



Macquarie University Research Online

This is the publisher's version of an article from the following conference:

Shepherd, J. (2002) Weaving a web of consistency : applying constructive alignment. *Celebrating teaching at Macquarie*, Macquarie University, NSW, 28-29 November, 2002. North Ryde, NSW.: Macquarie University.

PDF archived from CFL website before decommissioning as per agreement with Learning and Teaching Centre (LTC).

Weaving a Web of Consistency: Applying Constructive Alignment

John Shepherd

Actuarial Studies Department, Macquarie University, Sydney, Australia

ABSTRACT

“To a teacher of an applied mathematics subject this makes heart-warming reading. If only all students could share the insights of this student! Perhaps that would be expecting too much. Nevertheless, it is both reassuring and inspiring to know that many students can and do experience the excitement, confidence and satisfaction that come with that kind of understanding”.

This paper outlines the development of the course unit ACST201 over the period 1999-2001. The development was an attempt to implement several basic teaching principles within that unit. The reflection quoted above is regarded as one small indicator of the success of the development.

CONSTRUCTIVE ALIGNMENT

The development aimed to achieve what Biggs (1999) called constructive alignment. Constructive alignment amalgamates two fundamental principles of education; firstly, the basic premise that learning results from what the learner does (ie students construct their own learning), and, secondly, that effective teaching is teaching that encourages and supports the kinds of student activities that are appropriate to achieving the program's or the course's set learning objectives.

Constructive alignment requires consistency between the major components of the curriculum (the learning objectives set, the teaching and learning activities planned and delivered, and the assessment tasks set) such that students are supported in the learning activities required to achieve, and to know they have achieved, the learning objectives.

In his explanations of constructive alignment, Biggs often (eg Biggs (1999), p25) quotes Shuell (1986, p429): “If students are to learn desired outcomes in a reasonably effective manner, then the teacher's fundamental task is to get students to engage in learning activities that are likely to result in their achieving those outcomes.”

This deceptively simple statement provided the framework for the development. Decide what the *desired outcomes* are and the learning objectives are set. Design assessment tasks which relate to the learning objectives, giving students an opportunity to show that they are *achieving those outcomes*, and define what is meant by a *reasonably effective manner*. Then the teaching required is

to get students to engage in learning activities appropriate to the objectives. Shuell's statement emphasises that the curriculum components constitute a system, whose elements are interrelated and mutually supportive, and must form an integrated whole. The teacher's role is to weave a web of consistency.

WEAVING A WEB OF CONSISTENCY

In his Foreword to John Biggs' book *Teaching for Quality Learning at University* (1999), Paul Ramsden said of the author (page ix): "*He achieves unity between his objectives, his teaching methods and his assessment; and thus, to adapt his own phrase, he entraps the reader in a web of consistency that optimizes his or her learning.*" The aim of the development of ACST201 was to build a web of consistency, so that as many students as possible would take a deep approach to their learning as often as possible, and focus on the meaning of what they were discovering, whether they would normally tend to do that or whether they were doing it for the first time. The web of consistency would have to cater for students with varying goals, different motivations, a range of preferred learning styles, differing academic orientations, various levels of confidence and differing degrees of maths anxiety, as well as variations on a host of other dimensions, as outlined in the next section.

CONTEXT

The course unit (ACST201: Financial Techniques, Instruments and Markets) is a second year subject, offered each year in second semester. It is a core unit in the B App Fin program, and in the Finance stream of the B Bus program. It is often chosen as an elective unit by students from accounting, economics and other programs. Prerequisites for ACST201 are 18 credit points including ACST101 with a minimum grade of P (pass). Enrolments are high; 210 in 1999, 310 in 2000, 320 in 2001, and over 400 in 2002. The students comprise a very heterogeneous group, with diversity in ethnic background, cultural background, prior academic achievement, level of English language skills, age, study major, preferred learning style, job-hours worked per week, and prior work experience.

