AC 2011-1815: COURSE EMBEDDED CLASS ROOM ASSESSMENT TECHNIQUE FOR THE STEM EDUCATION

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Course Embedded Class Room Assessment Technique for the STEM Education

Abstract

The classroom assessment technique (CAT) is a teaching approach, which offers multiple benefits to both the students and the instructor. There are many assessment techniques available for this experiment, however, *minute paper format* is selected because of its simplicity and does not demand additional time commitment from the students. This is an in-class activity that provides both the students and the teacher useful real time feedback on the teaching-learning process. The end of semester course assessment process was utilized for the data collection instruments: completed CAT forms from each class, pre and post-test results and a general survey data. The data analysis confirmed major accomplishments which include improvement in student learning of the basic science and engineering concepts, linking the learned concepts to real world applications for student motivation in the course and furnishing real time student feedback to the instructor to modify course content delivery to engage students in their learning process. As result, the students' benefits include are, immediate clarification of the concepts in doubt (expressed in the CAT forms) to enrich their learning, provided non-intimidating communication link with the instructor to express their concerns and facilitated peer-learning opportunity. The end result of this effort is improved student performance in the final examination to achieve slightly better grades compared to their earlier examination performance.

Introduction

The conventional pedagogy of teaching in lecture format is slowly veining away since the higher education institutions are profoundly focusing on the student centered-learning technique to improve student retention and graduation rates. Historically many classroom instructors at higher education institutions thought that the delivery through lecture format might help disseminating a huge body of knowledge to large number of students at a given time. However, the most frequently cited article authored by Barr and Tagg¹ presented the paradigm shift, *From Teaching to Learning* to create a student-centered learning environment for promoting discovery and problem solving skills of the students. Some of these notable paradigm shifts include engage students to be active knowledge constructors rather than passive recipients of knowledge, produce learning compared to instruction delivery and transform the learning into outcome based activity, such as student learning². These paradigm shifts assist with kindling of students' motivation and confidence.

In the past decade several reports surfaced calling for significant changes in the delivering of the undergraduate science and engineering pedagogy that promotes critical thinking and problem solving skills along with proficient learning strategies.^{3,4} For example, publications from the National Academies Press such as, *Knowing what Students Know*⁵ and *How Students Learn*⁶ are gaining popularity to introduce various pedagogies to enhance student learning in a traditional classroom setting or online.

The National Academy of Engineering (NAE) recently produced two powerful reports: *Rising Above the Gathering Storm*⁷ and *Grand Challenges for Engineering*⁸. Both these reports emphasized education and research in the fields of Science, Technology, Engineering and Mathematics (STEM) to sustain global leadership position of the United States. It is a well-recognized fact that the United States is behind several developed and developing nations in producing graduates (US Citizens) in the STEM fields and threatens its global position as a leader of innovation⁷.

Based on these reports and findings it became obvious that education institutions are key stakeholders to solve these challenges facing the nation at this juncture. For example, one of fourteen Grand Challenges for Engineering proposed by the NAE is identified as *Advancement of Personalized Learning*⁸. In essence, the proposed changes are all focused on implementing student-centered learning pedagogies such as, active learning, inquiry-based and project-based learning strategies into the classroom. The benefits of these instructional techniques include: peer learning, interactions & communications with instructors and peers, student monitoring of their learning, application of their learning to real world examples and opportunity for providing student feedback to the instructor for real time content delivery improvement. This paradigm shift brings student learning into limelight compared to teaching and creates a learning environment more conducive to help the students to be independent and critical thinkers by processing the information provided to them².

Materials and methods

The course that is selected for introducing the CAT process is a junior level undergraduate course, UET 331, *Electronic Materials*, which is required for all undergraduate students majoring in electrical and electronics engineering technology BS degree at ASU. The undergraduate degree program is accredited by the Technology Accreditation Commission (TAC)/ Accreditation Board for Engineering and Technology (ABET). This introductory Materials science and Engineering course serves as a prerequisite to many other courses in the department and students consider this as one of the challenging courses in the curriculum of their degree program. Therefore, the objectives of this study are multifaceted. The major expected outcomes of this effort are, creating student-centered learning environment, promoting self learning and peer learning techniques, improving student performance in the course, and factoring student feedback into the teaching process to adjust content delivery in real time by the instructor. The focus of this study is to create student-centered learning environment by promoting interaction among the students and also with the instructor to improve students' problem solving and critical thinking skills. Additionally, the instructors' content delivery technique should motivate the students to become better learners by involving them in class discussions rather than teaching them the course content.

