

Computer Based Testing to Enhance Effective Teaching of International M.S. Students in Teaching-oriented Schools

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Abstract — Several teaching-oriented universities in the U.S.A. cater to a large number of engineering M.S. degree seeking international students. In their home countries, many of these students undergo an examination-oriented education system where studying intensely just before the examination is as rewarding as studying throughout the year. As a result, these students are conditioned for studying for examinations and are unfamiliar with the culture of studying continuously. They are thus unable to adapt to the culture of homework based education system that is so vital for the success of graduate studies.

One possible way to change these students' behavior is to conduct Quizzes regularly—preferably in every class. If the percentage of Quiz grades in the final score is high enough, then it is conjectured that students will take these quizzes seriously and study regularly. However, the practical problem of such an approach is that the grading load is greatly increased for the instructor.

Computer based testing (CBT), where the students take the test on a computer and the test is graded immediately, provides a solution to this dilemma. CBT quizzes can be administered in every class without increasing the grading load. Clearly, a CBT is effective only for objective-style questions and they therefore cannot replace homeworks. However regular testing would condition the students to continuous studying and quizzes designed around homework questions are likely to make students take homeworks more seriously.

Several popular online course management software such as BlackBoard and Moodle have the option of conducting CBT. In this paper, we discuss the pros and cons of using CBT in graduate courses, as well as analyze the various options provided by BlackBoard in designing CBT and provide suggestions in how to effectively use them.

I. Introduction

There is a popular perception that the undergraduate level is for “teaching” (i.e., imparting basic knowledge) and the graduate level is for “research”; i.e., the graduate level classes prepare students for doing research. In reality the graduate level education often has two tracks: the research oriented track for the “Ph.D.” students and a second teaching oriented track for the “M.S.” students, i.e., for students who seek a terminal M.S. degree. Some schools, such as Boston University, maintain little distinction between the M.S. students and post-bachelor's Ph.D. students, whereas some others, such as University of Pennsylvania or Yale University, maintain a strict distinction. Many schools view M.S. students as primarily a revenue source and use a lower standard for admissions criteria and a no-stipend policy. Thus, they may have weaker background than the post-bachelor's Ph.D. students. Usually, post-bachelor's Ph.D. students (for completing their Master's level requirements) and M.S. students take the same classes. This

poses no problem in schools with thriving Ph.D. programs and correspondingly large number of Ph.D. students with a stronger background because then the difficulty level of the classes can be set by the Ph.D. students. In fact, a “notch higher” difficulty level of the classes may benefit and motivate the M.S. students.

Not all universities with a graduate program, however, are research-oriented or have a strong Ph.D. program, A number of engineering schools in the U.S.A. have only an M.S. program with no (or a very small) Ph.D. program. A representative list of universities compiled by the author using the ASEE database can be downloaded from

http://raysaikat.googlepages.com/us_univ_classification.txt

In this list, the universities are separated into different categories based on the number of graduating students at different levels. The list shows that almost 75 universities in the U.S. have a graduate level that (almost) exclusively serves M.S. students. These graduate programs are primarily teaching oriented and resemble undergraduate-only schools in many ways; e.g., 3 or more sections per semester of teaching load on the faculty members is quite common. The M.S. programs serve as a convenient source of additional, or in some cases (e.g., University of Bridgeport), primary, source of revenue.

II. Student Body

The students who enter programs for terminal M.S. degrees generally seek non-research industry jobs¹. That is, these M.S. only programs are in essence “professional” programs (some universities may offer a separate *professional* track with more hands-on courses, but we do not separately consider those programs). Most of these programs are populated dominantly by international students.

