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Title: Assessment is Bloomin' Luverly

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Abstract

This study initially set out to explore the potential for implementing outcome-based assessment practices in a first year statistics unit. It has however evolved into a search for a pedagogy that enables clear definition of the desired learning outcomes in our students and alignment of instruction, student resources and assessment with these outcomes. Expert experience and previous unit materials and assessment were used as starting points for the pilot study. The aim was to develop a model which might feasibly be repeated and potentially applied in other faculties with analogous learning outcomes.

A recent revision of Bloom's Taxonomy was chosen to facilitate classification of an intended hierarchy of desired knowledge, processes and skills. Unit objectives were behaviourally framed to provide identifiable indicators of student outcome achievement. Assessment was similarly classified to align the desired and observable outcomes. Appropriate instructional techniques and authentic assessment were chosen commensurate with student interest and the development of higher order cognitive skills.

Students were given the objectives under assessment and an evaluation rubric. These were provided as focus material that would foster organization of responses. No marking schema was included to prevent students privileging one outcome above another. For continuous assessment, students worked in teams of two, each member completing complementary sections. Team solution fostered cooperative learning without providing opportunities for plagiarism.

Reflective practices and student and staff feedback throughout the study led to refinements in the procedures. Summative evaluation encompassed results of student assessment and surveys and interviews of both staff and students.

A lack of reliability in classification, according to the revised Bloom's taxonomy, of the objectives and assessment has been identified. Hence the current aim is to use expert experience to refine the taxonomy.

Introduction

In any instructional process, one of the fundamental questions that is continually asked by the teacher remains: "But how will I *know* when they understand the concepts." This question has been posed since time immemorial and has formed the crux of the dilemma facing practitioners today. But if this is a problem for the educators themselves, it is mirrored in the minds and hearts of students the world over. How do they know just what are the knowledge and skills required of them and how do they show that they have acquired them?

This study was born of a teacher's earnest attempt to provide focused assessment that did indeed assess what it claimed and provided 'signposts' for the learning of her students. Such focused assessment could afford a guiding framework for teaching and a powerful learning tool for students. There have been recent changes in syllabi in the state high school system founded on outcome-based learning and assessment, but little evidence of this approach in our universities. Many courses are content based, with 'lip service' paid to outcomes only evident in a broad specification within unit outlines.

To design a framework for guiding both teaching and learning has required consideration of:

- The processes of learning;
- The definition of learning through the use of learning taxonomies;
- Learning styles/needs;
- Appropriate forms of assessment.

The framework needed to be developed in the context of the globally defined graduate outcomes and through defined course content.

Action research affords an appropriate methodology for this type of study. Strategies were devised following an analysis of practical experience of an existing first year statistics program and its assessment. Implementation of the strategies, staff and student evaluations, review of students' assessment results and subsequent reflective practices have led to modifications, eliminations and further inclusions as the framework evolved.

Theoretical Background

Learning Theories

In designing assessment which aligns with all aspects of teaching and learning, due attention must be paid to the processes of student learning. The three main theories of learning which have been considered are:

- Behaviourist;
- Cognitive;
- Constructivist.

Anderson and Elloumi (2004) provide a structured outline of the required theoretical background. Behaviourists believe that learning results in changes in behaviour. To maximize learning, their strategies need to include:

- Clear definition of expected outcomes to provide focus;
- Sequencing conducive to learning;
- Opportunities for self testing of achievements of these outcomes;
- Interactive feedback on achievement. (Anderson, Elloumi et al. 2004)

The cognitive approach regards learning from the 'information processing' perspective and includes the aspects of motivation, memory, thinking and reflection. Practitioners of *cognitive theory* regard learning as taking place when knowledge is internally accommodated and personalized. From this viewpoint, teaching should involve:

- Checks to identify presence of appropriate and existing cognitive structures or provision of 'advance organizers' if there are none (Ivie 1998);
- 'Chunking' of material to be learned;
- Visual formatting of materials and careful sequencing of content to catch attention and promote clear perception of the desired learning;
- Provision of connective links between higher and lower levels of learning;
- Use of models;
- Setting of expectations;
- Opportunities to refine learning through application, analysis, synthesis and evaluation to contextualize the learning. (Blanton 1998; Anderson, Elloumi et al. 2004)

Motivation can be either intrinsic (derives from within the learner e.g. self satisfaction/sense of achievement) or extrinsic (usually generated by the instructor or course e.g. marks/grades, praise etc). Intrinsic motivation appears to be more powerful in eliciting deeper and life-long learning. (Avery 1999) Keller proposed a model for motivating students that endeavoured to:

