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Implementing Innovative Assessment Methods in Undergraduate Mathematics

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Abstract: The challenges associated with teaching undergraduate Mathematics will be discussed: Negative attitudes of students to Mathematics, Student's reluctance to practice Mathematics, and surface learning. Some (or all) of the ways in which assessment can be used to address these challenges will be discussed.
If strategically used, assessment methods/tasks can enhance the teaching and learning of mathematics. Some of the unique challenges that we as lecturers face in teaching mathematics can be remedied by selecting appropriate assessment techniques/tasks. Using the tutorial time fruitfully is one of the challenging aspects in teaching mathematics. Not taking tutorials and other formative assessments seriously is not an uncommon student attitude in higher education contexts (Baderin, 2005, Pope, 2001, Smyth, 2004). Students who are pressured for time often do not see the immediate value of formative assessment or of discussion as a useful learning activity (Baderin, 2005). The purpose of introducing the assessment method, implementation method, its advantages, and disadvantages will be examined. A reflection on the assessment method and concluding remarks will be provided.
KEY WORDS: Undergraduate Mathematics, Assessment methods, Surface learning

INTRODUCTION:

Effective integration of technology into the teaching and learning of mathematics presents a significant challenge to tertiary mathematics educators. Assessment issues in particular are widely considered in the literature as a critical factor in technology implementation, and this was confirmed in a Ph.D study investigating the overall use of technology in undergraduate mathematics.
A meaningful assessment of the undergraduate degree program in mathematics must focus on what students are learning and how well they can use the knowledge gained.

Meaning

Assessment is the process of gathering and interpreting information about student learning in ways that inform faculty and students of the extent to which student achievement is meeting expectations for learning. The learning goals describe the intended learning in the major consistent with the missions of the College and University. The assessment process is designed to provide information for improvement of the undergraduate curriculum, not the assessment of individual students. A student assessment serves no purpose unless it is communicated to faculty and they act on it as appropriate. Therefore the assessment process must be designed to have both involvement by and respect of the faculty.

Challenges Associated With Teaching Mathematics

Teaching mathematics has its own unique challenges. Many of these challenges can be addressed by choosing an appropriate innovative assessment method or task. Some of the challenges associated with teaching mathematics are the following:

Attitudes of students to mathematics

Mathematics is perceived by the majority of students to be an extremely difficult subject reserved only for the brainy few .Previous experiences of students are a major contributing factor to their attitude towards mathematics. The perception of heavy workloads further compounds the problem. As these attitudes can be a serious barrier to the students' learning; it is important that they be altered.
I concur with Entwistle and Ramsden (1983, p.202) that positive attitudes to studying contribute to student learning. In a number of instances, mathematics will be a prerequisite for courses in different faculties. Students who tried to avoid it end up compelled to study it.
Jackman and Goldfinch (2001) report that assessment has been used to improve students' attitude to mathematics in service courses in two universities. After implementing a project based assessment this study shows that there is evidence to support that the students' attitude to mathematics improved. There was renewed willingness to tackle not only recall but new types of problems, they were also keener to tackle real-life

problems and appreciated the usefulness of mathematics. This experience made it possible for students to have a positive experience of mathematics while being challenged intellectually.

Practice in Mathematics

In its nature, mathematics builds on previous knowledge. It is extremely difficult to master if there are gaps in the student's knowledge base. Large coverage of volumes of work in almost all mathematics courses can be a strong impediment to mastering concepts as the concepts are usually interdependent. Learning mathematics occurs largely by practicing it as opposed to being taught. Teaching serves mainly to guide the student and clear whatever misconceptions which may arise. Consistent practice on the part of the student is necessary to master the concepts. Students' lack of practice in mathematics results in knowledge gaps and hence becomes a barrier to their effective learning of mathematics concepts.

Assessment is considered to be a potential solution to this problem. A number of institutions have frequent short tests which will count towards the class mark. However, the marking of these short tests can be labor-intensive. Whilst institutions which use multiple choice questions for this purpose may succeed in getting students to practice mathematics, they may not get much satisfaction in preparing them for summative assessment, since major tests do not comprise multiple choice questions. The assessment method (peer-assessment), which is discussed in more detail below, addresses mainly this area, by ensuring that students get adequate practice in problem solving skills in mathematics while concomitantly being prepared for summative assessment.

