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Assessment is bloomin' luverly: developing assessment that enhances learning

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Abstract

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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 long been posed 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 the teachers' earnest attempts to provide focused assessment that did indeed assess what it claimed to assess, and also 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 large-scale changes in syllabi in the state high school system of N.S.W. and in the United States founded on outcome-based learning and assessment, but relatively little evidence of this approach exists 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;
- learning styles/needs;
- the definition of learning;
- appropriate forms of assessment.

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

As the problem that arises in the classroom, the classroom should provide an appropriate venue for its resolution. Action research affords an appropriate methodology for this type of study. (Gomm, 2004) The participant researchers' collective experiences, observations, reflections and analyses of practice in previous implementations of the research cycle were used to identify the successful strategies and student needs. These form the starting point for this study of a first year statistics program and its assessment. Following the development of an appropriate model and its subsequent implementation:

- staff and student evaluations;
- review of students' assessment performance;
- reflective practices

have led to modifications, eliminations and further inclusions as the framework evolves.

Theoretical background

Learning theories

The processes of student learning require due attention in designing assessment that aligns with all aspects of teaching and learning. The three main theories of learning are:

- behaviourist;
- cognitive;
- constructivist.

The construction of the learning framework has been supported by what the researcher's have perceived as compatible with the three main learning theories. However, the primary researcher's social constructivist perspective may still possibly be discerned. Decisions were made after surveying the types of strategies used by devotees of each of the three theories and still others not reported in this paper. Anderson and Elloumi et al (2004) provide a structured outline of the required theoretical background.

Behaviourism perceives learning as resulting in changes in behaviour. Some behaviourist considerations which could be implemented could 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.

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

- checks to identify presence of appropriate and existing cognitive structures, otherwise provision of 'advance organizers' where 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)

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.

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;
- tasks which provide individual engagement of the learner;
- opportunities for reflection;
- meaningful learning experiences which relate to the student's own 'world', either as a student of their selected discipline or their 'real life'.

Motivation is fundamental to successful learning. It 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) Song and Keller (1999) proposed a model for motivating students that endeavoured to:

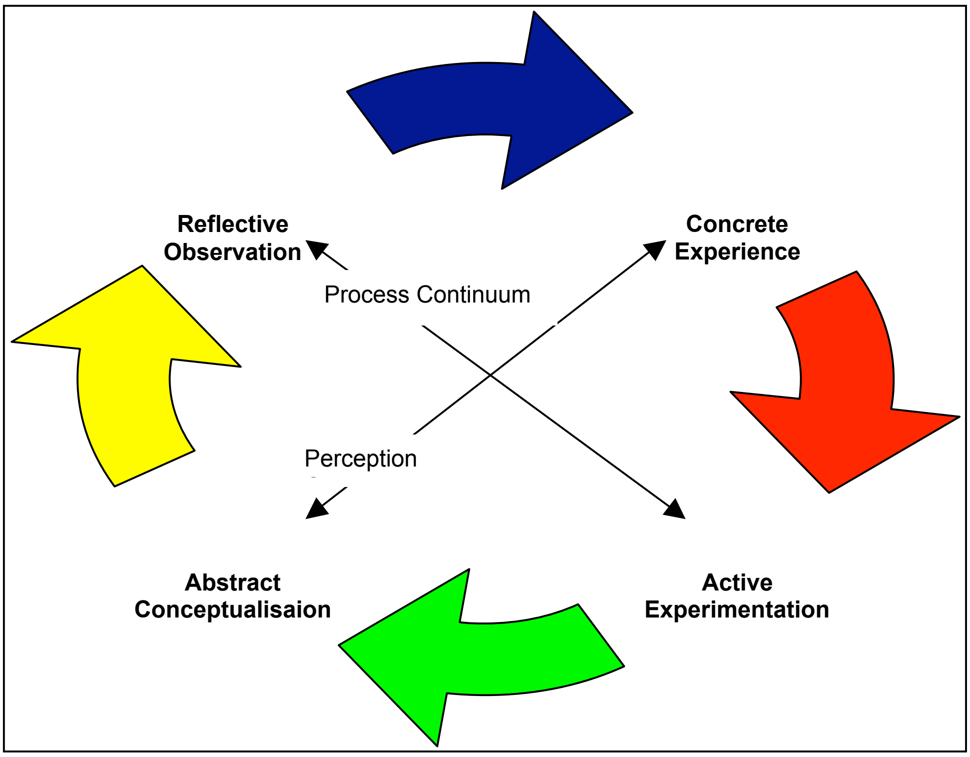
- catch attention;
- offer relevance;
- develop confidence (by defining expectation);
- promote satisfaction (through interactive feedback).