- Catch attention;
- Offer relevance;
- Develop confidence (by defining expectation);
- Promote satisfaction (through interactive feedback). (Song and Keller 1999)

Constructivists view the teacher as the facilitator in the learning process. They believe that learning takes place as the student actively participates, interpreting, processing and constructing new knowledge. Because they see learning as contextual they consider it to be more effective in practical situations. (Anderson, Elloumi et al. 2004)

In designing the pedagogy, consideration should be given to:

- Active learning processes;
- Interactive learning which allows collaboration of instructor and students in the process;
- A cooperative learning environment which may be more expeditious;
- Tasks which provide individual engagement to the learner;
- Opportunities for reflection;
- Learning experiences which made are meaningful through relating to the student's own 'world', either as a student of their selected discipline or their 'real life'. (Anderson, Elloumi et al. 2004)

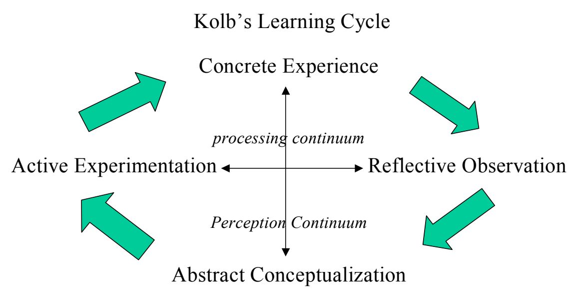
Any approach to learning needs to include strategies that will develop or enhance meta-cognitive skills. Although most intrinsically motivated students display these skills to some degree, any attempt to place students in charge of their own learning, needs to promote such skills.

There are common points to these three theoretical approaches. Assessment can be devised and implemented so as to 'tap' into many of the features of all three.

Learning Styles

If the assessment is to be 'fair' to all students then it should offer appeal to all styles of learner.

Kolb's experiential learning theory describes learning as taking place across two intersecting continua of perception and processing. He observed that learners appeared to demonstrate preferences for pairs of the phases of learning taking place at the ends of these continuums.



The Phases of Kolb's learning cycle. (Nieweg 2000)

Kolb described learners as:

- Divergers who prefer concrete experience and reflection on that experience;
- Assimilators who prefer reflection on and conceptualization of the experience;
- Convergers who conceptualise the experience and then experiment actively with the idea;
- Accomodators who prefer concrete experience and the opportunity to experiment with ideas formed by the experience. (Kolb 1984)

However, the most enriching learning experiences afford the opportunity to all participants to work cyclically through all four phases. Tasks that expose students to all of these phases are more likely to stimulate deeper learning. (Kolb 1984; Nieweg 2000)

Since interactive learning also supports deeper learning, tasks that allow collaboration, but still encourage independence and ingenuity need to be developed. The 'team' approach to assessment tasks also promotes confidence and pays more than 'lip service' to espoused graduate attributes that applaud 'community' values and 'sharing of talents'. (University of Wollongong, 2004) Tasks should also seek to use available technology as the community increasingly demands these skills of graduates and provide 'authentic' (Avery 1999; Evans 1999; Prestidge and Glaser 2000) or meaningful tasks which are modelled on those previously experienced.

Classification of Learning

But over and above all of this, students need to be aware of the knowledge and skills they are expected to demonstrate, i.e. the expected learning should be clearly defined. It is this definition that has proved expeditious in student learning in the high school system. The added advantage is that this expected learning could be carefully aligned with graduate attributes, course and unit outcomes, teaching objectives and pedagogy. (This was to prove possibly the single most distinct improvement in the course presentation.) It reinforces student learning as the prime focus for delivery and it is in the practice that this became increasingly evident to involved teaching staff.

But although we inform students of what they are expected to know, many are at a loss as to how they are to show such learning. Although the tasks may be modelled on previous class work, 'marking criteria' may clarify what is expected and help to define 'organizers' for responses. (Ivie 1998; Heady 2000; Prestidge and Glaser 2000; Romagnano 2001; Montgomery 2002) These 'guidelines' may become less specific as student learning develops. Careful thought needs to be given to inclusion of marks on these 'guidelines' as explicit and narrow alignment of marks with tasks may detract from the task as a learning tool. Experience teaches that such alignment may**:**

- Reinforce extrinsic motivation;
- Encourage the 'pass/fail' mentality;
- Restrict the value of 'organizers' in supporting student confidence;
- Remove focus from the 'guideline' as an 'advance organizer' which may enhance meta-cognitive skills;
- Encourage students to allocate relative importance based on marks allocated, when the intention is to encourage students to regard all aspects of the task as important and worthy of learning.