Need for the Assessment for undergraduate level students:

This article supports Gibbs' (1999) statement that, "Assessment is the most powerful lever teachers have to influence the way students respond to courses and behave as learners". Traditional assessment methods in mathematics are not as controversial as in other areas of study as the subject lends itself to more reliability and fairness. The usual methods that are used to assess mathematics are tutorial exercises, oral presentations of solutions to problems, short tests, class tests and written examinations. Oral examinations, projects, essays and computer based tests may be used.

Some of the creative formative assessment techniques available in mathematics are the following: peer-assessment, self-assessment, and students coming up with their own questions which could be considered for summative assessment purposes. Bolte's (1999) concept maps and interpretive essays are some of the innovative assessment tasks which assess student organization of mathematical knowledge. Students perceived these tasks as enhancing their mathematical knowledge. Formative assessment need not be used to only assess the student's mathematical content knowledge and mathematical processes like reasoning, communicating, problem-solving, and making connections. McIntosh (1997) suggests that formative assessment can also be utilized to assess the student's mathematical disposition such as attitudes, persistence, confidence, and cooperative skills. As these attributes are critically important in solving mathematical problems their improvement is essential to better performance. Peer-assessment offers one of the diverse assessment methods.

Techniques Used for assessing the undergraduate students:

Improving problem solving skills through Questioning

Effective questioning in the mathematics classroom attempts to support deep thinking about mathematics and helps students clarify their understanding for themselves and others. Such thinking is a necessary part of growth in understanding mathematical concepts and is developed in multiple conversations over time. It helps students to develop their ability to use mathematics in new situations, and to increase their long term retention of the big ideas of mathematics.

In the mathematics class room , the focus is on problem solving, mathematical reasoning,justifying ideas, making sense of complex situations and independently learning new ideas. Students must be provided with opportunities to solve complex problems, formulate and test mathematical ideas and draw conclusions.

Students must be able to read, write and discuss mathematics, use demonstrations, drawings and real-world objects, and participate in formal mathematical and logical arguments.

Standards-based instruction in mathematics is designed to clearly identify what students should learn at each level. It is our duty, therefore, to authentically engage all students in the discipline of mathematics as a foundation for approaching problems, data, and research to make meaning of information and gain proficiency in analyzing and solving problems.

THE PRACTICE:

Essential characteristics of an effective standards-based mathematics classroom include:

- Lessons designed to address specific standards-based concepts or skills. Student centered learning activities.

- Inquiry and problem solving focused lessons.
- Critical thinking and knowledge application skills
- Adequate time, space, and materials to complete tasks.
- Varied, continuous assessment, designed to evaluate both student progress and teacher effectiveness.
- The implementation of a standards-based math curriculum brings with it some special challenges. In addition to ensuring students are actively engaged, teachers should adhere to the following guidelines:
- Create a safe environment where students feel comfortable.
- Establish clear procedures and routines.
- Provide both challenge and support.
- Use carefully assigned and well-managed cooperative groups.
- Make frequent real life connections.
- Use an integrated curriculum.
- Appropriate amount of time is devoted to tasks.

Introduction of Effective Assessment Practices

OBJECTIVE: Effective assessment practices are essential to support mathematics instruction that produces improved student performance. Teachers and students have been placed under tremendous pressure to prepare students for the accountability measures and standardized tests required by the No Child Left Behind legislation. Despite these pressures, mathematics teachers must resist the tendency to rely on the results of standardized tests only to measure student performance in mathematics.

Assessment strategies can also be characterized as traditional or alternative in nature. Multiple choice, true/false or matching tests represent traditional approaches to assessment, whereas, strategies such as portfolios, journal writing, student self assessment, and performance tools may be considered alternative assessment strategies. Traditional and alternative assessments may be used for diagnostic, formative or summative purposes

- Utilize both traditional and alternative assessment strategies
- Ensure the inclusion of diagnostic, formative and summative strategies
- Increase use of open-ended assessment techniques

CONTEXT: The Standards for Mathematical Practice are:

1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically

The assessment places emphasis not only on the content at each grade level, but the Standards for Mathematical Practice. These learning outcomes are organized around four assessment claims and represent the mathematics content and skills that are relevant to 21st century college- and career-ready students. These are

Concepts & Procedures

The student can explain and apply mathematical concepts and interpret and carry out mathematical procedures with precision and fluency. In developing conceptual understanding and procedural fluency, students need to be aware of how concepts link together and why mathematical procedures work in the way that they do. Concepts should be built on students' prior knowledge, and students should have the opportunity to make connections between concrete and abstract representations. Students should be able to carry out procedures, describe concepts, and communicate results.

