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Signposting learning: Using defined learning outcomes to facilitate alignment of teaching, learning and assessment

Maureen M. Morris
University of Wollongong, Australia
maureenm@uow.edu.au

Dr Anne Porter
University of Wollongong, Australia
alp@uow.edu.au

Professor David Griffiths
University of Wollongong, Australia
David_griffiths@uow.edu.au

OVERVIEW

This case study forms part of an on going action research project that uses defined learning outcomes to develop deeper learning in a first year statistics subject at the University of Wollongong in Australia. A revision of Bloom's taxonomy allowed classification of the desired learning two dimensionally in terms of knowledge and cognitive processing skills. This learning definition facilitated framing of subject objectives behaviourally so that both students and teachers were made aware of the *hallmarks* associated with objective achievement. Assignment marking guides/criteria formed the basis of fair assessment and detailed and timely feedback on achievement. The learning framework aligned through the objects included active collaboration on authentic tasks using technology. Evidence of student learning was accumulated in a portfolio that was permitted as a Support resource in the final exam.

Evaluation has involved triangulation of evidence from multiple sources: student surveys, student assessment results, teacher discussion, and reflective practice.
Information about the class, module or programme

This action research project has tracked teaching and learning across 5 sessions in a fundamental statistics subject at the University of Wollongong in Australia. The students were predominantly from undergraduate Computing Science degrees, but also included some from science and education faculties. Most students were in their first year of their undergraduate degree. Because of the 'feeder' degrees, there is a greater proportion of males and the numbers have been traditionally greater in session 1 (300-350 students) than in session 2 (150-200 students). Students who failed in session 1 frequently repeated the subject in session 2.

The subject has extended over a single session (13 weeks) and has been frequently offered in both autumn (session 1) and spring (session 2). It was a compulsory subject for the Computing Science students. Content explored variability in *real* data through the use of technology (SPSS). The focus was on understanding concepts and evidenced-based decision making, and topics covered exploratory data analysis, probability models, regression and hypothesis testing.

DESCRIPTION OF THE CASE

Subject presentation:

- **Teachers**: A single teacher delivers the lectures but there is a change in lecturer between sessions. Several tutors conduct the laboratory classes. Some are experienced teachers, but academically successful novices are also employed in this capacity. They support learning during the classes, but are only permitted to direct students to relevant lab tasks when questioned about assignments.
- **Alignment**: To maintain focus in teaching and learning, all facets of the subject presentation are aligned through specified objectives. This process is transparent to students and hence provides motivation and builds confidence in students by providing a clearly *signposted path* to achievement. They are made aware of *what they need to know* and *how they need to demonstrate this knowledge.*
- **Lectures**: Lectures (3 hours/week) are not compulsory, but define the content for the subject. All Lectures are given in PowerPoint and files are available on the web from the outset of the session.
- **Laboratory class** (2 hours/week):
    - Students were encouraged to work collaboratively on lab tasks.
    - The role of the teacher is facilitator. Tasks are explicitly specified and student-centred.
    - *Experiential Learning* tasks involved active participation in authentic tasks. Data collection through measurement and student surveys focusing on current meaningful social issues provided the data for the tasks. Technology enabled cyclic exploration, testing and evaluation clearly and quickly by freeing students from the tedium of repetitive and mechanical calculations.
    - Technology: Expertise in the use of technology is a highly prized by professional disciplines, communities and universities. In addition in this subject the use of SPSS enabled students to participate in the more complex cognitive tasks involved in evaluation and decision making by providing clear and concise output from their selection of functions/tests.
    - Lab manual: The manual contained all tasks with space for student responses and commentary, statistical tables, SPSS notes and copies of the lecture notes. The tasks specified learning objectives and each week questions included space for reflective commentary, pen-and-paper exercises and student designed learning frameworks for the important concepts. The manual was intended to provide a *portfolio* of student learning. It was the only resources students were permitted to take with them into the final exam. Each the tasks were aligned with the lecture material through the objectives and assignments were structured around questions modelled in the manual tasks. Solutions to each week's tasks were placed on the web so as to provide feedback before associated assignment tasks were due for submission. Students were expected to check solutions in their own time.

ASSESSMENT:

Timeline showing assessment weeks and the assessable content (range of weeks)*

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 121	Week 13	Week 14	Week 15
					Ass 1 1-3		Ass 2 4-6			Quiz 1-10		Ass 3 7-10		Exam 1-13

* Note that these submission times varied only slightly across all sessions.