In general, international students form a large part of the student body in most engineering schools in the U.S.A. It is difficult to characterize their academic strength. Students from different countries seem to have different strengths; e.g., anecdotes suggest that Russian students possess great background in mathematics whereas students from Latin America are very good with traditional electrical engineering topics such as power engineering. Many of them, e.g., the students from different Indian Institute of Technologies (IITs) or Tsinghua University, come with outstanding undergraduate training. However, the M.S. student population in teaching oriented schools seems to show some common characteristics. We describe below these observations and anecdotal reasons that perhaps explain the observations. **Note that, these observations should not be construed as negative comments in any way, but merely as what the author has experienced.**

1. **Motivation:** Most students join M.S. program in order to get a job in the U.S.A. The primary avenue of getting a job in the U.S.A. for a person who is not a citizen or a permanent resident is the H1-B visa (work visa).² Due to immigration policies, it is easier to get the F-1 (student) visa and convert the status into H1-B after completion of the degree than directly getting the H1-B

¹ . Anecdotes tell that in the flourishing dot-com era of late 1990’s, many post-bachelor’s Ph.D. students would be lured away by the companies. That may be the reason that in some schools it is difficult, *de jure* or *de facto*, for a funded post-bachelor’s student to get an M.S. diploma even after completing the equivalent course works.

² Obtaining employment based permanent residency (the “green card”) for getting a job in the USA is not a realistic option for Indian and Chinese citizens. It takes 5-10 years for most of them to get the green card, even for those who are already gainfully employed in the U.S.A.

visa. Usually, the need for securing an employment is a strong motivation for acquiring marketable skills. Unfortunately, anecdotal evidence suggests the existence of so-called Software Consultancy firms that hire the M.S. graduates regardless of their skill levels as these firms simply act as a broker to circumvent the immigration policy that in effect grants the H1-B visa to the company instead of the individual. This diminishes the motivations of the students for learning.

2. **Educational Background:** While many international students have brilliant undergraduate training, most students who join M.S. programs in teaching oriented schools seem to have poor background. There are two possible reasons. First, most good students get a good job in their home country. So capable students who are seeking a job need not come to the U.S.A. This is especially true for Indian students. The economy in India is booming and there is a significant shortage of qualified individuals. Anecdotes say that in 2007, students graduated with a B.Tech degree from Indian Institute of Technology, Guwahati, got job offers in Bangalore (the software city of India) with an average starting salary of 1 Million Rupee/year (this is about double the full professor's salary in IITs, and about 5 times the average clerical salary). Clearly, they do not intend to come to U.S.A. for an M.S.

Second, the good students or the motivated ones who are able to get a job in their home country, yet choose to come to U.S.A. for getting a better education almost always join the Ph.D. program, or the M.S. program in the top research-oriented schools. In addition, most of them would not come without a stipend. Since the schools whose primary source of revenue is tuition from M.S. students do not provide stipends, good students from other countries tend not to join these programs.

Thus, the students who join the M.S. programs at teaching oriented schools are likely to be from the weaker half of their student populations.

3. **Time devoted to studies:** Although F-1 visa rule prohibits off-campus employment when the school is in session and limit on-campus employment to no more than 20 hours/week, anecdotes suggest that many M.S. students do odd jobs for a significant number of hours per week to cover their expenditure. Thus, many students do not have time to work on their studies since they work long hours and are tired afterwards.

A related phenomenon is that if a student has relatives in nearby places, the student would live with them. For instance, many Indian students at University of Bridgeport lives in New York and even in New Jersey as there is a large Indian population in those states. As a result, while these students are full time students, they commute to school. Since commuting long distances by commuter trains or buses is quite expensive, they try to minimize the number of days they must be on campus. The author has observed during advising that often these off-campus students select courses dictated by the day of the week the classes are offered, and not by their background and interest.

4. **Pattern of studies:** For the purpose of this article, one of the most important characteristics is that these students are not accustomed to regular studying that is so vital for proper graduate

level training. The author is most familiar with the Indian school system. In India (excluding the Indian Institute of Technologies (IITs) and Regional Engineering Colleges (RECs), and a handful others) many Indian universities are just an examination body. Students study in various colleges that are affiliated with a given university and they all get the diploma from that university. These colleges, however, differ widely in quality. While some of them are reasonably good, many others are below the minimum standard — many do not even have professors to hold classes. Therefore the established culture is studying only for the examinations; the importance of classes is limited since the examinations are not set by the teachers.