Problem Solving

The student can solve a range of complex well-posed problems in pure and applied mathematics, making productive use of knowledge and problem-solving strategies. Problem solving sits at the core of doing mathematics. Students who are proficient problem-solvers start by explaining the meaning of the problem to themselves and then look for an entry point. Students construct their own pathway through flexible thinking and the use of a variety of strategies, rather than having to follow a provided path to solve a problem. They use tools strategically and evaluate the reasonableness of their answers.

Communicating Reasoning

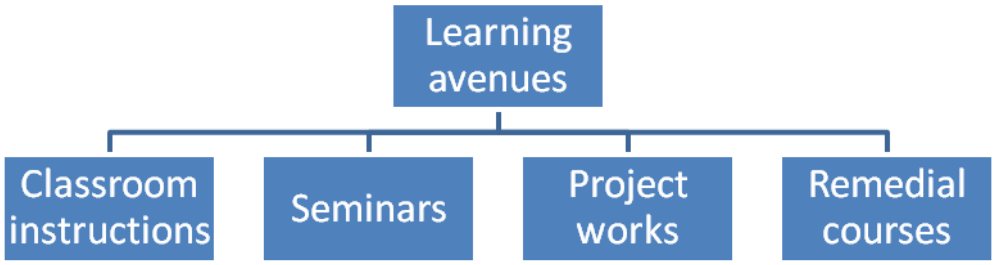
The student can clearly and precisely construct viable arguments to support their own reasoning and to critique the reasoning of others. The content and practice standards often describe opportunities for students to construct and present a clear, logical, convincing argument. Students should have the ability to analyze a provided explanation, identify any flaws in the explanation, and then present, if needed, a logical sequence of proof or a complete, correct argument. Real-world problems do not come neatly packaged. They often are complex and contain too little or too much information. Students often have to model the problem to better understand how to solve it. As students use this abstract model to work through a solution, they must interpret the results and check for reasonableness in the context of the original problem.

Implementation method

Tutorial problems were given to students about a week in advance and a submission date which coincided with the tutorial period was announced. During the tutorial period students were given a memorandum with ticks, a mark scheme (Appendix 1), and peer-assessment was introduced. We carefully went through each problem; an overhead projector was used for analyzing the solutions and explaining the marks allocation. Students were encouraged to write feedback on the scripts of the peers although a memorandum was prepared. They were encouraged to assess the root cause of the error and correct it. Students who were unsure about the mark allocations due to the different but correct solutions to problems shared the method with the rest of the class. An appropriate marks allocation based on the assessment criteria would be agreed on for each different solution. When students challenged some of the memorandum solutions to problems, we would agree on more elegant solutions. Some of the students who struggled to make a decision on the marking noted those questions for my attention, and I collected all the answer sheets for moderation. Students got them during our next lecture. Students were informed that the work served as informal formative assessment.

Those who had not attempted the problems were not allowed to mark peers. Mark schemes and solutions were given only to students who had attempted and submitted their solutions for marking. Since the tutorial attendance was a compulsory requirement, this put social pressure on the students to do the problems. Initially all the solutions to problems were marked, but later a manageable selection of problems was made.

Teaching-Learning Evaluation – Academic Symbiosis



Introducing the Peer-Assessment Method

The major motivating factor for me to introduce this method was the feedback I received from students the previous year, to the effect that they prefer to work independently in the comfort of their homes rather than in a tutorial session. They also expressed that they wanted their tutorials to be marked, and the marking turned out to be very time consuming. I was in search of a method which would ensure timely feedback, promote active learning, and more student participation in terms of problem-solving. The student composition had not changed much from the previous year, with very few students from previously disadvantaged backgrounds. I saw this group of students to be very similar in terms of mathematical background to the previous cohort of students. The small numbers were also amenable to experimentation with new methods of assessment. Evidence of the following claims appears in the section on "Result of evaluations" below.

