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Towards a framework for aligning learning outcomes, academic literacies and assessment criteria

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Abstract Although Australian students spend three or more years studying they can seem quite unaware of any of the expected learning outcomes of their course. They are often single unit focused, paying most attention to individual assessment items thus not developing a holistic view of their course. This paper presents a theoretical framework to support staff and students to recognise, scaffold and achieve learning outcomes and academic skills at unit level and to recognise how these contribute to course and graduate learning outcomes, within the boundaries of Australian university and professional accreditation requirements. A case study is described that demonstrates the manual implementation of the framework. The complex nature of the implementation suggests that a software solution is required to ease the process and ensure the resulting mapping will have some longevity by being maintainable.

Keywords Graduate learning outcomes · Assessment · Academic literacies · Scaffolding learning · Mapping framework · Australian university students

1 Introduction

As academics we view a qualification (e.g. a degree) as a holistic entity, which will provide students with the discipline knowledge and skills they require to gain employment within their chosen discipline once they graduate. Shepard (2000) suggests that such expertise "develops in a field of study as a principled and coherent way of thinking and representing problems, not just as an accumulation of information." (pp. 6–7). The degree and graduate (or generic) learning outcomes are articulated as

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overarching statements providing the general flavour of the qualification, usually within a discipline or disciplines, rather than specifying explicit outcomes. Specificity is provided at a lower level within the components that make up the qualification.

Students are expected to achieve learning outcomes during their studies including unit,[1] course[2] and graduate outcomes which all contribute to their qualification. Employers are seeking graduates who are able to contribute efficiently and effectively to their workplace from the day they start work. Professional bodies also specify outcomes of courses that they accredit, such as the Australian Computer Society (ACS) core body of knowledge (ACS 2012). The Australian Qualifications Framework (AQF 2013) further defines outcomes that students are expected to achieve at a level appropriate to the qualification they are completing.

Although Australian students spend three or more years studying they can seem quite unaware of any of the expected learning outcomes of their course. They are often single unit focused, paying most attention to individual assessment items thus not developing a holistic view of their course. Students do not view the whole course, or the units and associated learning outcomes in the context of potential employment or professional accreditation requirements. They focus only on those parts of their studies which are of immediate interest; they lose interest in those components which they perceive as having no relevance or as boring. So students address these parts with scant attention. This negatively impacts on their overall engagement with their courses, leading to poor learning outcomes in terms of the required knowledge and skills, resulting in decreased retention and progression.

The Assessment Reform Group (1999) asked the question "Can assessment raise standards?" and answered it. "Recent research has shown that the answer to this question is an unequivocal 'yes'. Assessment is one of the most powerful educational tools for promoting effective learning. But it must be used in the right way." As a follow up we ask the question "What is the right way?"

We argue that the answer is in the interrelationship of three major elements: aligning learning outcomes, academic literacies and assessment criteria. This approach is partially supported through the work of Biggs and Tang (2007) who argue that in order for assessment to have a significant impact on learning outcomes these must be constructively aligned. However, it is becoming more apparent to the authors that students do not have appropriate levels of academic literacy skills, on entry to higher education, to adequately comprehend the explicit and any implicit requirements of assessment tasks. Therefore it is necessary to constructively align not only the learning outcomes and assessment, but academic literacies as well. Lea (2004) suggests that course design should be underpinned by the outcomes of academic literacy research.

This paper reports on the initial outcomes of a project which aims to develop a theoretical framework to support staff and students to recognise, scaffold, and achieve learning outcomes and academic skills at unit level and to recognise how these contribute to course and graduate learning outcomes, within the boundaries of university and professional accreditation requirements. The developed framework will improve the cohesion of the components (i.e. the units of study) that make up a course and

[1] A basic component of any course offered by Deakin University is called a unit.

[2] A well-defined set of units offered by Deakin University is called a course, and when satisfactorily completed normally qualifies a student for an award of the University.

expose students to the relationship between these components and the course, ultimately leading to improved engagement, retention and progression.

2 Related work and our contribution

Constructive alignment (Biggs and Tang 2007) has been promoted as a means of ensuring that teaching and learning is aligned. But ensuring course and graduate learning outcomes are met has been problematic since the alignment has been limited to unit level outcomes as assessment occurs within units not courses. Further, alignment can only occur on explicitly stated learning outcomes, so unless the graduate (or generic) and course learning outcomes are embodied in the unit learning outcomes there is no guarantee that they will be assessed or, if they are, assessed at an appropriate standard.

There is a considerable body of work focusing on evidencing achievement of graduate attributes particularly in the Australian context, which builds on the constructive alignment espoused by Biggs and Tang (2007). Drawing on the outcomes of this research are three major projects, supported by the Office for Learning and Teaching (OLT) and its predecessor, the Australian Learning and Teaching Council (ALTC), which demonstrate the emphasis on ensuring the quality of award courses through performance indicators of teaching and learning. This Assurance of Learning (AoL) is evidenced through a number of indicators, amongst which is ensuring that graduate, course and unit learning outcomes are achieved at a minimum standard by all graduates.