Formative Assessment:

Assignments:

- Objectives were specified behaviourally for all assignments;
- Marking guides, aligned with the objectives provided *organisers* for student responses. In one session this was trialled as a (self) checklist for responses. After marking, the checked criteria specified at the basic achievement level (achieved/not achieved) were returned with the responses. The checked criteria provided:
    - Feedback to students on achievement of the subject objectives;
    - Feedback to teachers on misconceptions and need for remediation;
    - Evidence of *fair* assessment.
- Team work: Assignments were completed in teams of two. Each student submitted their own individual work, but questions were designed to be:
    - Complementary i.e. each student needed the results of their partner's solutions in order to complete their response. For example one student would complete analysis of a sample of data from the binomial distribution. The other would answer questions based on the theoretical model. Both students conducted a *goodness of fit* test using their partner's calculations. Roles would be reversed for the Poisson distribution.
    - Parallel i.e. same questions but different variables/data.

  These approaches afforded opportunity for collaboration without collusion. Students earned their own marks, but gained confidence by discussion concepts..
- Authentic: Tasks were meaningful both from a *real life* perspective and student interest/relevance. The thinking required modelled that of discipline experts.
- Technology: SPSS was required to produce all relevant supportive output. Students were expected to discriminate between relevant and irrelevant information from the large amount of output produced.

- Mid term quiz: Short answer questions based on theoretical concepts and pen-and-paper calculations. 5% of the assessment mark.

- Presentations: Short presentations were based on assignment work and students were marked largely on their ability to communicate statistical ideas to their peers. All used PowerPoint. 5% of the assessment mark.

- Participation: Student attendance and completion of Lab tasks provided 10% of their continuous assessment.

Summative assessment:

- Final exam: Questions were modelled on those experienced in the assignments and the quiz. Some involved interpretation of SPSS output in forming conclusions while others required justification from theory. It formed 50% of the final assessment mark.

RATIONALE IN TERMS OF EDUCATIONAL IDEAS

The aim in this project has been to foster the development of deeper learning in statistics. Deeper learning transcends classroom application of knowledge and skills as students transport them to their personal, academic and professional lives. (Lugenbehl, 2003) Assessment was used as the starting point for developing behaviourally framed objectives of the desired knowledge and skills. These objectives were then used to align all facets of teaching and learning. Using the revised learning taxonomy of Bloom (Anderson et al, 2000), teaching, learning tasks, assessment and expected responses were cognitively matched to the subject objectives i.e. intent was aligned with practice. Not only were teaching and assessment aligned, but learning expectations were more clearly defined for students, enabling them to set goals and match achievement against them.

This type of learning is best achieved through active engagement in tasks which draw upon real data to answer questions which are both socially and personally relevant (Lugenbehl, 2003) Students need to be:

- positively disposed toward the subject's presentation;

- perceive that their learning goals are clearly defined;

- view assessment as a fair evaluation of their achievement of the objectives and not just repetition of rotely memorised facts. (Morris and Puttee, 2006, Barrie, Ginns, and Prosser, 2005, Johnstone, Accessed: 2004).

To this end a learning framework was devised that encompassed:

- Collaborative learning: This approach fosters perseverance when tasks are difficult, intrinsic motivation, and transferability of acquired knowledge. However goals should be clearly defined and ownership promoted; (Morris, Porter and Griffiths, 2006, Kuh, 2003, Pfaff and Huddlestone, 2003, Mohammed, Klimoski and Rentsch, 2000, Livingstone and Lynch, 2000)

- Experiential learning to encourage reflective problem solving and hence deeper learning (Kolb, 1984);

- Authentic tasks engaged students in meaningful tasks and provided context for their learning;

- Tasks and their solutions to generated models of statistical thinking; (Klenowski, Askew and Carnell, 2006)

- Lab manuals became portfolios of student learning as students included worked solutions, student devised learning frameworks and reflective exercises provided further motivation as they were permitted to take these resources into the final exam (Klenowski, et al, 2006). Students were expected to check their solutions against those released to the web, and were made aware that their manual would not be a supportive resource unless errors and misconceptions were rectified. Ownership and independence were promoted to both intrinsically motivate and encourage confidence;

- Marking guides for assessment which gave students a skeleton of the required responses and the more detailed marking criteria indicating achievement at the most basic level, served as organisers for student knowledge. (Ausubel, 1978, Ausubel, 1960) Framed against the assessment task objectives and afforded clear specification of the desired learning behaviours in the context of discipline process and knowledge. For this reason they provided valuable feedback to both teachers and students on achievement.

