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Some issues on assessment methods and learning in mathematics and statistics

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This paper looks at the application of some of the assessment methods in practice with the view to enhance students' learning in mathematics and statistics. It explores the effective application of assessment methods and highlights the issues or problems, and ways of avoiding them, related to some of the common methods of assessing mathematical and statistical learning. Some observations made by the author on good assessment practice and useful approaches employed at his institution in designing and applying assessment methods are discussed. Successful strategies in implementing assessment methods at different levels are described.

1. Introduction

Assessment forms an important part of the learning process of any subject area. The primary objective of an assessment component is to measure how well the learning outcomes are achieved by the students. This may be carried out in a variety of ways depending on many factors such as the subject area, nature of topics being assessed, depth and breadth of the course content and the educational level of students. Naturally, in mathematics and statistics the assessment of learning can take place in more ways than in many other subject areas, as there are different dimensions to the learning process, some of which are unique to the field of mathematical sciences. For example, in mathematics, the learning process includes: developing problem solving skills, understanding the concept of theorems and the ability to prove them, and abstract thinking, all of which can be assessed in different ways. Similarly, statistics has rich application in many areas such as business, finance, medicine, science and technology. This makes it possible to devise different types of assessment techniques that may be suited to a particular area of application.

As pointed out in the Smith report [1], not all learners learn in the same manner or respond positively to the same styles of assessment. In this context, this paper explores the effective application of some of the assessment methods in practice and how that will impact upon students learning. Particular emphasis is placed on assessment strategies that inspire and prepare students well and on ways of making students perform better. The underlying theme of the paper is on effective application of assessment techniques that allow students to express their understanding to a greater extent, enhance their knowledge of the subject and its application, and optimise their learning.

2. Assessment methods at different knowledge level

There are common methods of assessment that can be applied at all levels of a degree programme whereas some methods are more suited to assessment of learning at specific levels. For example, assessing students' ability to undertake independent work which involves extensive modelling, analysis, presentation and project report may be more suited to the final stage of a degree programme. Including weekly tutorial work as part of the assessment is more suited to the first year of an undergraduate programme. Traditional take-home assignment, class-room test and exam can be applied, in general, at any level. Therefore, it is important that we apply appropriate assessment methods suitable for the overall knowledge level of the class to successfully assess mathematics learning. The choice of methods should ensure that it brings out the mathematical understanding of students as much as possible.

Assessment methods used for students majoring in mathematics or statistics may not always be the best ones for assessing mathematical learning of students majoring in other subject areas. One approach we found useful in assessing the statistical learning of students majoring in life sciences is to design a task, as part of their assignment, to make them look through the latest issues of a journal in their subject area to find an article that uses some of the statistical techniques they learned in the course. Students would have to read the article and write a brief summary of the statistical analysis presented and discuss the results and conclusions. This approach makes them better understand the application of statistical techniques and realise the importance of statistics in their field. This method is better suited to service teaching as the emphasis may well be on the application of appropriate statistical techniques learnt rather than on their theoretical development.

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Another point is that even within a class of students at a specific level of a degree programme, it is very common to find students with varying ability and skills. Some students find it easier to demonstrate their learning in one particular method of assessment whereas others in the same class may find that method more difficult than other forms of assessment. In this regard, it is advisable to have a combination of assessment methods in a course which allows students to express their understanding to a greater extent. In fact, different types of assessment techniques are appropriate for different purposes and therefore a good mixture of them should be employed [2].

3. Types of assessments

It is common practice to call upon more than one assessment method to assess mathematics learning in a course at tertiary level. Which methods are best suited is dependent mainly on the objectives of the course, course content, and the nature of the topics covered. Most courses at undergraduate level will have an exam and at least one other forms of continuous assessment.

At first year undergraduate level, we found over the years that including weekly tutorial work as part of the assessment is a good practice for many reasons. The main reason was that it motivates the students and keeps them interested in the course throughout the term. It gives them a chance to see how well they are performing, as regular feedback is given, and makes them engaged in the course while gradually building up their knowledge of the subject as well as confidence in dealing with mathematical problems.

The way it worked in our institution is as follows, although slightly different models with the same approach can be adopted. Each week, in addition to the usual tutorial, students are given extra questions to work at home and are required to submit their solutions the following week. Tutorial assistants mark them and give it back to students with feedback regularly. Following this approach means that students do well not only on this assessment component but also on other forms of assessment for this course, as their learning has been enhanced with regular feedback. This method has worked well in the first year of our undergraduate programmes over the years and our student performance and progression are much better than they were when other methods were employed. This strategy helps students deepen their learning rather than driving them towards surface learning. The whole learning process becomes more enjoyable for students.