Advantages of the peer-assessment method

The marking process turned out to be the most educational aspect of this assessment practice. The students found using assessment-criteria and applying a marking scheme to be quite useful. The practice of having students implement the assessment criteria assisted them in the *assessment criteria* internalization. Moreover, this exercise further equipped them to be able to do self-assessment, a necessary skill in life-long learning. As the marking of the tutorials was similar to that of tests, this method made assessment transparent and hence the students were better equipped to tackle the tests/examinations. This assessment method resulted in *more*

practice in mathematics, since social pressure was applied to encourage more students to participate. I was able to monitor students' progress using the results of this assessment. This aided in my timely informal intervention if I was not happy with the progress of the student. The method better prepared them for summative assessment. Baderin (2005) found that what students mainly look for in tutorials, in addition to clear up difficult points of content, is to become better informed of how to meet the assessment requirements.

Another advantage of this method is the act of being the assessor and having to provide feedback. For the assessor, peer-assessment involves relatively high order cognitive skills, like comparing, contrasting and communicating, which can significantly deepen the "student as assessor's" understanding of the topic and the requirements of the assessed task (Topping 1998). Exposure to different problem solving techniques is one of the benefits of this method. The students expressed their appreciation of the sharing of the different solutions due to the implementation of this method. Students were *motivated* and positively influenced by marking good solutions of their peers.

Timely feedback was provided orally and in written form. Firstly, in the form of a memorandum and its discussion in class, secondly in the form of discussing the different solutions that students battle to mark, thirdly through reading the peer's script, fourthly by reading comments made by peers or the lecturer during the moderation process on the individual student's script. The method encouraged students to pay attention and reflect on their written solutions (as the different solutions were discussed), and hence more engagement with their work was experienced *increasing learning*. Students found the written solutions to be extremely useful. *Reliability* and *fairness* were enhanced by having a clear mark scheme and a proper moderation system. The deliberation on the different solutions to problems further enhanced these features of this assessment. *Active learning* was achieved by introducing the method.. The method enhanced maturity both in conduct and mathematically. An *improvement of summative assessment marks* was observed after introducing this method. This approach guided students towards achieving the course learning outcomes and was thus *valid*. Moreover, the method offered an additional diverse useful tutorial activity.

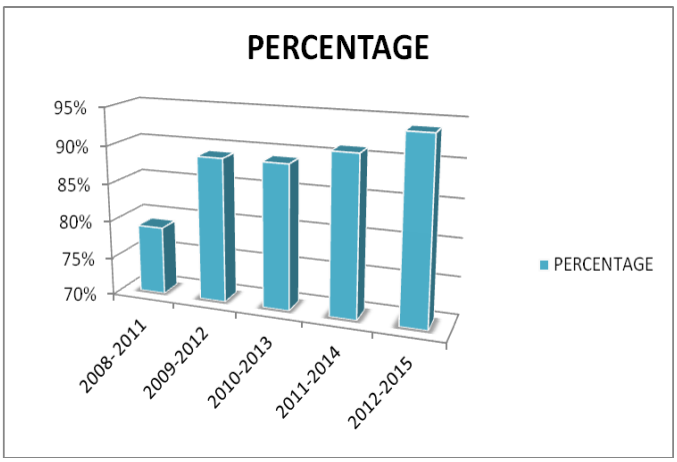
Disadvantages of the peer-assessment method

This method required a lot of planning and competence on the part of the lecturer since designing a marking scheme which would not need any alteration was not easy particularly for this course. Anticipating problem areas is also another aspect which required experience so as to preempt them during the marking process. Mastery of the subject by the lecturer was necessary as some of the solutions students wrote were totally unexpected and time was limited. The number of hours spent on marking tutorials was not significantly reduced by the method. During the moderation process the lecturer ends up marking the work, particularly if the students do not have the mathematical competence to mark it. Pope (2001) points out that this moderation and quality control of the 'marks' can prove very time consuming for the lecturer.

This method was frustrating to some competent students who found themselves marking work which has not been carefully thought through. Some students, particularly the strong ones, found deliberating on the different solutions to problems to be annoying and time consuming.

As the above disadvantages served as advantages as well, it was impossible to rectify them. To put more clarity on this statement, the other side of the coin is that a student who wrote poorly benefited from marking another student's good work, deliberating on some questions offered students the different ways of solving the same problem, competence on the part of the lecturer was an advantage to all.

Evidence of Success: With the assessment techniques, the pass percentage of students have increased from 79% to 94%



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