In summary, in the author's experience, the international M.S. students in teaching oriented schools have weak background, and they tend to spend less than expected time in studies except before the examinations. Our objective in this article is to examine if there are methods that can be effective with such students in improving teaching.

III. The Proposed Approach

Graduate level courses ideally are for increasing the depth of a student's education; i.e., for the so-called specialization. Thus, ideal graduate students are self-motivated and learn without constant supervision. But as illustrated in Section II, the ideal scenario may not be the reality with many M.S. students. Therefore, we need to take an approach that will attempt to condition the students towards the studying pattern of an ideal graduate student.

In the author's view, the most important aspect of an ideal graduate student's studying pattern is *continuous* studying. In engineering, a practitioner has to constantly retrain himself/herself to remain relevant. This fact is especially apparent in software development where tools change almost every year. Thus the graduate student must learn *to learn*. The habit of continuous studying is one of the most important habits required for a lifelong learning exercise.

When students only care for the examinations, they do not study on a continuous basis. Especially for students who come from an environment where examinations can be tackled reasonably well by rote, studying at the last minute is usually as rewarding as studying the whole year, and most students who simply seek the degree choose to do the former.

Usually, graduate students develop the habit of continuous studying by doing regular homeworks. The M.S. students we consider are not habituated to doing homeworks. In the author's experience when homeworks are given to them, unfortunately they tend to copy the homeworks, sometimes even from a solution manual, perhaps to minimize the time spent. Therefore, assigning a large percentage of the final score on the homeworks is unwise.

The viable option is conducting tests (quizzes) on a regular basis, preferably in every class. Interestingly, the students are less prone to plagiarism in an examination hall, which is probably due to the culture of strict conduct of examinations in their home countries. If a significant percentage of the final score is based on these quiz grades, then the conjecture is that the students will take the quizzes seriously (because they are conditioned to take examinations seriously) and therefore study, at least to some extent, regularly. There are two issues. The pedagogical issue is whether such an examination based approach is

appropriate. After all, we would like to break their undesirable studying habit. Second, the practical issue is tackling the significant increase in grading load that an already overloaded instructor would have.

We note that the short period of M.S. programs (typically 3-5 semesters with significantly less campus hours than their Ph.D. counterparts) are insufficient for changing a lifelong studying habit. On the other hand, giving quizzes in every class (or every week) will prompt the students to study the class material regularly. These quizzes perhaps will contain objective questions only. The homeworks therefore would remain necessary practicing subjective skills such as working with conceptual ideas (e.g., theorem proving as opposed to number crunching) or writing skills. However, the quizzes can be designed skillfully to make the students take homeworks seriously: (i) make the homework grade small (e.g., 10%) compared to the quiz grades (e.g., 30%), and (ii) make some of the quiz questions based on the homeworks. In this way, doing homework is now rewarding since doing well in quizzes would depend up on whether or not the student did his/her homework. Note that having only mid-term and end-term examinations that incorporate homework material would not have the same effect: (i) Students tend not to plan so far into future. (ii) By the time they realize that they should take homeworks seriously, it is already too late. (iii) Since it is not wise to give a high percentage of the score for the homeworks, the system reduces to a couple of high-stake examinations. Regular quizzes, when designed correctly, should prompt the students to study and do homeworks on their own on a regular basis, thus help them break their old habit of studying just before the examinations and instead develop the habit of studying continuously. We therefore are of the opinion that having regular quizzes is a great approach for M.S. students.