Fundamental to the design of a working framework that recognizes this theoretical background, is the statement of expected learning, i.e. the statement of the assessment objectives. Evaluation of student learning can be very subjective without some generalized frame of reference. Bloom and his associates pursued early research in this field. Their original intention was to devise a taxonomy of learning which would facilitate discussion by educators. Bloom's taxonomy offered a classification of knowledge and skills in what purported to be a hierarchical structure, highlighting representation of both higher and lower order knowledge and skills. Thus it became a useful tool for evaluation of assessment against teaching objectives. Framing the objectives in behavioural terms enabled observation of achievement. (Bloom 1974)

Such behavioural specification earned the taxonomy a great deal of criticism. Anderson, Krathwohl et al (2001) have highlighted some of the criticisms leveled at Bloom. They refer to claims that it was only useful in the realm of behaviourists, recognizing only learning as an altered pattern of behaviour. However this criticism fails to see the objective as a *means* towards recognizing learning rather than as the *end* in itself. They also discuss the criticism that it 'limited' recognition of achievement. Specificity in defining an objective may simplify assessment of its achievement, but may also cloud recognition of any more complex learning being exhibited. It can prove a challenging exercise to define creative achievement in its terms and its application may be less than reliable for different educators from different fields.(Anderson, Krathwohl et al. 2001)

Anderson, Krathworl et al (2001) undertook a revision of Bloom's taxonomy, separating knowledge from the cognitive processing dimension to form a two-dimensional classification of knowledge and skills. They recognized the inherent lack of hierarchy in the taxonomy, but maintained an evident hierarchy did exist within each classification. (Anderson, Krathwohl et al. 2001)

Bloom's taxonomy is not the only classification tool available to educators. The SOLO taxonomy is closely aligned with the developmental stages of Piagetian theory. The taxonomy classifies learning into levels of increasing complexity. Learning at the lowest stage (pre-structural) does not recognize connections between pieces of information. Whereas at the highest level (extended abstract), connections are made not only in the current context but extend beyond. (Biggs and Collis 1982)

Implementation

In the subject that was the focus of this study, assessment was comprised of:

- Three assignments;
- Midterm test;
- Laboratory tasks;
- Oral Presentation (not treated here);
- Final exam.

All were aligned with the objectives and with each other.

The Assignments

Statements of the specific objectives accompanied each assignment together with a set of marking criteria that provided students with indicators of desired outcomes and hence structures for responses. As students were presumed to have learned from previous assignments, the Marking Guidelines of the second and third assignments were less detailed. Students were required to use a statistical software package for data analysis and to word-process assignments, interweaving output with their own words.

Assignments were completed in teams of two. Each assignment question was comprised of two parts and each member responded to one only. These parts were designed to complement or supplement each other, and team members were encouraged to collaborate and share responses. For example, in Assignment 2 one student would complete questions dealing with a model from a Poisson distribution, generating expected frequencies for a sample based on the given model (working with theory). The partner would generate a random sample and answer questions based upon that sample and, using expected frequencies from their partner's output, would conduct a 'Goodness of Fit' Test for their sample (working with data). In the next question, the roles were reversed for a question dealing with the Binomial distribution. This approach ensured the need for collaboration. It appears to have promoted confidence in the students because it afforded opportunity for discussion and clarification of more complex tasks without having to surrender independence of response.

The questions were aligned with appropriate laboratory tasks in order to reinforce prior learning. Data files had been generated from data collected through a web-based survey. The last assignment involved collection of new data in addition to its analysis.

Tutors were cautioned about responding to questions relating to the assignments. Students were to be directed to appropriate lecture and laboratory material. This was to reduce the chance of diminishing the ‘quality’ of anticipated learning. Guided and repetitious performance demands far less of students than when minimal guidance is given.

Marking listed a set of targeted responses each of which was marked on a 0/1 scale. This facilitated prompt and detailed feedback that simply listed what had been achieved (one mark) and what had not (zero marks). Students have perceived this process as ‘pretty fair’, since generally each student could potentially earn ‘what they deserve’ and be neither limited nor completely supported by the other member of the team. Weaker members received some help, but could not end up with their submission completed by another. There appeared to be little evidence of ‘collaboration’ (branded as ‘plagiarism’ in the assignment preamble) outside the team structure. The teacher’s perception is that such plagiarism appears to have been more prominent in previous approaches to assignments.