The main objectives of the course unit are for students to:

- (a) further develop the mathematics of finance techniques they first learned in ACST101; and
- (b) use the mathematics to understand some of the basic concepts and principles of finance, such as discounting cash flows, prices and yields, the effects of tax, fees and charges, interest rate risk and reinvestment risk, duration, arbitrage opportunities and the arbitrage pricing principle, pricing forwards and options, and contingent payments.

Unit learning objectives

To set the desired emphasis on understanding, it was felt important to express the unit's learning aims and objectives in terms of levels of understanding. A hierarchy of levels of understanding could be directly related to the criteria set for the various assessment grades.

Grading criteria

The SOLO Taxonomy (Biggs & Collis, 1982) was used as a model to construct grading criteria that represented a hierarchy of levels of understanding. The aim was to give the message that the kind of learning that would be rewarded in this course unit was understanding of increasing levels of depth. The SOLO Taxonomy, in its generic form, appears to lend itself more readily to the humanities than

to mathematical or applied mathematical subjects. However, SOLO was used as a guide in the sense that it portrays a hierarchy of levels of understanding. In the context of ACST201, this structure was implemented as a series of levels of understanding, increasing with successively higher grade levels. “Understanding” was expressed in terms of problem solving and of communication.

The thesis used was that the ability to solve problems which differed from those seen before may be closely related to the extent to which the basic principles behind the financial mathematics techniques are understood. In other words, students who rely on memorized formulae to solve standard types of problem may not “understand” the basic principles, at least to the extent that they can cope with problems that differ slightly from the norm. The ability to solve problems that differ from the norm is regarded as an indicator of the extent to which a student “understands” the basic principles behind the financial mathematics techniques. Further, students who can solve problems which differ significantly, rather than slightly, from the norm, can be regarded as having a higher level of understanding than students who can solve problems that differ slightly but not problems that differ significantly.

Consequently, the following table of criteria for each letter grade was adopted in the year 2000:

Grade	Level of understanding
F	No evidence of achieving C level understanding
C	<i>Able to perform basic numeric procedures on standard problems in familiar scenarios; able to explain the rationale for numeric procedures, and to interpret the results of those procedures</i>
B	<i>Able to apply basic principles to solve problems which differ slightly from the familiar; able to explain the rationale for those solutions, and to interpret the results, in clear, simple, non-technical language; able to combine two basic procedures to solve composite problems</i>
A	<i>Able to apply basic principles to solve unfamiliar, non-standard problems; able to explain the rationale for those solutions, to interpret the results, and to generalise the implications, in clear, simple non-technical language; able to combine two or more basic procedures to solve composite problems</i>

OVERALL STRUCTURE OF TLA’S

Past feedback from ACST201 students showed that some described themselves as “lazy” or “undisciplined”, in the sense that they often did little, or insufficient, work during semester in some subjects, and relied upon “cramming” at the end of semester, just before the final exam. Thus, another aim for ACST201 was to create a supportive infrastructure that would encourage as many students as possible to work consistently over the semester, and minimise reliance on final cramming. Teachers often advise, instruct or warn students to work continuously throughout the semester, often with little effect. A web of consistency requires that the unit be organised in such a way that it is difficult not to work continuously. So, several supporting strands were woven:

- (almost) weekly Tutorial Tests, based on what was learned in the previous week’s workshop;
- regular (approximately every four weeks) In-Class Tests, based on several topics;
- active involvement of students in workshops, so that they were more likely to attend regularly;
- availability of revision and practice problem sets in the electronic workbook;
- regular (approximately every two to three weeks) assignments.

Lectures as workshops

Each week's classes comprised one 2-hour "lecture" and one 1-hour tutorial. Tutorial classes ranged in size from 25 to 35 students, depending largely on the size of the classrooms available. In order to involve as many students as possible in active learning, the "lecture" classes were conducted more like workshops. Short mini-lectures of perhaps 10 to 15 minutes' duration were used to introduce new ideas, or to pose problems or problematic scenarios. Realistic financial problems were presented, and students were asked to think how they would use their financial mathematics to solve them. After a few minutes, students were asked to discuss and compare their approaches in groups of two or three.

