

## **AC 2007-1256: DIFFERENTIATED INSTRUCTIONS IN STATICS LEARNING**

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# **Differentiated Instructions (DI) in teaching undergraduate statics**

## **Abstract**

This paper presents the first time implementation of DI in an engineering sophomore Statics class, along with qualitative feedback obtained from informal student survey and anecdotal observations. Several academically advanced students have really liked the approach and find that it meets their individual needs, while addressing the instructional needs of their fellow classmates whose wants in a classroom are slightly different. The paper discusses the planning and implementation process involved using examples, which the author hopes will assist other instructors in DI adoption as a means of addressing the needs of a varied student population in any given classroom.

## **Introduction**

"Three principles from brain research: emotional safety, appropriate challenges, and self constructed meaning suggest that a one-size-fits-all approach to classroom instruction is ineffective for most students and harmful to some." <sup>1</sup> Still classroom teaching/instruction at most colleges and universities is carried out with the one-size-fits-all approach. While most school districts in the United States of America implement DI in their public schools that will address students with diverse needs, abilities, strengths, experiences and interests in order to best support their learning, most colleges do not adopt this technique. So what is differentiated instruction? According to Tomlinson and Allan: "The idea of differentiating instruction to accommodate the different ways that students acquire knowledge involves a hefty dose of common sense, as well as sturdy support in the theory and research of education. It is an approach to teaching that advocates active planning for student differences in classrooms." <sup>2</sup> DI calls for teachers to be proactive in utilizing a wide array of curricular and instructional approaches. <sup>3</sup> Active learning involves students in solving problems, answering questions, formulating questions of their own, discussing, explaining, debating, or brainstorm during class. <sup>4</sup> DI utilizes several aspects of active and co-operative learning, but also adds the detail of accommodating the needs of different students ranging from the advanced learner to the remedial learner.

During the past few years of teaching, personal experience has shown that all students in a class are not of "one-size" as far as learning and instruction needs are concerned. Still most educators adopt the "one-size-fits-all" approach to teaching undergraduate classes. Discussion with colleagues about students being bored in classes because they learn quickly often leads to comments like: "they should be in an Ivy-league university" or "they should have opted for top research schools", "they should not be in our undergraduate programs" is often heard. Most instructors are more inclined to these statements than take the bold approach that classroom instructions can be modified to address varying needs. As teachers, most of us will agree that teaching to the average, or just above average will address the needs of most of the students. Still as teachers we also realize that this approach partly short changes the weaker and brighter students. Based on these observations, work has been done to use the model of DI in teaching an undergraduate statics class. The next few paragraphs describe the planning and first time

implementation process involved using examples, which the author hopes will provide some guide to other instructors in DI adoption as a means of addressing needs of a varied student population in any given classroom.

### **First Steps**

The first step in the implementation involves assessing the background and ability of students. To this end, the first class of the semester a pre-statics test that helps in evaluating the present level of educational preparation (similar to Math-Statics Baseline Test<sup>5</sup>) is administered. The test is graded before the next class and students are categorized for their instructional needs. (This is very similar to performance based analysis carried out in public schools to identify students as gifted OR talented OR those that need remedial help). In the current implementation, only the top few students were selected for DI implementation. The weaker students were identified for follow up, but no DI was used, beyond monitoring their progress during the semester and providing feedback as done in a regular class. (Remedial instructions could be one option, but was not done in this implementation). In the first few classes, with the help of informal conversations, an interest inventory is generated for those students that have scored very well in the pre-tests. This first step is typically called by different groups as “Know your students”, “student assessment” OR “Present Levels of Educational Preparedness (PLEP)” in DI. This year the students were informally interviewed to see if they would like to be challenged above and beyond the regular class-work. Only those identified as willing participants were selected for further implementation of DI techniques.

### **Teaching Strategies**

The typical class size was under thirty students meeting for fifty minute period, three times a week during the fall semester. A total of three sections were taught in the fall this past year. There were no laboratories as part of this class, though all the students had an engineering laboratory during their freshmen year in which they had built bridges from popsicle sticks. This had made them aware of problems in statics in general. All students had a common final examination and there was no differentiation in grading for students who had challenges in the class.

Typically most instructors pick a teaching strategy and continue to use this based on previous experiences and successes they have had with this approach. The strategy is then modified on an as needed basis, but generally remains the same for all the students and for all classes they teach. Occasionally the strategy will differ for different classes, but will not differ for the students in a given class. To implement DI, it is very important to have a repertoire of teaching strategies – because the very fundamental principle of DI is “one size does not fit all”.

Utilizing the information obtained from the student assessment, the teaching strategies were adopted for the class.

New concepts (for the whole class) were introduced in a similar manner to traditional classes. (For example the topic of resolving vectors in two arbitrary, non-perpendicular

directions using sine and cosine law). For concepts that the whole class had demonstrated a clear understanding – a review is first carried out which is very similar to what most instructors would do in a typical class. (Known in DI circles as Direct Instruction). Then the concept is posed in the form of an inquiry-based learning approach. For example, this semester the concept of “dot or scalar products of vectors” was clear to all the students, so a brief review of the definition was followed by an inquiry/problem based approach with the question, “how to find the angle between two vectors using dot or scalar products?” This exercise was carried out with the help of a handout given to the class. This was later followed by how to find the projection of one vector in the direction of the other. This time the students were asked to work in small groups to come up with the solution after an illustration of how the cosine of an angle is defined in a right angled-triangle. Following this, the students were assigned “in class problems” which were designed by incorporating two or three variations. Based on student’s aptitude – one could either solve the problem in full by using numbers only OR symbolic approach followed by graphing the solution.