The course assessment technique is not a new concept; however, the technique's effectiveness is closely related to the nature of course content. For this study, one 300

and one 400 level classes were selected with moderate (20-30) and small (5-10) student enrollments taught by the same instructor. The variables of this study are class size and course content type. The CAT exercises are designed to assess student learning and how it impacted students' success in the course. To encourage higher percentage of student participation, 5% of the overall course grade credit was assigned to the CAT activity.

The over arching goal of this experiment is to motivate students to become monitors of their own learning, develop critical thinking skills and provide feedback to the instructor to make real time adjustments in the teaching style of the instructor for the improvement of their learning. This is a win-win process to benefit both the students and the instructor.

Course Description

UET 331 is the only materials science course for the BS degree-seeking students and is a prerequisite course for other junior level courses; for example, devices, sensors, senior level courses in the degree concentrations, integrated electronic systems and alternative energy technologies. The course is primarily a lecture-based course. Before introducing the CAT process, the course assessment was relied on three exams (two mid-term and one final exams) and homework assignments. Since student learning and student feedback to the instructor became the key objectives of this focused study so the assessment process is altered to examine the progress with respect to these objectives. The new assessment process included pre and post-tests, quizzes, two mid-term and one final exams and CAT assignment at the end of each class followed by class discussion in the next class. However, no control group is used for this study because of the credit assignment to the CAT activity.

Course Modification

A prescribed textbook, *Materials Science and Engineering An Introduction*⁹ along with lecture notes served as course content to the students. The Blackboard portal is used to deliver the class notes in an electronic format to the students. The lecture material is posted to the Blackboard portal site one week prior to the scheduled class period. The sequence of the course topics was arranged wherever possible to reinforce the earlier learned concepts. For example, structure of crystalline solids, crystal defects and diffusion are covered in that sequence to explain interrelated concepts. Problems related to various crystal orientations in cubic systems including both crystal directions and planes are solved in the class and also assigned as homework assignments for reinforcing the concepts learned in the class and also augment problem-solving skills. Critical thinking and imagination played significant role in these assignments and some students struggled with them. However, the CAT process provided an opportunity for the students to communicate with the instructor about the topics that presented challenge to them and prompted further clarification in the class and also promoted peer learning. This exercise also provided feedback to the instructor for making adjustments in the content delivery technique.

Classroom Assessment Technique (CAT)^{10,11}

Purpose

The purpose of introducing the Class Assessment Technique (CAT) is to aid students improving their learning in real time. Additionally, motivate them to provide feedback to the instructor in a timely manner for clarification of difficult concepts taught in the class.

At the end of the class period, about 5 to 10 minutes are allocated for the students to reflect back and answer the following three written questions: important concept or concepts learned in the class that day, identifying items for further clarification and connect the concept learned that day and link it to a practical application. If for some reason if a student could not complete the CAT form in the class then time extension was given for electronic submission by 8 pm on the same day.

Mid Course Changes

The student feedback through the CAT process informed the instructor that the students preferred the problem solving activity to be performed in a traditional manner using the chalk board to solve the problems and also requested to include a summary of important concepts at the end of each chapter in the lecture notes.

The Electronic materials course ((UET 331) is a small-to-medium size (15-20 students) class and the class participation averaged around 83% with maximum and minimum being 100 and 60% respectively. However, the lowest percentage participation occurred only once during the semester. This activity carried 5% credit towards the course grade and that could have been one reason for achieving higher student participation percentage.

Evaluation process

Several instruments are used to evaluate effectiveness of the CAT process. The first and foremost is completion of the CAT form. Both students and instructor benefitted from this process.

Student benefits:

- Quick recollection and reflection on the items discussed in the class.
- Identified and provided feedback to the instructor what they did not understand in the class for clarification.
- Promoted self-monitoring of their learning
- Enhanced critical thinking skills by relating learned concept with a practical application. This process reinforced their understanding of a concept.
- Students used most of the feedback material from the instructor as a study guide to prepare for the quizzes, exams and also for a quick review. The

students also learned from the questions asked by others in the class to facilitate peer learning.

- The CAT process also encouraged communication between the students and the instructor. (Students were busy with part time work, family and education most of the time. Mandatory CAT activity facilitated the communication path.)

Instructor benefits:

- Student feedback assisted the instructor to clarify ambiguous items clearly in the next class.
- The instructor was able to identify problem areas related to student learning and was able to make changes in real time for continuous improvement of the delivery of the material.
- The instructor was able to motivate students to think outside the box and encouraged them to ask questions beyond the material covered in the class.
- The CAT process became a communication link between the instructor and students.
- Instructor returned the graded CAT forms before next class and also at the beginning of the next class period explained the items that the students identified for additional clarity. The written responses for the student's questions with clarifications were posted on to the Blackboard the same day or earlier. This process became good tool for the instructor to make changes to content delivery in real time.
- The process definitely helped large class size compared to small class size based on a quick poll in the class.
- A small survey instrument is designed to compile student feedback to this process and analysis of the survey results are provided in the assessment section for future modifications of the CAT process.