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 them.

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. These pairs of preferences lie at either end of either of the two continua.

Figure 1. Phases of Kolt'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' (Cobb, 1993; Avery, 1999; Evans, 1999; Prestidge and Glaser, 2000) or meaningful tasks which are modelled on those previously experienced.

Defining the learning

Even defining such a supportive framework for learning, both teachers and students need to be aware of the knowledge and skills the students are expected to demonstrate, i.e. the expected learning should be clearly defined. It is such definition that has proved expeditious in student learning in the high school system. The aim here has been to explicitly align the expected learning with graduate attributes, course and unit outcomes, teaching objectives and pedagogy in clear statements of the objectives available to teacher and student alike. This alignment process focuses the subject delivery directly at student learning and it has become increasingly evident to the participant researchers that this process is fundamental to successful teaching/learning.

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*. The assessment tasks may be modelled on previous class work, but 'marking guides' may clarify what is expected and offer 'organizers' for responses. (Ivie 1998; Heady 2000; Prestidge and Glaser 2000; Romagnano 2001; Montgomery 2002) The 'guides' may be explicit in initial tasks, but become less so as student learning progresses. 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. (Black, 1998) The 'guides' were given to students without the marks in order to offer structure for responses. This was because the premise held by the researchers that their inclusion would:

- reinforce the extrinsic motivational value of aggregating marks at the expense of the intrinsic value of accumulating knowledge;
- encourage the 'pass/fail' mentality;
- detract the value of 'organizers' as a 'scaffold' for giving 'complete' responses. In turn this may diminish student confidence in their capacity to provide complete answers.

- remove focus from the 'guideline' as an 'advance organizer'. Such tools afford structures which work to enhance a student's capacity to organize their own learning (*meta-cognitive* skills). For example, comparing two data sets may require observation and analysis of a number of different features of each set. The detail may be clearly defined in the 'guide' for the first assessment task, explicitly defined or even omitted in subsequent tasks.
- encourage students to allocate importance of the knowledge based on the relative weighting of the marks allocated. The intention, however, should be to encourage students to regard all aspects of the task as important and worthy of doing well.

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 their 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 the behaviourists, recognizing learning as only in 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 the taxonomy's 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 that an evident hierarchy did exist within each classification. (Anderson, Krathwohl et al. 2001)

Table 1: 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)

Although the revision of Bloom's taxonomy was chosen for this study, it is not the only classification tool available to educators. Another, 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)

Table 2: The phases of learning as described in the SOLO taxonomy

Demonstrated learning	Pre structural	Unistructural	Multistructural	Relational level	Extended abstract level
Students acquire disconnected information	✓				
Students make simple obvious connections		✓			
Students make many connections			✓		
Students demonstrate the relationship between connections				✓	
Students demonstrate overview of the connections				✓	
Students extend connections beyond the current context					✓
Students generalize and transfer from specific to abstract					✓

(Biggs and Collis 1982)

