judge the quality of their answers.

Conclusions

Each of the tools presented were very easy to develop and evaluate during the term and each has had a lasting impact on the courses taught. For example, over the past year a correlation has been established between student performance on the pre-tests and their success (and survival) in the Fluid Mechanics classes. As a diagnostic tool, these pre-tests have helped to identify skill levels present at the beginning of a term and they have served as a test bed for examining new problems. Results from these pre-tests have led to a series of easy to implement solutions whose impact has extended beyond the given class. For example, to help those students entering the course with low math backgrounds to succeed, a set of optional problems has been developed for gradual distribution throughout the term. These problems are meant to be introduced before content that they support so that students will be prepared and able to handle the new content. For students identified by the pre-test as having special difficulty with the math background, these problems are not optional. These tools, and the outcomes generated to address the problems, provide not only immediate action on the issues that they uncover, but they also can help to remove the barrier that exists between the professor and student: openly expressing an interest in the factors that influence student success is one way to have a positive impact on student performance in a class.

Bibliography