Solving the problem was then modelled "live" by the lecturer, with emphasis on working from first principles to produce an equation from which the required solution could be found. Whenever feasible, all steps in working towards a solution were written "live" on overhead projectors, so the whole process was transparent. The emphasis during "live" problem solving was on explaining the rationale for, and the meaning of, every equation written down in financial terms, or in plain English, but not in mathematical terms.

Handouts provided at workshop classes included copies of all problems tackled, so that students did not have to waste time copying down the problem details. They were encouraged instead to start thinking about how they would solve the problem. Students were able to access detailed copies of the full solutions from the Economic & Financial Studies Reference & Information Centre (ERIC) after the workshop.

Workshop class climate

To facilitate active learning during workshops classes, it was felt important to encourage collaboration. Getting students to discuss possible solutions, and explanations for calculation results, in groups of two or three seemed a better route to maximum activity than relying on solo effort. So a high priority was to establish and maintain a personal, friendly atmosphere, in which as many students as possible would feel relaxed and comfortable enough to join in discussion with their peers. At the beginning of the first class, the lecturer introduced himself and shared a little of his family and professional background and his leisure interests. Also, in the first class, "ice breaker" activities were used to encourage each student to meet and learn a little about at least three other students. In subsequent classes, the lecturer made a point of beginning each class with a smile and a welcome, and with some brief informal chat about sport or his research or current affairs or something else unrelated to the day's topic.

Electronic workbook

Students were advised to purchase an electronic workbook from an Internet publishing company named Perdisco. The workbook, authored by the ACST201 lecturer, provides several sets of problems relevant to the topics dealt with in ACST201. Some of the problem sets review concepts and techniques which students should have learned in the prerequisite unit ACST101. Other sets provide week-by-week problem solving practice for the main topics in the unit. Finally, the workbook provides the five assignments that form part of the assessment regime in ACST201. In return for the purchase price (\$30), students receive a username and password which gives them access to the workbook on the Perdisco website. They are then able to use their workbook all day every day, from wherever they can get Internet access. Each student receives a different collection of problems for each set, because numeric and other variables in each problem are randomized. Also, each time a student attempts a particular problem set, it is presented with different numeric values. The review and practice sets can be attempted as many times as the student wishes. Having accessed a problem set, the student can enter her answers then and there, or can print the questions

and enter the answers later (but within 48 hours of the first access). On entering her answers, the student receives immediate feedback, in the form of a percentage score, together with full, step-by-step solutions to each problem, individualized for the actual randomized values in the questions. The feedback can be printed if desired. The five assignments provided with the workbook are accessible for preset ten-day periods, timed to mesh with the schedule of workshop topics. Each student has two attempts at each assignment, and the higher of the two scores is recorded. A different set of randomized values is used for each attempt. It was decided to allow two attempts at each assignment in order to give the clear message that, in this unit, the primary objective is for students to learn the material covered as thoroughly as possible, and to emphasise that a mistake is not an opportunity for a teacher to penalise a student, but an opportunity for the student to learn from the mistake.

COMMUNICATIONS: COURSE UNIT WEB SITE

A WebCT site was established for the course unit. Its primary function was to provide a communications platform for student/teacher and student/student interactions. Students were given access to both private and public (ie bulletin board style) e-mail. Thus they could contact the unit lecturer, either privately or publicly, and other students, either privately direct or publicly via the bulletin board. The WebCT site was also used as a noticeboard, where the lecturer could post reminders of, changes to, and clarifications of administrative matters, and as a source of copies of workshop Powerpoint slides and handouts, Tutorial Tests and solutions, In-Class Tests and solutions, past exams and solutions, Learning Portfolio specifications, etc.