Most degree programmes expect students to demonstrate skills and abilities to undertake independent work in the form of a project. Students are required to use their independent thinking to take on academic project work and demonstrate analytic and problem solving skills. This type of training and the associated assessment process are designed to take place normally at the final stage of the programme. This may be a new area for most students, especially at undergraduate level, and therefore it may require some preparation and guidance to make a smooth transition from the usual classroom-based study to the world of independent learning. As noted by Croft et al [3] in their key finding, students need more explicit help to become independent learners.

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When preparing students to take up independent work such as a final year project, one idea that may be useful is to have a few seminars or open discussion sessions on specific topics (pre-assigned) for the class. Students are required to read about the topics prior to the seminar and take active part in the open discussion. The atmosphere created provokes mathematical thinking [4] and assists students develop it further. This approach helps students in the class to motivate themselves, develop an interest, and gain an understanding about the nature of independent work and the ability to take this on. For the assessment part, these sessions can be followed by an assignment which requires a critique of a research paper from a journal in one of the topics covered in the seminars. The topics may be different for different students. Following this method enables students to acquire general knowledge of the topics covered in the seminars and to have deeper understanding of the topic used for their critique. This will certainly broaden their knowledge in the subject area and also help them sharpen their writing skills in preparation for the more independent project work in the following term.

Most students found this approach very enjoyable and appreciated the gradual exposure and training in embarking on challenging independent work rather than being thrown at the deep end with a specific project title. This also helped them better demonstrate the evidence of achievement of intended learning outcomes.

One other form of assessment we found interesting was peer-assessment, which is particularly useful for group work where students team up in small groups and carry out a set task together and do a presentation. The presentation is open to peer-assessment by other groups. Each group is allowed to give a mark for the other groups (except for their own!) and the average of the marks awarded to a given group by the students can be taken into account when grading or assigning marks for the presentation. This method is ideal for presentations, as students become more competitive during peer-assessment and hence perform better and respond to questions well.

Peer-assessment is employed in our mathematical modelling skills courses in the first two years where students work on mathematical/statistical modelling problems for a week, write a report on their findings, and do a presentation to the class. This approach creates opportunities for independent thinking, generates interaction and competition among students and is therefore worth practicing wherever possible to enhance mathematics learning.

4. Problems with assessment techniques and ways to avoid them

Aspects of the assessment that receive little attention are the difficulties and problems students face with some of the assessment techniques. Most of the assessment methods will work smoothly, if designed properly, without any major cause for concern. However, in a few cases, even for a well designed assessment component the nature of the assessment type may cause some difficulties for students. Most common problems students faced have been associated with three types of assessment: exam, presentation and report writing.

The main problem with the exam is the time constraint. Students will have a limited amount of time to answer a question fully, so a question should be clear and concise and should not be unnecessarily long. This becomes more of an issue when questions contain computer output which is quite common for exams that cover topics in applied statistics. As the primary objective of the assessment is to measure the mathematical learning of students, tasks or questions should be written clearly without causing any confusion and be easy to understand at students' level and be in a manageable form. Discussions with students revealed that the questions students categorised as tough in exams are mostly of this type.

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Although time is a constraint in presentations, the problem most students face with presentations is of a different kind. Students feel that in a presentation they have two jobs in hand. One is to present their work to convey the results to the audience and the other is to respond to comments, criticism and questions. This may be a difficult and nervous task for some students who are very good at producing quality work but not at presenting it. Presentation will run smoothly if we make students feel at ease as much as possible. It would help them if the atmosphere and build up to the presentation is warm and friendly. It is important to ensure a good start to the presentation which enables them to focus fully on presenting their work and finish on time.

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Some students may feel nervous during question and answer sessions, especially questions from their assessors. The general observation is that students' performance is very much enhanced during this session if they are made to feel at ease and relaxed. It would be a good idea to begin with a question that may be on a specific part of their presentation rather than outside of it. It is desirable to have constructive questions before any criticism is offered. Questions that can be thought provoking and stretching their boundary are best served towards the end.

Report writing for a project is the other problem faced by many students even at the final stage of their programme. There are many bright mathematically minded students who are not good writers and there is a point in arguing for requiring mathematicians and statisticians to write more, see for example [5, 6]. Students should be given proper guidance on presenting their work in an academic project report. Project planning, execution, time management and scientific writing may well be new areas for most students and hence proper support may be necessary.

How to structure their report, do a literature survey, reference the material they used, avoid any plagiarisms issues are some important areas that should be covered in preparing students to take on independent project work.

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As noted by [7], the writing process is an effective way for students to piece together ideas into a coherent story and develop arguments in support of their report. Mathematicians must be able to report on a problem and how it can be modelled or solved mathematically to a general audience. Similarly, it is essential that statisticians are able to explain and interpret the results of their analysis well in writing to non-statisticians. In this regard, it is beneficial to make them write more at each stage of their degree, by means of modelling skills activities, case-study, analysis of open-ended problems, and personal development portfolios etc. If this is implemented from the beginning most students would be confident of producing good quality project reports when they reach their final year.

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