The practical problem with having quizzes in every class is the additional grading load on the already overloaded instructors. Thus, as such very few instructors would like to take this route. However, this problem can be circumvented by conducting the quizzes *online*. I.e., the students would take the quizzes on a computer and the computer would grade the quizzes and store the scores in a gradebook instantaneously. The only increase in load is the modest amount of time that must be spent in generating the questions. With practice, this could less than 30 minutes.

IV. Computer Based Testing

Computer based testing (CBT) refers to conducting tests online. The most important advantage is that the grading is done by the computer and therefore there is no grading load. Another advantage of CBT is that it provides the instructor additional options in designing the tests that are not possible in paper based tests, for example, a dynamic difficulty level of questions. The disadvantage is that CBT is useful, insofar as grading is concerned, only for *objective* questions (i.e., where the answers do not depend on the subjective view point of the student). In engineering disciplines, however, objective questions can very well test the student's understanding and capabilities, except perhaps for testing skills such as theorem proving, or the student's writing. Questions from the latter categories can still be included, and students can type in the answers. But they cannot be graded by the computer and the instructor needs to grade them manually.

Many schools use web-based course management software. The popular ones are BlackBoard (commercial), webCT (commercial) and Moodle (open source).³ These software have in-built tools to create and conduct online quizzes. The author is familiar with the BlackBoard system and our discussion

³ See also the TuningFork software from a start-up: <http://www.conceptwaves.com>

will be restricted to the BlackBoard (BB) system.⁴ However, Moodle also has similar features. Therefore, the discussion could also be useful for instructors who use the Moodle system. Note that both BB and Moodle is configurable (extendable) through programmed *modules* and the exact setup may differ from system to system.

The BlackBoard (BB) system allows creating a *test*, which is a set of *questions*, independently. Then a test can be added to other sections of the BB, such as the Assignment section, where students can access them. Tests are created using the *Test Manager*. There are two sets of features: (i) at the test display level, and (ii) at the question level.

1. **Options at Test Display level:** The test display options allow you to change how students view the questions. The important options are:
 - a. **Multiple attempts:** Enabling this option will allow the student to take the test more than once (the limit could be a finite number or even unlimited). The grades of each attempt can be seen. This option is more relevant for online courses; for traditional courses, single attempt is the suggested option.
 - b. **Force Completion:** This option will make the student finish the test once started. This option should be enabled to emulate a usual paper based test.
 - c. **Timer:** Setting this option displays a clock when the students take the test. A limit can be set, but BB has no option of stopping the test if the student goes over the time limit. However, in the gradebook, an exclamation appears instead of the score if the student exceeds the time limit and the instructor can manually change the grade in those cases. The students need to be told to submit the test (i.e. click on the submit button) when the time is up, similar to collecting the script at the end of a paper based test.
 - d. **Display period:** The instructor can choose a period within which the test will show up. This should be used and the test should only be displayed till the end of the quiz period for preventing students taking the test later on.
 - e. **Password:** A password can be given to the test. This option should be used to prevent students from taking the test outside the classroom (controlled environment).
 - f. **Presentation:** This option dictates whether or not all questions will be displayed simultaneously. If the questions are to be displayed one at a time, then options are present to dictate whether or not they are displayed in a random order and whether or not the student is able to go back to an earlier question (backtracking). This option is an interesting feature of a CBT that is not realistic in paper based testing. The author prefers giving questions one at a time and in random order with back-tracking prohibited. This makes the test difficult for the students who now must be sure about the answer before proceeding to the next question. The option of seeing one question at a time along with randomization, to some extent, prevents plagiarism in the classrooms since students do not work on the same question at the same time.

Note that since these tests are web based, they can be taken from outside the class-room. Thus, a student can cheat by taking the test from outside the room with additional resources for the answers. BB provides options, such as (e) to make that difficult. Some system provides instructors the options

⁴ webCT is now under the company that produces BlackBoard.

to specify IP addresses of the computers from where the test is to be taken. That is more secure (however, not full-proof since it is possible, although hard, to do IP-spoofing).