ASSESSMENT

Assessment in the unit was based on a package of components: best six results in nine 15-minute Tutorial Tests; results in all three 50-minute In-Class Tests; results in all five Assignments; a Learning Portfolio; a 3-hour written Final Exam.

Such an extensive and varied package was chosen for several reasons:

- to provide a range of types of assessment task, in order to cater for varying learning styles among students, giving as many students as possible an opportunity to demonstrate their learning in terms of their own particular strengths;
- to provide a framework encouraging continuous effort throughout the semester (instead of a disjointed series of increased efforts just prior to major assessment events);
- to optimize the mastery at the time of concepts and techniques encountered early in the semester, so that they are well understood when required to help understand new applications later in the semester.

Students were given a choice of two assessment weightings. One gave more emphasis (about 60%) to the Final Exam, and less (40%) to the other components, while the other put less weight (about 50%) on the Final Exam, and more (50%) on the “during semester” components. The rationale for giving this choice was that students would tend to value more highly, and therefore pay more attention to, a learning “contract” which was not all one way, but in which they had some influence over the way things happened. Although the difference in weights was not great, many students said they valued this choice, because it gave them the opportunity to allow for their own perceived strengths and weaknesses in performing on different types of assessment task.

Tutorial Tests

In most weeks (nine of thirteen), the tutorial began with a 15-minute Tutorial Test, comprising 5 or 6 short problem-style questions based on the previous week's workshop class. Tutors distributed the Tests, which students attempted without access to notes or other material. At the end of the 15 minutes, tutors supervised redistribution (in a different way each week) of the Test papers amongst students, and each student then "marked" another student's paper while the tutor worked through the solutions. Finally, the tutor collected the papers, to record the marks and return them the following week. Students thus had immediate feedback on their Test performance. They could also access copies of the Test problems, and sample solutions, on the unit web site, immediately after all tutorials for the week were completed. The Tutorial Tests also provided incentive for students to "keep up to date" by regularly revising what they learned at the weekly workshops.

In-Class Tests

In each of weeks 4, 8 and 11 of semester, a 50-minute written Test was held, during the first half of the regular 2-hour workshop class. The Test comprised four or five problems, testing what had been learned in the approximately 4-week period since the previous Test (or since the start of semester). Students had to attempt these Tests under difficult circumstances. The venue was a lecture theatre where there were few spare seats. Instead of a desktop students had only the small fold-down rest to work on. This meant they had little space to juggle the question paper, an answer booklet, their one-page summary sheet and a calculator. They must have also felt quite "hemmed in", in an almost-full lecture theatre where the inevitable tension generated by a test must have made many feel quite stifled. In order to minimise the temptation to copy other students' answers in such close quarters, two versions of each Test were written, with each printed on different coloured paper. Each version comprised an equivalent set of problems, but the numeric values in each were different, in order to produce different solutions.

Learning Portfolio

Students were asked to submit, a couple of weeks before the end of semester, a Learning Portfolio comprising three tasks. Two of the tasks involved building a spreadsheet model, and the third task was a reflective writing exercise.

Reflective writing task

After about nine weeks of the semester, students were asked to reflect on their learning experiences in the unit. They were asked to write one to two pages on: how they had approached their learning in this unit; how their approach compared with their learning in other units; what links they saw between what they learned in this unit and what they learned in other units; what they thought of the workshop classes and the tutorials; what they thought of each of the assessment components; anything else they wished to say about their learning in the unit.

Spreadsheet modelling tasks

Students were asked to construct two spreadsheet models, where each model performed financial calculations or analysis related to topics dealt with during the unit. One model was to price a bond of any given characteristics, and another was to determine the duration of a fixed interest financial instrument.

Use of a summary sheet in tests and final exam

Students were told they could bring with them to each of the three In-Class Tests, and the final exam, a single A4 sheet of paper, with anything they liked written or printed on one or both sides of the sheet. This was quickly dubbed a "cheat sheet" by many students! The purpose of this measure was to reinforce the notion that what was important in this subject was to achieve understanding of the basic principles and how to apply them. Memorizing formulae, or other material, was neither

necessary nor desirable. Students could bring with them to all exam situations whatever reference material they thought they may need (so long as it could be 'stored' on one A4 sheet of paper).