The entire pedagogy encouraged independent learning and the development of meta-cognitive skills in organising their knowledge and thinking. Statistical thinking requires background knowledge of concepts and processes but also a disciplined approach to exploring and testing solutions. These skills are essential to most professional disciplines and indeed to life in general. Hence generalised structures for such thinking are widely applicable.

EVALUATION

EVIDENCE: Tracking the progress of research project across 5 sessions has involved triangulation of data from multiple sources:

- web survey of students' perceptions of :
    - the importance of the subject's presentation to their learning;
    - their individual learning;
- student assessment:
    - assessment results and grades;
    - use of Bloom's taxonomy (Anderson, 2001) to tally the cognitive demand for the different levels knowledge and skills identified in the examination questions and solutions;
    - proportional representation of the awards of grades;
- attendance and submission rates;
- survey of teaching staff;
- peer review through workshops and conferences;
- reflective practice.

Results:

Student perception of subject presentation:

The following observations appear relevant:

1. Assignments were perceived by most students as important to their learning but the ranking diminished slightly in 2005, session 2.

2. Solutions and lab classes, manual and tasks were consistently recognised as valuable to learning.
3. There was a consistently lower order ranking of the importance of teaching staff compared to the self directed learning facets.
4. Students do not appear to value objective specification highly.
5. Students value the pen and paper midterm as a learning experience.
6. Marking guides were not valued as highly as might be expected.

Table 1: Percentage of Students Ranking as Moderate to Extreme Importance to Learning (Percentage within Implementation)

Area of Presentation	Implementation					Mean % (rank)
	Autumn 2003	Autumn 2004	Spring 2004	Autumn 2005	Spring 2005	
Solutions	*	90.1	93.6	96.7	100	95.1 (1)
Assignments	93.7	93.1	95.2	88.7	95.2	93.2 (2)
Lab manual	*	92.1	88.8	91.9	95.2	92.0 (3)
Lab tasks	79.3	87.1	88.9	88.7	97.3	88.3 (4)
Lecture notes	*	86.1	87.3	79.0	85.7	84.5 (5)
Lab classes	80.5	87.2	76.1	82.3	85.7	82.4 (6)
Marking guides	*	65.4 (g)	69.9 (g)	66.1(c)	76.1(g)	69.4 (8)
Midterm	82.5	74.2	80.9	71.0	57.1	73.1 (7)
Online lecture notes	46.0	43.5	84.1	79.0	90.5	68.6 (9)
Lectures	76.2	73.3	55.5	79.0	57.2	68.2 (10)
Teamwork	*	*	65.1	67.7	71.5	68.1 (11)
Tutor	*	71.3	20.6	77.4	80.9	62.6 (12)
Learning strategies	*	*	34.9	64.5	67.2	55.5 (13)
Objectives	*	43.5	47.6	50.0	47.6	47.2 (14)
Forum	*	51.5	36.5	45.2	14.3	36.9 (15)
Text	*	25.7	36.5	29.0	23.8	28.8 (16)

* Not surveyed

(g) Guide given before the tasks as a marking guide.

(c) Guide given after the tasks as a student checklist with provision for student check.

(Morris, Porter and Griffiths, 2006)

Student perception of learning:

Student overall perceptions of their learning were disappointing as they were at odds with the overall achievement in assessment. A greater awareness of achievement level had been expected. However perceptions of topic learning indicated greater confidence. Students are more perceptive of their achievement in terms of content (possibly indicative of *surface learning*) than they are of their development of *statistical thinking* (*deeper learning*).

Table 2: Student Perceptions of Overall Statistical Learning (Percentage within implementation)

Responses	Implementation				
	Autumn 2003	Autumn 2004	Spring 2004	Autumn 2005	Spring 2005
Too difficult	*	17.8	3.2	9.7	4.8
Tried unsuccessful	*	27.7	14.3	32.3	23.8
Tried limited success	*	37.6	19.0	16.1	23.8
Tried moderate success	*	11.9	54.0	30.6	42.9
Learned a great deal	*	3.0	9.5	9.7	4.8

* Not surveyed

(Morris, Porter and Griffiths, 2006)

Student assessment

The only apparent distinction in the distributions of assessment marks is for both sessions in 2005. However, there were significant changes in exam results from the observation phase in 2003. A comparison of exam results across all sessions using ANOVA and ad hoc statistical tests support (at the 0.05 level) the distinctly lower level of confidence in 2003 and the higher level in Session 2, 2004. Patterns in the final marks reflect those evidenced in the marks.

In the sessions selected for analysis, student perceptions of topic learning align with observed exam results in those topics. Rankings of proportions of students regarding their topic learning as moderately to extremely successful correlates highly ($r \approx= 0.8$) with the topic rankings proportions of marks achieved.