The learning framework

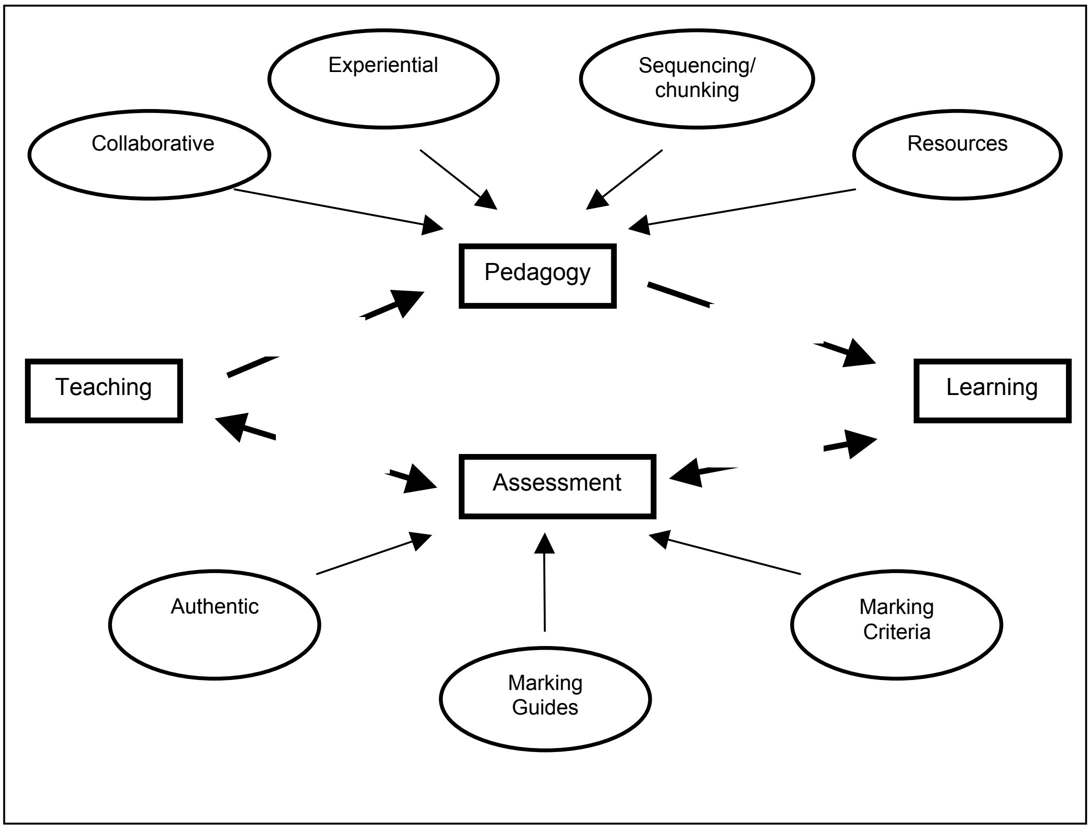
In the light of the surveyed theory, the learning framework has been chosen to include:

- content which has been appropriately 'chunked' and sequenced;
- experiential and interactive learning opportunities;
- collaborative tasks and assessments;
- relevant and engaging tasks and assessments;
- marking guides as 'advance organizers';
- marking criteria and 'worked' solutions to provide detailed and timely feedback.

All facets of the subject's presentation and evaluation were aligned through the objectives. It is this process of alignment which appears to have underpinned any success which has been observed in implementing the selected framework.

The targeted level of student learning was evaluated by 'coding' question of assessment tasks using the revised Boom's taxonomy, although this proved a less than reliable task.

Figure 2: Teaching learning framework showing selected learning strategy inputs



Implementation

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

- three assignments;
- midterm test (not treated in detail in this paper);
- Laboratory tasks which were completed and recorded in a Lab manual
- Oral Presentation (not treated in detail in this paper);
- Final exam.

All were aligned with the objectives and with each other. The focus for this paper is the assignments. However alignment of all key components means that evaluation of the assignments involves due consideration to all facets of the subject which impact upon the teaching and learning.

The assignments

Statements of the specific objectives accompanied each assignment together with a set of marking guides (no marks indicated) 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, but present their own solution to their own part of the problem. They could not 'collaborate' with anyone other than their partner. 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 their simulated data). In the next question, the roles were reversed for a question dealing with the Binomial distribution. This approach ensured the need for collaboration. Student Evaluation responses indicate that the 'teamwork' appears to have promoted confidence in the students. 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. In an attempt to engage students in analysis of 'real' data, the tasks required access to data files generated from data collected through a web-based survey of the students themselves. The last assignment involved the student's personal collection of data in addition to its analysis.

Attempting to exercise some measure of control over student assessment, tutors were cautioned about responding to questions relating to the assignments. They were instructed to direct students to appropriate lecture and laboratory material and not to model 'answers' with similar or related problems. 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.

The marking criteria (not provided in advance to students) 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 the whole assessment 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 team members received some help in terms of collaborative discussion, but could not end up with their submission completed by another. There appeared to be little evidence of illegitimate 'collaboration' (branded as 'plagiarism' in the assignment preamble) outside the team structure. The teachers' perception is that such plagiarism appears to have been more prominent in previous approaches to assignments.

The laboratory classes

These classes provided collaborative and experiential learning exercises seen as imperative to learning and were conducted in computer rooms. The Lab manuals/workbooks contained the bulk of required learning materials, a course introduction, assignment specifications, objectives and tasks for each week, technical notes and PowerPoint slides of lecture material. Space was provided for pen-and-paper responses and to allow for students to paste in computer generated output. Thus students ultimately produced 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.