Student feedback on experience of using the “cheat sheet” has often featured these comments:

the sheet is often not used during the tests, partly because time is considered to be short, partly because the types of questions asked are such that reference to the material on the sheet is not helpful, and partly because the process of producing the sheet helps to ensure that the material is learned anyway; the sheet's greatest value is its role as a “security blanket”; ie many students report being less anxious and more confident in the knowledge that temporary “mental blocks” are not going to be a major problem because they can refer to the sheet as a prompt; the process of producing the sheet is a valuable form of revision which itself constitutes learning, which makes the process worthwhile even if the sheet is not used during the test or exam.

Observation of students' summary sheets during tests and exams suggests that there are a number of approaches taken to producing the sheet. Some focus on definitions, concept explanations, formulae, lists, the steps involved in standard procedures and personalised reminders of things easily overlooked or things which have previously caused problems. Others take particular problems from workshops, practice sets, assignments and previous or past years' tests and write out both the problem and its step-by-step solution. Each year, a small number of students reported that they did not take advantage of this opportunity for the first test because they did not think it was genuine. They thought that the lecturer was joking when this was announced!

Outcomes

Students provided vast amounts of feedback, through both the reflective writing exercise and the last question in the final exam, which was a “letter to a friend” exercise (Biggs, 1999, p) asking them to explain to a friend what they had learned during the semester in ACST201. The students' responses to both these exercises produced clear examples of surface, deep and achieving approaches. Many students reflected at length, or in depth, on their learning, frequently offering valuable (from the teacher's perspective) insights into their perceptions of university study, learning, teaching, assessment, classes and so on. Surface approaches usually produced short, superficial answers to the trigger questions, just (or not quite) satisfying the minimum length of one page. Some students (blessedly few!) interpreted the task as requiring the showering of false or exaggerated praise on the course unit and the teacher. Such cases were somehow obvious – the “manufactured” praise had a hollow ring.

CONCLUSIONS

The author experienced for many years of university teaching the frustration of trying, largely unsuccessfully, to inspire, encourage, beg, cajole or pressure students into taking a deep approach to their learning of applied mathematical subjects, and out of resorting to formula memorisation and “plugging in numbers”. The problem was that what the author was saying, loudly and often from the front of a crowded lecture theatre, was drowned out by what students perceived to be the demands of assessment (eg test and exam questions which could be answered by plugging numbers into standard formulae), the message of textbooks (practise the same types of problem over and over), the roaring of grading based on the accumulation of marks (never mind quality learning, just focus on quantity of marks and you'll get there by accumulating enough little bits of credit), reinforced by the all-pervasive, ever-present institutional context (saying forget about learning, it's

all about prerequisites, grades, credit points, coherent studies, grade point averages, corequisites, avoiding plagiarism, misread timetables and special consideration).

Applying the principle of constructive alignment, by building a web of consistency, with a central and consistent message that “learning for understanding is possible, more satisfying, more resilient, more relevant and more interesting” works.

The feedback from students is the main indicator of the success of the approach. While not all students took a deep approach to their learning, and many still relied on a surface approach of memorizing formulae, plugging in numbers and memorizing standard responses to requests for explanations, many students did strive to understand, and found it a refreshing, stimulating, enjoyable and, often, novel experience.

REFERENCES

- Biggs, J B (1999), *Teaching for Quality Learning at University*, Buckingham: Open University Press.
- Biggs, J B & Collis, K F (1982), *Evaluating the Quality of Learning: the SOLO Taxonomy*, New York: Academic Press.
- Ramsden, P (1992), *Learning to Teach in Higher Education*, London: Routledge.
- Shuell, T J (1986), “Cognitive conceptions of learning”, *Review of Educational Research*, 56, 411-436