The Midterm Test

The test was based on material from the first three quarters of the course and provided an opportunity for students to approach an exam armed with their self-created and (hopefully) completed Lab manual as a guide to expected learning. Familiarity with the material and their previous classroom experience appeared to both relax and encourage optimism in appropriately prepared students.

The Laboratory Classes

The classes were conducted in computer rooms and SPSS was the main program in use. The Lab manuals/workbooks contained the bulk of required learning materials a course introduction, assignment specifications, objectives and tasks for each week, SPSS notes and PowerPoint slides for lectures. Space was provided for pen-and-paper responses and to allow for students to paste in output from SPSS thus producing their own expanded workbook intended as a further valuable learning resource. Weekly tasks involved ‘preparation’ questions, data collection (both qualitative and quantitative), organization, analysis and interpretation of output.

Whilst a tutor provided support and guidance, the tasks were designed to encourage student-centred learning. The team approach was actively encouraged, particularly in the initial classes. This ultimately led to a relaxed and collaborative learning environment. To promote continued learning outside class hours, the tasks were designed to be too long to be completed in class time. However, students worked phrenetically to complete each weekly task in class, resulting in a distorted perception of the workload. In future implementations this needs to be clarified with students to minimize stress. Marks were allocated (10%) for completion of 10 out of 12 labs.

Worked solutions were later uploaded onto the Web. Because many students fell behind, they were encouraged to download solutions to complete the manual as they would be able to take this resource into the final exam. Most students realized eventually that output was of little use to them without experience in interpreting that output. The classes were busy but relaxed, with most students actively engaged at all times. Few students left the classes early, and although attendance was not compulsory, it remained stable, with most students appearing to recognize the relevance to the course structure.

The Final Exam

The final exam was aligned with laboratory tasks and assessment. Students were permitted to take their completed laboratory manual into the exam as a reference. However, because of the analytical approach taken in all facets of continuous assessment, questions represented a more interpretive and analytical approach than previously used in examinations in this subject. It was anticipated that students would find it more difficult than in previous years because of the increase in the higher order cognitive component.

Students did appear more ‘comfortable’ with the course and what was expected of them. This appeared to lower stress levels ahead of the examination.

Evaluation

The students’ attitudes were surveyed on through the Web. At the same time they were given the opportunity to volunteer to be personally contacted for interview. The survey sought responses on:

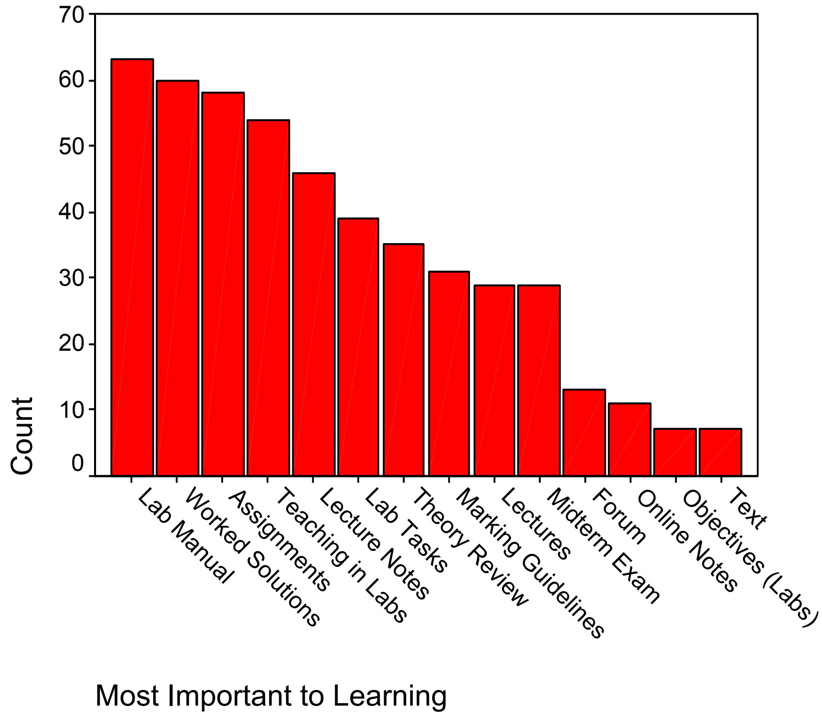
- Details of attendance at lectures and laboratory classes;
- Which aspects of the course they perceived to be important to their learning;
- Their attitudes to ‘teams’;
- Their perception of the relevance of completing the laboratory tasks in their exam preparation;
- Their overall perception of their learning from this course;
- Their assessment marks.

They were also given the opportunity to detail:

- The parts of the course they were comfortable with;
- The parts of the course they found difficult;
- Their perception of the ‘fairness’ of the assessment.