2. **Options at the Question Level:** There are different set of options, most of them obvious, depending on the choice of the question type (described below).
 - a. **True/false.** In this question category, the student needs to determine whether or not a given statement is true or false.
 - b. **Multiple Choice.** In this question category, the student needs to choose one true answer from a set of answers to a given question.
 - c. **Multiple Answer.** In this question category, the student needs to choose one or more true answers from a set of answers to a given question.
 - d. **Maching.** In this question category, the student needs to match statements in left column to the statements in the right column.

These four categories of questions are the most important types. There is of course a chance that a student selects a random answer and gets it correct. But that probability of such happening becomes quite low with at least 4 alternatives and no partial marks. The author has not noticed any problem in this regard. The bigger question is how one may guarantee that students actually understand and not learn by rote for answering the questions. **The trick is to ask the question about implications and not assertions.** Implications can only be constructed if the student has understood the subject material. An example is as follows: in computer science, NP-hard problems are computationally difficult. Eulerian path construction is *not* an NP-hard problem, whereas Hamiltonian path construction is. Now if one asks a T/F question: “Is Eulerian path NP-hard?” the student may be able to answer this by rote. However, if the question is changed into “It is more desirable to pose Sequencing by Hybridization (SBH) as an Eulerian path problem than a Traveling Salesman Problem (TSP).” answering this correctly requires the students to know that TSP is essentially a Hamiltonian Path construction problem and hence NP-hard, SBH can be modeled both as an Eulerian path and an Hamiltonian Path problem, and that Eulerian path problem is faster to solve and thus more desirable.

A thorough pedagogical discussion regarding the extent of efficacy of objective questions in evaluating a student’s understanding of a subject is outside the scope as well as page limits of this paper, however, we hope that the previous example illustrates the basic point that well designed objective questions can, in fact, evaluate a student’s understanding quite deeply; at least sufficiently enough for a weekly quiz. In the rest, we complete the descriptions of other types and conclude the paper.

- e. **Ordering.** In this category of questions, the student needs to put a set of statements in the correct order.
- f. **Fill in blanks and fill-in multiple blanks.** As the name suggests, in this category of questions, the students need to fill-in one or more blanks. The author use this category for questions with multiple numeric answers since the category “Calculated Numeric” does not have the option of multiple numeric answers.
- g. **Either Or.** This category is essentially a True/False question category.
- h. **Calculated Formula.** In this question category, there are “variables” that appear in the question text and the computer randomly selects their values from a given range (thus different students see different numeric values). A formula must be provided based on

the variables that represent the correct answer. In the BB installation that the author used, this feature did not work other than formulas with very simple expressions.

- i. **Calculated Numeric.** In this question category, there is a numeric answer to the question. The instructor can set a range in the answer to accommodate rounding off errors. This category would be ideal, but in the BB installation the author used, each question can have only one answer (i.e., an array of numeric answers are not possible).
- j. **Essay and File Response.** This question category allows the students to upload a file containing the answer or write an essay. These questions are not graded automatically; the instructor must do so manually.
- k. **Other options.** There are image based questions, such as *Hot Spot*, that expands on traditional questions.

In all cases, the instructor may choose to give feedbacks after each question, based on whether or not the answer was right. This is again a feature that does not exist in paper based tests. But the author has not used it, primary to prevent possible plagiarism during the exams (if the answer is shown, it can be passed on to other students). It is also suggested to sit the students randomly *before* the examination begins since it is not possible to move an errand student to a different seat later.

V. Conclusion

Computer based testing enables an instructor of a course for M.S. students in a teaching oriented school to condition them to the habit of regular studying without increasing the grading load. The author has used them in class successfully with increased student attendance and attention. There are issues with computer access, some time is lost if the class has to go to a computer lab for the test, possible web outages during the test, etc. However, the benefits of CBT significantly outstrip its disadvantages in creating better motivated students at the M.S. level.

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