The first project, The National Graduate Attributes Project (GAP) (Barrie et al. 2009) explored "why Australian universities have on the whole, been unable to achieve the sort of significant systematic changes to student learning experiences, required to achieve their stated aims of fostering graduate attributes" (pg. 1) with a focus on developing a community of practice "to engage in curriculum renewal and foster graduates attributes" (pg. 4). The project identified a number of elements which contributed to the success of "implementing curriculum renewal to achieve graduate attributes" (pg. 5). These include: conceptualisation of graduate attributes; engaging all stakeholders (including professional associations and industry groups); a coordinated implementation of graduate attributes through curriculum planning and explicit embedding of graduate attributes in assessment; effective quality assurance processes; support for appropriate staff development; and a strong student-centred approach ensuring the embedding of graduate attributes value-adding to the learning for students. These elements form the basis of the GAP framework which can be used by universities when "engaging in curriculum renewal to achieve graduate attributes" (pg. 5). In contrast to the generic approach that the GAP project took, the project undertaken by Taylor et al. (2009) focused on the development and assessment of graduate attributes in Business faculties where the aim was "to promote and support strategic change in advancing graduate attribute development in Business education through engagement of staff and students with learning and assessment processes that embed graduate attribute development." (pg. 1) Assessment processes, criteria and standards were developed within a framework that encouraged participation of both students and their educators (pg. 5). A software solution that had been developed as an online assessment system was used to support the process. It enabled staff to develop assessment criteria within standard assignments to address graduate attributes and students could engage

with these attributes by monitoring their performance of each criterion. The use of the software also allowed academics to moderate marks across groups within each class.

More recently Lawson et al. (2013) have undertaken a project looking at how institutions implement assurance of learning (AoL) processes. This project focused on two key elements of the AoL process, namely "mapping course learning outcomes [and] collecting data on student performance in relation to each learning objective." (p.12). The project built on the work of Taylor et al. (2009) who focused on business education.

A number of Australian universities have focused on students' achievement of learning outcomes. For example Macquarie University (2013) has adopted this approach in their teaching through the evaluation of the achievement of learning outcomes. The project in particular concentrated on (i) validity, where assessment of a student's knowledge and skills usually results in an empirical 'indicant' i.e. a number (mark) or a grade that represents the knowledge and skills being assessed; (ii) reliability, which refers to both the accuracy and precision of measurement; different tests of a student's particular knowledge or skills, if administered independently of one another, should all give the same result; and (iii) good qualitative assessments that should be credible, dependable and confirmable. Curtin University, on the other hand, uses student evaluation of learning and teaching (using eVALUate) to gain feedback on different aspects of students learning beyond just marks. One item on the evaluation relates to students' achievement of learning outcomes. In Curtin University (n.d.) assistance is provided to academic staff in understanding what learning outcomes are, how to align assessment with learning outcomes, and implement assessment strategies that allow students to demonstrate their achievement of learning outcomes thus encouraging students to not only achieve the learning outcomes but also to recognise that they are doing so. However, teaching or student achievement of academic literacies are not considered in the advice provided here.

Our institution is currently undertaking a university-wide review of all course offerings with the intention of ensuring their quality and relevance as well as increasing the capacity to engage students in interesting and industry relevant learning activities (Deakin University 2013). This major course enhancement has been sanctioned by the highest levels within the University and is timed to coincide with the reviews and updates required by the Australian Quality Framework implementation, which is to be fully implemented by 2015 (AQF 2013) and the demands of the new regulatory environment for higher education providers, enforced by Australia's Tertiary Education Quality and Standards Agency (TEQSA). It would appear that our institution's course enhancement project reflects many of the recommendations presented by Barrie et al. (2009), Taylor et al. (2009) and Lawson et al. (2013) and encompasses the requirements demanded by the AQF and regulated by TEQSA.

Stages and processes within the course enhancement have been well defined and each stage is supported by centralised institutional services. One outcome of the course enhancement project is that course and graduate learning outcomes are being explicitly mapped to unit learning outcomes and hence to assessment within units, as recommended by Barrie et al. (2009) and Taylor et al. (2009). These stages and processes are at the university level. The process presented in section 3.2 'Developing LOs and Assessment–Practical Process' is our original work at the unit level.

Although our courses have always (over the last 20 years at least) focused on specific assessment criteria and their alignment with learning goals, learning activities

and attribute development, the alignment has been within units and did not explicitly address course or graduate learning outcomes but rather were addressed implicitly. We also addressed in our courses the requirements of industry and employers but this information has not necessarily been systematically captured in the learning outcomes. The course enhancement process is providing us with an opportunity of reviewing the graduate, course and unit learning outcomes (GLOs, CLOs and ULOs) in the context of: our institution's mission for learning and teaching; professional accreditation requirements; industry expectations; and enhancing and aligning the learning activities and assessment to the various learning outcomes. At the same time major course reviews now include the requirement to explicitly demonstrate that all graduate and course learning outcomes are assessed, not just the unit learning outcomes, by providing a comprehensive mapping of assessment to unit learning outcomes as well as course and graduate learning outcomes.