Tasks draw on different theoretical ideas such as loosening and tightening constructs to engender creative thinking and then to consolidate ideas (Kelly, 1955). Still other tasks involve experiential learning (Kolb 1984; Nieweg 2000), while some emphasise collaborative learning (White, 1995), activity based exercises using real data and authentic assessment (Cobb, 1993; Avery, 1999; Evans, 1999; Prestidge and Glaser, 2000), and some promoted the development of metacognitive skills through reflection on activities and frames and concept mapping (Turban, 1990; Novak and Gowin, 1984). The sequencing of tasks typically follow a listening, speaking, reading, and writing pattern.

To promote continued learning outside class hours, the tasks were designed to be too long to be completed in class time. However, students worked frenetically 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 to maximum 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 some experience in its interpreting. 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 subject learning framework.

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 final exam

The final exam was aligned with laboratory tasks and assignments**.** Students were permitted to take their completed laboratory manual into the exam as a reference. 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.

However students did appear more 'comfortable' with the subject and what was expected of them. Student Evaluations indicated lower stress levels ahead of the examination than had been evident in previous semesters.

Evaluation

Process

Student learning was evaluated through the summative measures of marks (assignments, lab marks, midterm, presentation and final exam marks). Students were also surveyed as to their attitudes to the components of the subject's delivery and the ranked level of importance to their learning. They chose from a set of specified scaled responses. Similarly they were also asked to select statements that reflected their level of learning in this subject.

Qualitative data was also collected. Students nominated topics with which they felt 'comfortable' and those they found 'difficult' (open text) and described their attitudes to the 'fairness' of the assessment (open text). There was provision for further comment if they wished and some students volunteered to be interviewed personally. Triangulation of the data from all of these sources, together with attendance rates was to be used to support the belief that the framework had indeed enhanced student learning. (Bloor, 1997) Teaching staff were similarly surveyed.

Results: student attitudes

One hundred responded (from a total of 200 students enrolled). The following chart summarises students' responses to which aspects of the learning environment were regarded as *extremely important or moderately important* to their learning. The table lists the responses ordered by proportion of respondents.

Table 3: Student responses (n=100) to perception of importance to learning (ranked by proportion)

Component	'Extremely important'	'Moderately important'	Total regarded as important
Lab manual	64%	29%	93%
Lab task solutions on Web	61%	30%	91%
Assignments	59%	35%	94%
Lab classes	54%	34%	88%
Lecture Notes	46%*	41%	87%
Lab Tasks	39%	49%	88%
Theory review in lab classes	35%	37%	72%
Marking guides (assignments)	31%	35%	66%
Midterm exam	29%	46%	75%
Lectures	29%	45%	74%
Forum	13%	39%	52%
Objectives in Manual	7%	37%	44%
Textbook	7%	19%	26%

* Students could not differentiate between these items and hence results are difficult to interpret.

Students have indicated the importance of the *Lab manual* as a focus for completion of all assessment. It is also the only resource that they may take into the final exam, so they have worked diligently to complete it. The results indicate the value students have placed on active and collaborative learning experiences. They have perceived the *assignments* as strongly influencing their learning, but show their need for the detailed feedback to be found in worked solutions. They still appreciate the small group 'teaching' (T*heory review*) of the tutor in lab classes, but also view the *lecture notes* as guides to essential content. *Marking guides* do not rate as highly as had been expected, but this may have been because it was an innovation and students appear to rarely read the entire preamble in assignments. Most students, however, felt that they had improved their achievement in assignments by using the *Marking guides* and hence they were considered as moderately to extremely important by 66% 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 guides* and the objectives have also been defined in the *Lab Manual* and in each of 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 (presumably themselves) in the two person team.

Table 4: Reported attendance rates (13 week semester)

Subject	10-13 weeks	7-9 weeks
Lectures (Tuesday- 2 hours am)	58%	24%
Lectures (Thursday- 1 hours)	43%	20%

Attendance rates were reasonable as attendance is not compulsory. The subject has been designed as student-centred and has sufficient support resources in place to enable students to complete it independently.