Table 3: Boxplots of assessment marks across all implementations

Assessment marks	Final exam marks	Final Mark

Notes: Records containing a zero final exam mark have been eliminated for analysis

Boxes indicate middle 50% of data

Hard horizontal line indicates median mark

All outliers are indicated by record number

2003 had a slightly different structure for assessment

There was a fall in pass rates in 2005 and this was accompanied by a decline in grades higher than credit.

Table 4: Percentage Pass Rates for all sessions 2003-2005

Autumn 2003	Autumn 2004	Spring 2004	Autumn 2005	Spring 2005
89.3	90.6	85	79.6	76.9

Cognitive demand of the exams:

Deconstruction of the exam questions and solutions using Bloom's (Anderson et al, 2000) revised taxonomy do reveal an interesting pattern. Analysis at this time has been restricted to comparison across implementations of the question related to regression. Using the percentage of marks allocated to the questions and solutions, there appear to be developmental changes which include a broader representation of knowledge types and increasing representation of higher order cognitive processing skills.

Attendance and submission rates

As attendance was only surveyed in the last session only two sources of attendance rates are available: anecdotal evidence of teachers and the assessment mark reflecting completion of lab tasks. However as all solutions were ultimately released on the web and students were able to download them to complete the manual before the final exam, this may not be a reliable indicator of attendance. Teachers reported approximately 60% attendance at lectures however for most sessions tutors reported over 80% attendance in laboratory classes.

Other critical influential factors

1. Timely release of solutions to lab tasks: This was essential as tasks modelled assignment questions and students needed to correct errors and misconceptions. Release was 1-2 weeks after the weeks for which the tasks were scheduled.

2. There was a different lecturer for the first and second sessions.

3. First session failures frequently re-enrolled in second session.

4. Second session assignments were very similar to first session but required different data. Some students had access to the session one solutions.

5. Lab solutions from previous sessions became more prevalent in the last two solutions and the majority of students downloaded more solutions than they constructed by completing the tasks.

CONCLUSIONS/OBSERVATIONS/REFLECTIONS

Teaching perspective

Performance patterns do vary across sessions. One possible factor influencing this is the teachers themselves. The teacher for session 1 has designed the course and its resources and has written most of the lecture material. The teacher is a committed educator and her style of teaching is both dynamic and engaging. The session 2 teacher is more conservative in delivery, but nevertheless committed to improving the teaching and learning of their students. Because of this project, he has endeavoured to remain faithful to the spirit of its objectives.

Despite the best of intent of all concerned, there have been hand-over issues, particularly in the poor specification of timed release of solutions which may have impacted on some results in some sessions. There needs to be rigorous documentation of the timeline to prevent such difficulties arising.

As time passed, students tried to shortcut the effort needed to complete lab tasks. Many became less committed in lab classes and used previous sessions' solutions to avoid the work. Since the subject learning revolves around participative learning tasks, the less committed students were not adequately prepared for assignments and in turn the final exam. There is an apparent shelf life for our strategies. In recent sessions the lab completion mark has been replaced by a series of lab quizzes based on fundamental processes and concepts in the lab tasks. Students appear to have discovered early in the session that downloading solutions is inadequate preparation for these quizzes. Marks in assessment appear again to be improving.

The careful alignment of teaching intent and teaching practice appears to have facilitated a number of improvements in teaching and learning:

1. An increase in cognitive demand in assessment. Initially this was not accompanied by a change in achievement levels. The falls in marks evident in 2005, however, seem more likely to have resulted by student shortcuts to learning than the increase in level of difficulty of their exams.
2. The marking guides/criteria have promoted both student belief in the fairness of assessment and enabled fair and just assessment and reporting of achievement against the subject objectives.

3. The marking criteria also expedited marking by minimising discretionary decision making as they were specified at the level of achieved/not achieved. They also provided useful templates for designing assessment tasks for future implementations.

4. Feedback was both timely and detailed.

Student perceptions

Student attendance at lectures indicates a weak appreciation of their worth, however most seem to regard the lab classes as very important.

Student comments indicated that they regarded the subject as 'well structured' and that the learning required was clearly signposted. They perceived assessment as fair and that 'each person earns their own marks' in team assessment. Most believed that if they 'complete lab tasks that they will be prepared for the final exams'. However their comments indicated that they believed it to be a high demand subject and that they needed to spend up to six hours outside of class completing the required lab tasks. Assignments also appeared to make large demands on their spare time. This was not surprising (indeed it was expected by teaching staff) but was more indicative of the increasing extra-curricula demands upon students.

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