What the course enhancement process does *not* do is provide guidance or support for a framework to capture the mapping of assessment to GLOs, CLOs and ULOs or ensure that the stated minimum standards are captured in a way that is useful to those who are designing learning activities and assessment to ensure the right standards are targeted and are achievable. As part of our School's implementation of enhancement to our courses we recognised the need for a systematic approach to capturing the mapping information in a way that is meaningful to staff as well as adding value to students' learning. The following sections describe: the theoretical framework that we developed in response to these demands; a case study that describes a manual implementation of the framework to a single unit; and finally, explores the limitations of the manual system and suggests further work to ensure the framework remains a viable, effective and efficient solution towards assuring learning.

3 The framework

The increased demands of aligning assessment with learning and graduate outcomes which have been designed in response to discipline, AQF and professional accreditation requirements, following a well-defined course-wide view, is so multi-dimensional and complex that a uniform framework, together with a supporting software-based solution, is required. This will allow us to:

a) manage this complexity and provide support for staff to maintain the relationships between the components, and
b) provide students with a means to view components in a way that will be meaningful to their learning.

In the following discussion, section 3.1 covers the logical design of the framework and section 3.2 includes a process to develop outcomes and assessment criteria. The logical design is presented in a formal manner followed by commentaries. It focuses on a variety of outcomes, captures data and their relationships to provide different views for both academics and students. Section 3.2 describes the practical process to develop learning outcomes and assessment materials which involves a number of steps.

3.1 Logical design

The framework is developed to:

1. Ensure that all unit and course outcomes are specified, cross referenced and assessed;
2. Capture data relating to learning outcomes and academic literacies providing a staff view and student view of the data;
3. Capture relationships among unit outcomes, assessment, academic literacies, course and graduate outcomes as well as external professional requirements.

This framework is presented as a dependency graph of outcomes, standards and criteria (Fig. 1). Individual nodes could provide services or data exposed in the form of tables. The graph is conceptual and does not contain the various relationships between nodes and items within those nodes but rather represents the complexity of the data that the framework must handle.

The details of each node in the graph are presented within the relevant services or data. We propose that:

- **Node 1** identifies the set of Knowledge and Skills Standards (KSS) based on the following function:

$$KSS_{ij} = f\left(UGLO_i, CSLO_{ij}(AQF, ACS)\right), i = 1..n, j = 1..m, \text{where CSLO is based on AQF and ACS standards.}$$

where UGLO denotes a set of University Graduate Learning Outcomes, CSLO denotes a set of Course Specific Learning Outcomes, and where $n = |UGLO|$ and $m = |CSLO_i|$. Clearly there is a one-to-many relationship from UGLO to CSLO.

The UGLOs are determined in response to the requirements of government bodies, accreditation organizations such as IEEE/ACM and the ACS, business and industry demands, and student expectations. The CSLOs are defined by specialists who are with

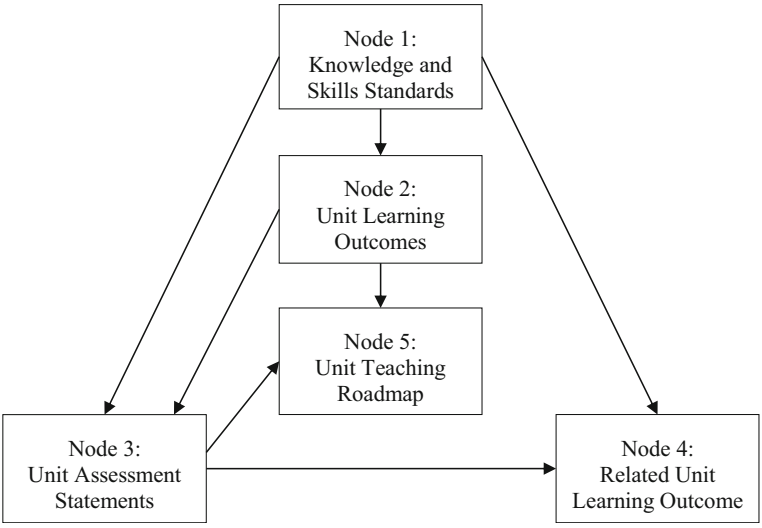

Fig. 1 Dependency graph of outcomes, standards and criteria

the organization unit that offers or is prepared to offer the course and are approved by the university. The CSLOs reflect the current state of the specific discipline, in particular in the area of the course.

- **Node 2** identifies a set of Learning Outcomes for a Unit (ULO).

  For each unit learning outcome (ULO) and grade, there is a set of assessment criteria (AC). In order to obtain a pass grade, a student must demonstrate that they have met all assessment criteria associated with that grade for all ULOs. In order to obtain a higher grade, a student must demonstrate that they have met all assessment criteria associated with that higher grade for all ULOs, as well as all assessment criteria associated with all lower grades.