Results: student learning

Table 5: Mean assignment and final exam scores (n=186)

Task (relative weighting)	Minimum (%)	Maximum (%)	Mean (%)	Std. Deviation (%)
Assignment 1 (10%)	25	100	63	16.9
Assignment 2 (10%)	16	100	69	20.1
Assignment 3 (10%)	1	100	68	20.3
Midterm (5%)	0	100	54	20.0
Exam Mark (50%)	7	100	54	18.4

There is evidence of an increase in level of achievement between the first and second assignments, but this was not repeated between the second and third. There was some commonality between the first two tasks, but the third was vastly different and conceptually more difficult. It is heartening that there is little evidence of a decline in achievement! The midterm was held after the second assignment, and hence students benefited from learning in the prior tasks. The midterm was similarly structured to the final exam, and hence differed in format from the assignments. By the second and third assignments, some students were feeling the pressure of the workload, and hence either submitted trivial attempts or failed to submit at all.

Table 6: Individual correlations (all significant at the 0.01 level of significance)

Task	Assignment 1	Assignment 2	Assignment 3	Midterm	Final Exam
Assignment 1	1	0.39	0.30	0.40	0.39
Assignment 2		1	0.57	0.29	0.39
Assignment 3			1	0.26	0.43
Midterm				1	0.73
Final Exam					1

Correlations between the assignments and the final exam are all weak, but positive and statistically significant (_=0.01). The significant cross correlations impact upon the any regression analysis involving all of these variables. The midterm is closer in style to the final exam, and benefits from the prior learning afforded particularly by assignment 1.

The final exam mark (%) was regressed against the marks for the above listed assessment tasks (%).The following table gives abbreviated output.

Table 7: The coefficients[1]

Model	Coefficient	Std Error	t	Sig
(Constant)	1.63	4.06	0.4	0.70
Assignment 1	0.04	0.06	0.8	0.45
Assignment 2	0.06	0.05	1.2	0.25
Assignment 3	0.19	0.05	3.7	0.00
Midterm	0.59	0.05	12.3	0.00

[1] Predictors: (Constant), Midterm (%), Assignment3 (%), Assignment 1 (%), Assignment 2 (%) Dependent Variable: Exam (%)

While 53% of the variation in exam marks is explained by the midterm, only 60% was explained by all of the variables. The coefficients are all positive, indicating that their impact is to increase achievement in the final exam, but only the coefficients of assignment 3 and the midterm are statistically significant.

Although the regression analysis does not provide strong evidence of the value of the assignments in enhancing learning, it does afford supporting evidence which supplements the data from the other sources.

Comparison of final grades between 2003 and 2004 in this subject does not indicate any obvious improvement for this implementation (a little disappointing for the researchers). However two subtle changes can be detected:

1. There has been a slight reduction in the failure rate (but also a slight reduction in the percentage allocation of High Distinctions). Thus there has been a narrowing in the variance of student achievement levels.
2. Coding of the exam questions using the revised Bloom's taxonomy for this implementation and the previous one, indicate a shift in the level of learning to a higher order. Some basic knowledge and procedural application questions have been replaced by more analytic and interpretive ones. This would seem to indicate a 'more difficult' exam, but with no accompanying decrease in level of performance. (There has been no scaling of results for this subject). Maybe we have some evidence of success!

Descriptions included in the work of Anderson, Krathwohl et al, again used to help classify the behaviours sought in assessment questions in the past two final exams. (Anderson, Krathwohl et al., 2001) This process has highlighted a shift in weighting from questions related to *Procedural Application* to those requiring *Analysis* and *Evaluation* – a shift to higher learning.

Results: administration

The Marking Criteria have expedited marking this semester. All assignments were marked by one person and returned to students within one week. The process of right/ wrong marking has facilitated this. This approach needs to be carried through to the next implementation.

Results: identifying the next step

The task now is to transport the benefits of this experience into the next implementation. The aims of the researchers are now to:

- Characterise the parts of the Lab manual which best illustrate how to set and sequence tasks to maximize learning, that is to identify 'what works' and 'what doesn't work'. The manual has been extremely successful. Implicit strategies need to be made more explicit in order to generalize and to assist others in implementation.
- Refine the evaluation tools by eliciting attitudes to learning for the topics specified to the text responses in this implementation. There may even be an opportunity to explore student perception of learning in even greater detail.

Conclusion

Alignment has been fundamental to the processes that have been developed. It has been achieved through the use of the revised taxonomy of Bloom. However the classification of learning still remains 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 is bound to prove difficult to use and use reliably!

So the obvious question again repeats itself: "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. One potential solution might be provided through reflective observation of students learning. Some educators might be motivated to classify student learning using the following hierarchy:

- *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 taxonomy, indicative behaviours need to be described for each of its categories. This too will form an integral part of further implementations in this continuing research into effective processes for teaching and learning in higher education.

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