The last three questions allowed for open-ended responses. Further provision was made for additional comments.

One hundred and one students responded (from a total of 200 students enrolled). The following chart summarises students’ responses to which aspects of the learning environment were regarded as most important to their learning.



Although this describes first selection of the students, it does not give an indication of the spread of the responses. This is better seen in the following table listing the responses ordered by ranking the mean of responses.

Descriptives

	N	Minimum	Maximum	Mean	Std Deviation
Theory Review	99	1	5	3.91*	1.09
Lab Manual	99	1	4	3.57	0.67
Assignments	99	1	4	3.54	0.66
Worked Solutions	99	1	4	3.53	0.76
Teaching in Labs	98	1	4	3.42	0.72
Lecture Notes	99	1	4	3.35	0.70
Lab Tasks	99	1	4	3.25	0.73
Lectures	99	1	4	3.01	0.80
Midterm Exam	99	1	4	3.00	0.83
Marking Guidelines	99	1	4	2.81	1.07
Online Notes	99	1	4	2.29	1.08
Forum	99	1	4	2.27	1.06
Objectives in Manual	99	1	4	2.22	0.95
Textbook	99	1	4	1.84	0.98

* Distorted by higher maximum value

The obvious differences in the rankings relate to Theory Review (in lab classes), Marking Guidelines and Online Lecture Notes. Most students felt that they had improved their achievement in assignments by using the Marking Guidelines and hence they were considered as moderately to extremely important by 75.8% of respondents. Since Lecture notes were included in the Lab Manual, students rarely had the need to consult them the Online Lecture Notes (not consulted by 36.4% of respondents).

Although many students claimed not to have used the Objectives (29%), interviews of both staff and students indicate that they were aware of their presence and purpose (despite claiming not to have referred to them). Perhaps their effect is operating subliminally as an ‘organizer’ for the learning/teaching processes. Since the Marking Guidelines and the objectives also form part of the Lab Manual and the Assignments, the measure of their effect may be masked, and revealed only in further interview.

Most students also appeared to have appreciated the ‘Team” approach. Nearly 60% of students found it productive and useful. Expanded comments also lend support to the notion that it may have helped to reduce ‘cheating’, and increase confidence in the students. However, 13% of students perceived that the load had fallen upon one student.

In an attempt to evaluate any shift in assessment of knowledge and cognitive processing skills in comparison to the previous year, the exam questions were classified using the revised taxonomy of Bloom. This revised taxonomy is a two-dimensional classification of knowledge and skills as illustrated below.

Two-Dimensional Cross-Classification of Types of Knowledge by Cognitive Processing Skill

Knowledge Dimension	**Cognitive Processes Dimension**					
	Remember	**Understand**	**Apply**	**Analyse**	**Evaluate**	**Create**
Factual						
Conceptual						
Procedural						
Meta-cognitive						

(Anderson, Krathwohl et al. 2001)

Descriptions included in the work of Anderson, Krathwohl et al, were included to help classify the behaviours being asked for in assessment questions (Anderson, Krathwohl et al., 2001). In the comparison highlighted a shift in weighting from questions related to *Procedural Application* to those requiring *Analysis* and *Evaluation*.

The process of classification however, proved both frustrating and time consuming. Simple requests such as ‘explain’ contain so many subtle nuances dependent upon the context. A student may be asked to ‘explain using the output given’. This requires discriminating between relevant and irrelevant information and using it to *justify*. Alternatively, the students may be asked to ‘explain’ a concept with the aid of a diagram (*interpret*), or to ‘explain’ a process i.e. list the steps involved (*recall* a procedure). These all demand different levels of skills. It would appear that without discipline specific vocabulary, such a general taxonomy may prove difficult to use! The obvious question then arises: “Is it possible to track assessment of knowledge and cognitive processing skills more effectively?”

Most teachers have developed notions of levels of learning. Is it possible to formalize them to enable the tracking? Fair assessment would require definition of observable behaviours related to these notions. Reflective observation of students learning may lead some educators to classify by:

- *What* (Bloom’s *Knowledge* component?): Symbols/terms, formulae, procedures, concepts, theories or models;
- *How* (Bloom’s *Procedural* component?): Simple/complex;
- *Why* (Bloom’s *Understand, Analyze, Evaluate, Create*);
- *When* (Transfer of knowledge and skills);

- *Personal Awareness* (Bloom's *metacognitive* component).

To effectively test the usefulness of this approach, indicative behaviours need to be described for each of these categories. This will form an integral part of further implementations in this continuing study.

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