  As many grading schemes are used worldwide and percentage ranges for a particular grade may differ from one institute to another, in this paper we use A, B, C, D, and F generally where A is associated with the highest percentage score and down to F being related to the lowest score (normally a fail grade).

  The *Assessment Criteria* to obtain the g^{th} grade is denoted as AC_g. Let AC_g be a set of relations where $g \in \{F, D, C, B, A\}$ such that:

  - $\{AC_F\}$denotes that the student has not met the Assessment Criteria required to obtain a pass grade in the Unit,
  - $\{AC_{Dd}, d = 1..n_d\}$denotes the Assessment Criteria required to obtain a pass grade in the Unit,
  - $\{AC_{Cc}\ c = 1..n_c\}$denotes Assessment Criteria required to obtain a satisfactory grade in this Unit,
  - $\{AC_{Bb}, b = 1..n_b\}$ denotes Assessment Criteria required to obtain a good grade in this Unit, and
  - $\{AC_{Aa}, a = 1..n_a\}$denotes Assessment Criteria required to obtain an excellent grade in this Unit.

  The ULO_i of a Unit under a relation AC_g, $g \in \{F, D, C, B, A\}$ and the Unit's set of *knowledge and skills standards* (KSS) is defined as:

$$ULO_i = \left\{ kss_{ac} \in KSS \middle| ac \in AC_g \right\}$$

- **Node 3** provides a set of *Unit Assessment Statements* (UAS) that depend on the particular unit's discipline, assessment regime, assessment criteria and academic literacies. Examinations, assignments, tests, quizzes and so on are considered as elements of the set of Assessment Tasks (AT); each task is associated with a weight and a set of academic literacies (AL).

$$UAS = \left\{ assessment_{tj}, weight_{tj}, ac_{tj} \subset AC, al_{tj} \subset AL, t \in AT, j = 1..\ n_t \right\}$$

  In other words, for a particular assessment question, there is a one-to-many relationship from that question to assessment criteria, and there is a one-to-many relationship from the question to academic literacies.

- **Node 4** is a function determining a *Related Unit Learning Outcome* (RULO) of a student. Suppose PIN denotes the *Private Identification Number* of a student. Thus,

$$RULO_{PIN} = f\left(assessment_{tj}(PIN), weight_{tj}, ac_{tj}, al_{tj} \right)$$

where $assessment_{tj}$(PIN) is the result received by $student_{PIN}$ for an individual assessment task, and $weight_{tj}$, ac_{tj}, al_{tj} are from the Unit Assessment Statement (UAS).

- **Node 5** provides a set of data that specify the *Teaching Roadmap* of a unit. It is defined by the tuple: <Week; Topic; ULO_g, g ∈ {F, D, C, B, A}; UAS>

  Those data could be represented by a matrix where the number of rows equals the number of teaching weeks (Week) and columns are specified by other components of the tuple: Topic; ULO_g, g ∈ {F, D, C, B, A}; UAS.

3.2 Developing LOs and assessment–practical process

We suggest the following steps based on the formal framework presented in section 3.1, our experience in developing unit learning outcomes, assessment criteria related to these outcomes, and assessment components (assignments, quizzes and examination):

1. Create an Overview by considering the following:
   a. University Graduate Learning Outcomes
   b. Course Learning Outcomes
   c. A vision of the unit:
      i. its outcomes and content
      ii. outcomes and content of pre-requisite units
      iii. assessment criteria to pass pre-requisite units
2. Develop Unit Content and Assessment
   a. List the topics of the unit content
   b. Specify the types of assessment
   c. Consider other units in the course, for example pre-requisite units
3. Create Unit Learning Outcomes
   a. Create ULOs in a most general and disjoint form as this will allow the development of assessment criteria for different grades
   b. Try to express each ULO in a short phrase rather than writing a few sentences
   c. Brainstorm what students need to know and be able to do in terms of obtaining a pass, credit, distinction or high distinction grade
4. Specify Assessment Criteria
   a. From step 3, for each grade, specify the minimum assessment criteria that students must demonstrate to obtain that grade
   b. Ensure criteria are disjoint

5. Rationalise unit content and assessment criteria

    a. ensure that the unit content only covers what is required by students to demonstrate their ability to achieve assessment criteria for the specified unit learning outcomes
    b. ensure that the assessment criteria only covers the unit content
6. Create Assessment Tasks

    a. As each learning outcome must be assessable, ensure that all assessment criteria are both demonstrated by the student and assessed by staff
    b. Ensure that all assessment criteria for a particular progressive assessment item are covered in a timely manner allowing students to complete that required assessment task such as:

        i. assignments
        ii. quizzes
        iii. examination
    c. Some students may not demonstrate their ability to pass based on their progressive assessment; provide a second chance by ensuring that another assessment task such as an examination also covers all assessment criteria for a student to pass the unit
    d. Ensure that one or more assessment tasks allow a student to achieve a higher grade by including higher level assessment criteria

4 Case study

The proposed framework has been built to be general; it does not show any details. Therefore, this section presents the feasibility and application of this framework in the form of a case study. For this purpose the authors decided to use a first year unit, entitled 'Critical Thinking and Problem Solving' which is compulsory in several of the Bachelor of Information Technology courses: BIT(Computer Science and Software Development), BIT(Games Design and Development), BIT(Interactive Media), BIT(IT Security), and BIT(Mobile and Apps Development).