To address the needs of several styles of learning – instructional material is presented in several different ways. Again using the dot product as an example, for some students it is just a formula to memorize (reinforced during instruction), while for other students it is a basic concept of geometry (again reinforced by instruction). With some topics like reduction of force systems, the students who were better placed in the initial tests were given further instruction (in a small group within the same classroom) in topics like reduction of a force system to a wrench, while most of the students were working on more basic problems. (Occasionally this instruction had to be continued after the class was dismissed). This way more depth in topics was provided for some students, while the basics was covered for the whole class. Trusses were another example where DI was used. While most of the class was instructed on 2-D trusses, the group of students who were advanced was instructed on handling problems in 3-D trusses. In the topic of shear force and bending moment diagram, DI was introduced by challenging the advanced students to find maximum and minimums using calculus, while the class figured this out by using calculators and plotting the general expression. In addition the DI group was also made to think about stresses based on the loads obtained and failure scenarios. Homework problems too were prepared with variations in depth of solution needed and assigned based on individual student assessed needs. Figure 1 shows one homework problem assigned to the students. This problem consisted of finding the resultant of two forces and the associated angles, was assigned in its simplest form as solving for a number. The second option is to solve for a general solution and adopt this solution to several similar problems in the same homework. Homework was collected and graded uniformly for the whole class. No differentiation was made in grading based on level of depth or difficulty of problems, or if the student was part of DI group.

Other elements of DI, such as co-operative learning are implemented in problem solving during class and for assigned homework. Based on the assessment done at the beginning of the semester, students were grouped to sit side by side in class during the semester. After the introduction of the basic concept and solving an example problem, the groups were assigned the next problem. Groups were clearly instructed to first discuss the solution to the problem – starting with what was the goal in this problem, to be followed

by analyzing the given information and what needs to be solved. Then they had to proceed to discussing the solution technique and explain it to the group. Following this they had to solve the problem on their own. After solving the problem the group had to discuss it among themselves. At the end of the allotted time the instructor discussed the steps with the whole class and ran through the solution. At this point the classroom as a whole discussed any misunderstandings or erroneous approaches before concluding the exercise.

Ideas similar to “minute paper” and “muddiest points” were implemented in class to help classroom assessment of learning. Many times students were given a minute and asked to explain and discuss new concepts among themselves and their neighbors immediately after the instruction in class. At the end of the minute – answers to the questions were provided and the concept was again summarized. Students have indicated that this minute break gave them time to collect their thoughts and stay focused in class.

As part of immediate assessment, during problem sessions a walk around the class by the instructor provides a quick feedback about student comprehension and in turn presents another opportunity for the instructor to reiterate the concepts and clarify any confusion.

### **Next steps**

Based on the initial success which was largely gathered from informal conversations with students, particularly with those who did very well in the initial assessment; it is planned to implement this technique in a more formal manner in the next academic year along with well instrumented surveys to evaluate the success of DI in a undergraduate mechanics class.

1. Tomlinson, C. & Kalbfleisch, L. (1998, November). Teach me, teach my brain: A call for differentiated classrooms. *Educational Leadership*, 52-55.
2. Tomlinson, C.A., & Allan, S. D. (2000). *Leadership for differentiating schools and classrooms*. Alexandria, VA: ASCD.
3. Fischman, B. (as viewed on Jan 17, 2007)  
<http://www.education.pitt.edu/leaders/FAQ/differentiatedinstruc.htm>
4. Felder, R. M. (as viewed on Mar 7, 2007)  
[http://www.ncsu.edu/felder-public/Cooperative\\_Learning.html](http://www.ncsu.edu/felder-public/Cooperative_Learning.html)
5. Mehta, S., and Danielson, S., "Math-Statics Baseline (MSB) Test: Phase I," Proceedings, 2002 ASEE Conference and Exposition, Montreal, Canada.
6. <http://www.teach-nology.com/tutorials/teaching/differentiate/planning/> (as viewed on Jan 17, 2007)

The post is to be pulled out of the ground using two ropes  $A$  and  $B$ . Rope  $A$  is subjected to a force (tension) of 600 lb and is directed at a known angle  $\phi^\circ$  from the vertical. If the resultant force acting on the post is to be always 1200 lb, vertically upward, determine the force  $T$  in rope  $B$  and the corresponding angle  $\theta^\circ$ . Challenge: plot the value of  $T$  and  $\theta$  as a function of  $\phi$ . For students having difficulty use  $\phi = 30^\circ$

NOTE : If you obtained a general solution to problem 1, then you can use it here and for the next two problems too.

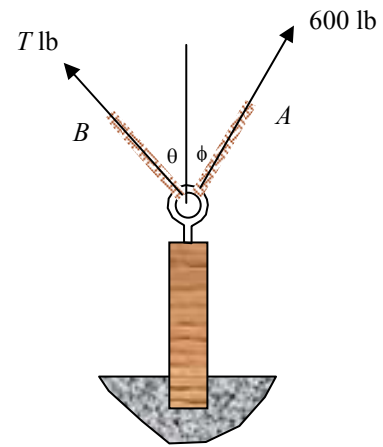


Figure 1. Homework example showing variations