Assessment Process

The CAT assignments and survey results and written comments from few students are instruments directly used to assess the CAT concept performance. However, student's performance in quizzes, exams and the total course grade are the indirect assessment tools used for this process.

The CAT concept in general received well by the students, which is indicated by average participation above 80%. It also helped by providing small percentage of credit to the activity as a part of the total course grade. A total of 26 CAT assignments were

collected and graded for the medium size class and 20 for the small size courses respectively. The class periods for the scheduled mid-term exams were excluded for the CAT activity. Each CAT assignment was credited for 10 points and in general the lowest score obtained for these assignments was between 6 and 7 points. Small percentage of students had difficulty in relating the concepts to a real world example. Overall the performance was above average. The survey instrument designed had some redundancy and this instrument will be modified for the future use. The questions 1-3 are designed to inquire how popular this assessment technique is within the ASU system.

Student Survey Data and Results

Survey Questions:

1. First time CAT users
2. Course challenge level compared to other ASU courses
3. Course learning level compared to other ASU courses
4. Course applicability beyond course completion
5. Instructor clarified ambiguous questions
6. Monitors of self learning
7. Instructor cared about student learning
8. Altered study skills
9. Instructor factored student feedback
10. Instructor responded to questions in a timely manner.

Summary of Survey Results:

- Above 80% of the students in the class exposed to this process for the first time.
- 90% of the class agreed that the instructor clarified the concepts that are in doubt in a timely manner.
- Above 80% said the process helped them to monitor their individual learning.
- Above 80% of the class said the course material would be applicable beyond their school years.
- 75% of the class found the UET 331 class was more challenging compared other courses taken at ASU.
- 50% of the class found that learning level of the course was more challenging compared to other ASU courses.

Instructor findings:

- The student feedback definitely helped to make adjustments in the delivery techniques.
- Working out the word problems on the Blackboard helped the students to understand the logical approach to solve a word problem.
- The students were engaged in a thought process that is beyond the material covered in the class based on the questions they posed for clarification in the CAT forms. This indicated that the process helped the students' motivation.
- The students who did not participate in the process earned the lowest course grade in the class. This is an indirect inference that the process enhanced student learning.

Proposed Changes for continuous Improvement:

A few changes will be made during the next offering based on the feedback provided by the students for continuous improvement. For example, reading assignments will become part of the course assessment that is followed by in class questions. To involve students in the class, randomly selected students will be invited to solve word problems in the class.

Pre and Post Test Data

Figure 1

Figure 2

The students in the class are divided into two groups A and B for this analysis. The students in the groups A & B scored in the pretest an average score of 60% and 70% respectively. The same groups' performance in the post-test enhanced from 10-20 as shown in the Figure 1. Since the pre and post- tests were conducted electronically, it is not clear if the students used web resources to answer the test, especially for completing the pre-test. During next offering of the course both pre and post-tests will be conducted in classroom to gather more meaningful data. Then the student performance improvement in the post-test was compared to the whole class and this data is shown in the Figure 2. Fifty percent of the class showed 20% and the remaining fifty percent of the class equally divided with 10 and below 10% improvement in their performance compared to the performance in the pre-test.

Conclusion:

The classroom assessment technique (CAT) is a teaching approach that provides benefits to both the students and the teacher. The CAT is nothing but a formative evaluation technique that has dual purpose of assessing the extent to which the students understand the lecture material delivered in the class and also effectiveness of teaching methods used by the instructor. Formative evaluation techniques are used more frequently and also found to be valuable to improve course content, teaching techniques and or pedagogy and student learning. The results of the study presented in this paper proven to be true in achieving most of the CAT objectives outlined in the beginning of the process. The CAT process also improved communication between the students and the classroom instructor to improve student performance in the course. Assigning a small percentage of course credit also found to be beneficial to achieve higher student participation. A small percentage of students who did not participate in the CAT process achieved lowest grade in the class indicating that the CAT process did improve student learning. The process also enhanced teaching effectiveness in delivering the course content more conducive to engage the students in their learning based on pre and post-test results. Overall this study is meaningful and provided positive results in achieving better student learning through modifications of the classroom teaching techniques. However, this paper reports initial results of this effort and to assess its impact fully, further study needs to be continued for a longer time to realize its influence on student-centered learning pedagogy.

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