4.1 Learning outcomes and assessment

Five documents were produced to record not only the variety of outcomes, assessment criteria, academic literacies, assessment statements, and weekly unit content but also the relationships among these entities. These five documents contain:

1. Deakin Graduate Learning Outcomes, Course Learning Outcomes, and Minimum Standards (MS), which is an implementation of Node 1: Knowledge and Skills Standards. For each DGLO, there are 1 or more CLOs. For each CLO, there are one or more MS. (Appendix, Table 4)

2. Unit Learning Outcomes and Assessment Criteria for each grade, which is an implementation of Node 2: Unit Learning Outcomes. For each unit learning outcome and grade there can be 0 or more with attainment criteria. (Appendix, Table 5)
3. the types of assessments and their weights, instructions and questions for each assessment task, which is an implementation of Node 3: Unit Assessment Statements. For each question there are 0 or more assessment criteria relating back to Node 2, (Appendix, Table 6–an exemplar of one type of assessment)
4. alignment of unit assessment tasks to graduate, course and unit learning outcomes, which is an implementation of Node 4: Related Unit Learning Outcome. For each assessment task there are 1 or more DGLOs. (Appendix, Table 7–an exemplar of one type of outcome)
5. unit teaching roadmap showing the topics, related assessment, unit learning outcome and references to attainment criteria, which is an implementation of Node 5: Unit Teaching Roadmap. (Appendix, Table 8)

4.2 Framework evaluation

The first major evaluation of the effectiveness of the framework was undertaken by completing the case study presented in the previous section. The framework is now being applied to a second unit, Computer Networks, a level two compulsory unit in the BIT suite of courses. We also plan to carry out short term evaluation of the framework effectiveness and also a longer term impact of the framework. The authors will conduct the evaluation with representatives from stakeholder groups including students, staff, employers and accreditation bodies.

The short term effectiveness will be evident through:

- feedback from staff involved in course enhancement and alignment courses (elicited through campus-based focus groups);
- perceptions of students in planning their courses and from assessment of their knowledge and skills against potential employer requirements (elicited through anonymous surveys).

Longer term impacts will be measured through evaluation of the outcomes including:

- impacts on student satisfaction with their learning (through University-wide satisfaction surveys)
- impacts on students' employability (through the Graduate Destination Surveys data collected and published by the Australian Bureau of Statistics); and
- ongoing management of courses and units including their modification and supporting flexibility of study.

Evaluation results will be used by the project team to provide ongoing improvements to the framework processes and the software. Presentations within the University and at suitable educational conferences and publication in appropriate academic journals will be created from this project and its evaluation. The evaluation results will also be used to improve student understanding of the role of learning outcomes in their studies.

4.3 Traditional assessment versus numeric results based on assessment criteria

In this subsection we present numeric results obtained in a traditional fashion versus numeric results based on assessment criteria as described in section 4.1 above. The traditional method is to accumulate marks based on each assessment item whereas students accumulate points based on their achievement of a ULO at a particular level in results based on assessment criteria.

Assessment Criteria

- there exists N ULOs where N is directly related to the unit; N=5 in the case study.
- marking is based on assessing ULOs
  - each ULO is assessed at different standards: A, B, C and D.
  - for a particular standard, there can be one or more assessment items per ULO
- overall there exists M assessment items per unit, where M = M(A) + M(B) + M(C) + M(D). M=6 in the case study.
  - M(D) = 6 at pass standard that cover all ULOs
  - M(C) = 6 at credit standard
  - M(B) = 6 at distinction standard
  - M(A) = 6 at high distinction standard
  - M_D is the number of assessment items passed out of M(D)
  - M_C is the number of assessment items passed out of M(C)
  - M_B is the number of assessment items passed out of M(B)
  - M_A is the number of assessment items passed out of M(A)
  - $K = M_D + M_C + M_B + M_A$
- assessment criteria to obtain a pass
  - M_D/M(D) such as 5/6, each student demonstrates their ability to achieve at least M_D assessment items to obtain a pass grade
  - there must be a minimum number of items that allows the student to progress to other units for which this unit is a prerequisite and that accreditation bodies require
- the formula to allocate a numeric value R, where R is the final result; what is the formula
  - F–If a student achieves less than M_D out of M(D)
  - D–if a student achieves at least M_D/M(D) then R = 50+K/M*10
  - C–if a student achieves at least M_D/M(D) and M_C/M(C) then R = 60+K/M*10
  - B–if a student achieves at least M_D/M(D) and M_C/M(C) and M_B/M(B) then R = 70+K/M*10
  - A–if a student achieves at least M_A/M(A) then R = 80+K/M*20

4.4 Example of the critical thinking and problem solving unit

In 2013, the number of students enrolled in this unit was 289. Assessment items where marked in two ways: the traditional numeric fashion, and using assessment criteria based. This provides an opportunity to compare these two types of assessment.

Table 1 shows two percentage profiles based on the traditional numeric fashion and assessment criteria marking and ranked by grade. The traditional numeric profile shows results are skewed to the lower grades. In comparison, the assessment criteria based results are generally higher for the B and C grades and generally lower for the D grade.

Table 2 shows two percentage profiles based on the traditional numeric fashion and assessment criteria marking. This table was produced by computing the grade averages for the traditional numeric fashion. Then for the same group of students in each of these grades, the groups' averages were determined using the assessment criteria results. In addition, for each group we show the average K and range of K (K is the number of assessment criteria achieved). This table also shows that average results for all grades increased. Consequently, in this case study, the assessment criteria scheme provided better results.

Table 3 shows two percentage profiles based on the traditional numeric calculation and assessment criteria marking, ranked by grade. In this table, the set of students achieving a particular grade using the traditional method differs from the set of students receiving the same grade based on the assessment criteria scheme. Table 2 shows improved results. Table 3 not only confirms this benefit using another measure, but it also provides an extra comparison.

5 Conclusions

We carried out an analysis of the results to compare and contrast the traditional numeric assessment and criteria based assessment.

- Assessment based on assessment criteria:
  - allows students to plan to achieve a particular grade, including plans to just pass, and
  - allows us to see what students have achieved and learnt (not achieved and not covered).

Table 1 Comparing percentage profiles

Grade	Traditional numeric results		Assessment criteria based results	
	Number of students	Percentage %	Number of students	Percentage %
A	41	14.2	36	12.5
B	42	14.5	60	20.8
C	60	20.8	72	24.9
D	84	29.1	61	21.1
F	60	20.8	58	20.1

Table 2 Comparing the same students

Traditional numeric results		Assessment criteria based results			
Average result (100)	Grade	Mark as a percentile ranking (100)	Average K (out of *M*=24)	Kmin	Kmax
88	A	91	21	18	24
73	B	77	18	14	21
63	C	68	15	11	20
53	D	58	12	7	18
28	F	28	7	0	13

- For every student that submitted assessment items, there is a very strong correlation (0.92 using Chi-squared test) between the marks they received from the numeric and assessment criteria schemes. A high correlation was expected as normally good students would receive a high mark despite the type of assessment, and similarly for average and poor students. Note, students that did not submit any assessment item were not included as clearly both 0 marks would unjustifiable increase the correlation value.
- On average, students received a higher numeric result based on the assessment criteria scheme.
- A numeric assessment scheme hides what each student has achieved and/or learnt; in some exceptional cases a student receives a low numeric result which doesn't correlate to the large number of assessment items that he/she passed.
- Four exceptional cases have been identified: (i) a student received a D grade based on the traditional numeric assessment scheme, but passed 18 out of 24 assessment items and received a final result of B Grade; and (ii) three students received an A grade based on the traditional numeric assessment scheme, passed 18 out of 24 assessment items and received a C grade.

Table 3 Comparing results by grade

Grade	Traditional numeric results	Assessment criteria based results			
	Average result (100)	Mark as a percentile ranking (100)	Average K (out of *M*=24)	Kmin	Kmax
A	88	97	21	18	24
B	73	77	17	13	21
C	63	66	14	10	19
D	53	55	12	7	17
F	28	23	8	0	15

These outcomes suggest that using assessment criteria-based assessment is at least as good a means of assessing students' knowledge and skills. Further, students are provided the opportunity of demonstrating their achievement of skills rather than their ability to accumulate marks (which weaker students seem to be quite strategic about!).

6 Future work

This project provides an innovative solution to managing the quality assurance processes imposed by the Australian Qualifications Framework (AQF 2013) and the need to align assessment and learning outcomes at all levels within a courses of study. As a quality assurance process is in place the Australian higher education sector, there is potential for our outcomes to be adopted by other tertiary institutions.

The next step of our project is to design and build a software solution, based on the presented framework, which will:

1. Provide a course-wide context,
2. Provide a means of mapping the outcomes and ensuring that they are adequately covered at all levels and are assessed at appropriate standards;
3. Assist students by explicitly describing the relationships between unit learning outcomes, course learning outcomes, graduate outcomes and assessment; as well as explicitly describing the criteria required to demonstrate achievement at various levels by developing extended rubrics.
4. Help staff identify strengths and weaknesses in their courses and units by highlighting strong and weak relationships between staff expectations and student knowledge and skills;
5. Help staff rationalise the delivery of their course and units to ensure that learning outcomes, assessment and academic literacy requirements are aligned.
6. Ensure that a strong, cohesive mapping of assessment to ULOs, CLOs and GLOs is maintained and enforced over time.

The presented framework and its implementation in the form of a software system will support staff and students to recognise, scaffold and achieve learning outcomes and academic skills at the unit and course levels, within the boundaries defined by the discipline, the university and professional bodies as well as ensuring that the course quality is maintained and course learning outcomes are assured.

We also suggest that a more comprehensive comparison of unit outcomes be undertaken to determine whether using a criterion-based approach to measuring student achievement of skills encourages or discourages grade inflation, in other words that the validity reliability, credibility, dependability and confirmability of assessment is not compromised compared to a numeric approach

Deakin University is heavily involved in further improvement of learning, building better learning environments for students, and increasing student satisfaction and employability. Therefore, it is anticipated that if this pilot project is successful it will be adopted by the wider University community and be supported institution-wide.

Appendix

Table 4 DGLOs, Course LOs and minimum standards

Deakin graduate learning outcomes	Course learning outcomes		Minimum standards	
1 Discipline-specific knowledge and capabilities: appropriate to the level of study related to a discipline or profession	CLO1.1	Have a broad, coherent knowledge of the IT discipline with in depth knowledge in at least one of the following specialised areas (major sequences): • Computer Science • Games Development • Interactive Media Design • Mathematical Modelling • Networking • Software Development • Security	MS1.1	Apply an integrated understanding of a complex body of knowledge in one or more specialised areas of IT.
	CLO1.2	Design, develop and implement IT systems and software, and associated policies and procedures for optimal use and apply industry standards and best practice in one or more specialised areas of IT.	MS1.2	Acquire and translate user requirements into formal specifications of a system or application and implement/model a system and/or application based on a formal specification.
	CLO1.3	Have detailed knowledge of, and be able to implement project management principles.	MS1.3	Manage projects utilising project management principles and tools.
	CLO1.4	Have knowledge of the dynamic environment of IT and explain the impact of this phenomenon.	MS1.4	Explain the impact of the dynamic nature of IT environments.
2 Communication: using oral, written and interpersonal communication to inform, motivate and effect change	CLO2.1	Communicate in an IT context to inform, motivate and effect change utilising a range of verbal, graphical and written methods, recognising the needs of diverse audiences.	MS2.1	Demonstrate communication skills in an IT context.
3 Digital literacy: using technologies to find, use and disseminate information	CLO3.1	Utilise a range of digital technologies and information sources to discover, analyse, evaluate, select, process and disseminate both technical and non-technical information.	MS3.1	Select and use a range of appropriate tools to facilitate information management and knowledge transfer in an IT context.

Table 4 (continued)

Deakin graduate learning outcomes	Course learning outcomes		Minimum standards	
4 Critical thinking: evaluating information using critical and analytical thinking and judgment	CLO4.1	Evaluate information using critical and analytical thinking and judgement to identify problems, analyse user requirements and propose solutions.	MS4.1	Analyse critically and reflect on complex information, concepts and theories to support problem solving.
5 Problem solving: creating solutions to authentic (real world and ill-defined) problems	CLO5.1	Apply theoretical constructs and critical analysis to real-world and ill-defined problems and develop innovative IT solutions.	MS5.1	Identify problems, analyse user requirements, provide solutions to meet user needs and to critically evaluate the effectiveness of the solution.
6 Self-management: working and learning independently, and taking responsibility for personal actions	CLO6.1	Apply knowledge and skills to new situations in professional practice and/or further learning in the field of IT with adaptability, autonomy, responsibility and personal accountability for actions as a practitioner and a learner.	MS6.1	Demonstrate autonomy, professional judgement, adaptability and responsibility and ethical behaviour as a practitioner or learner.
	CLO6.2	Reflect upon and critique skills developed and plan for their own future continuing professional development.	MS6.2	Self-critique learning needs and create a personal professional learning/ development plan.
7 Teamwork: working and learning with others from different disciplines and backgrounds	CLO7.1	Apply the principles of effective team work as a member of diverse teams.	MS7.1a	Work collaboratively in one or more roles in diverse cultural and professional teams.
			MS7.1b	Participate effectively in planning and executing an authentic project.
			MS7.1c	Reflect on own performance in achieving team goals and contributing to team cohesiveness.
8 Global citizenship: engaging ethically and productively in the professional context and with diverse communities and cultures in a global context	CLO8.1	Apply professional and ethical standards in the development, design, construction and management of localised solutions.	MS8.1	Demonstrate global, cultural and social awareness of the diverse needs of communities and cultures when developing IT solutions.

Table 5 Unit learning outcomes and assessment criteria

Unit learning outcomes	Assessment criteria to pass this unit	Assessment criteria to obtain a credit in this unit	Assessment criteria to obtain a distinction in this unit	Assessment criteria to obtain a high distinction in this unit
At the end of this unit, students will be able to:	To achieve each unit learning outcome, a student must demonstrate the ability to:	To achieve a Credit grade, a student must meet all criteria to obtain a Pass grade and demonstrate the ability to:	To achieve a Distinction grade, a student must meet all criteria to obtain a Credit grade and demonstrate the ability to:	To achieve a High Distinction grade, a student must meet all criteria to obtain a Distinction grade and demonstrate the ability to:
1 Analyse requirements using critical thinking techniques	a Identify claims, issues and arguments within requirements b Identify deductive and inductive arguments	a Recognise clutter within requirements by identifying items that are relevant to a particular problem	a Identify statements that are vague, ambiguous, general or credible	
2 Solve problems in a variety of ways	a Explain the 'Divide and Conquer' problem solving technique	a Explain the 'Trial and Error' problem solving technique b Identify the four types of categorical claims	a Determine an argument's validity using truth tables b Apply categorical logic operations	a Determine an argument's validity using symbolic logic b Determine an argument's validity using categorical logic
3 Comprehend algorithms	a Step through an algorithm to determine its outputs	a Desk-check an algorithm		
4 Design and develop algorithms	a Design and develop an algorithm (using sequence, selection, and iterative constructs) that we find in daily life and independent of computers	a Develop simple numeric algorithms such as min, max, count and average	a Develop an algorithm to locate an item in a sorted or an unsorted list b Develop sequentially cohesive modules	a Develop an algorithm that processes a file to generate a report b Develop functionally cohesive modules c Develop modules utilising data coupling

Table 5 (continued)

Unit learning outcomes	Assessment criteria to pass this unit	Assessment criteria to obtain a credit in this unit	Assessment criteria to obtain a distinction in this unit	Assessment criteria to obtain a high distinction in this unit
				d Develop modules utilising stamp coupling
5 Ensure corrections of an algorithm	a Determine whether or not (provided) pre-conditions, post-conditions and assertions are correct for an algorithm that we find in daily life and independent of computers	a Determine whether or not (provided) pre-conditions, post-conditions and assertions are correct for a simple algorithm such as adding two time values (hh:mm:ss)	a Develop pre-conditions, post-conditions and assertions for a simple algorithm such as adding two time values (hh:mm:ss)	

Table 6 Critical thinking and problem solving

Assignment 1	Assessment criteria
Due Date Tuesday, November 20 at 8:00 am, 2012 Instructions • Answer all the following questions. • Place your answers in an MS Word document, including name and ID.	
Question 1	
For each of the following problem solving techniques, find definitions from three different sources and write these down exactly. Your research materials can be text books, dictionaries, Wikipedia, other credible resources and web sites, and so on. a) Divide and Conquer b) Trial and Error In addition, you must provide perfect referencing. You must use the Vancouver style of referencing for this assignment. A description of this referencing style can be found at: http://www.deakin.edu.au/current-students/study-support/study-skills/handouts/vancouver.php	
Question 2	
For each of those problem solving techniques (Divide and Conquer and Trial and Error) from question 1, write down a definition using your own words. These definitions must be related to problem solving. • Do not copy meanings from question 1 or other places. • Don't forget to reference.	2a–P 2a–C
Question 3	
This question is based on the first paragraph in the introduction section of the 'Geelong Food Relief Centre IT Project Brief' document. This paragraph contains a number of claims and arguments. a) Provide a list of all claims that can be explicitly found within this paragraph. b) Provide an issue based on the first claim of this paragraph. c) Provide one complete diagram of the arguments contained in this paragraph. The method you use should clarify the argument's structure. Use the method presented by Moore and Parker on pages 52–54.	1a–P
Question 4	
This question focuses on the introduction section of the 'Geelong Food Relief Centre IT Project Brief' requirements document. When designing a database it is important to know the amount of data to be stored because computers and software packages have memory limits. Provide a list of sentences, word for word from this introduction section, that are relevant to designing the centre's database.	1a–C
Question 5	
The following list is based on the 'Geelong Food Relief Centre IT Project Brief' requirements document. Your task is to determine whether each statement is vague, ambiguous, general or credible. Indicate your choice by writing VAGUE, AMBIGUOUS, GENERAL, CREDIBLE or NONE as your answer. a) Geelong Food Relief Centre aims to deliver nutritious food to individuals and families experiencing hardship. b) Every year our centre serves over 8,000 families. c) This database will be used to keep records. d) We are looking for something that is easy for anyone to use. e) David Manning was the manager of the Geelong Food Relief Centre on August 2, 2012.	1a–D
Assessment • Examination 40 % • 2×assignments (15 % each) 30 % • 3×practical assessments (10 % each) 30 %	

Table 7 DGLOs and unit assessment

Deakin graduate learning outcomes	Assessment	Linked DGLOs
1 Discipline-specific knowledge and capabilities: appropriate to the level of study related to a discipline or profession	Assignment 1	(DGLO 1,4) Analysing real world IT requirements. (DGLO 2,3) Research, review, write and reference. (DGLO 5) Explaining problem asolvingtechniques. (DGLO 6) Meeting deadlines.
2 Communication: using oral, written and interpersonal communication to inform, motivate and effect change	Assignment 2	(DGLO 1,2,4,5) Designing and developing algorithms using IT standards. (DGLO 6) Meeting deadlines.
3 Digital literacy: using technologies to find, use and disseminate information	Quiz 1	(DGLO 1) Solving problems using truth tables. (DGLO 4,5) Solving problems using truth tables and categorical logic. (DGLO 6) Meeting deadlines.
4 Critical thinking: evaluating information using critical and analytical thinking and judgment	Quiz 2	(DGLO 1,4,5) Stepping through an algorithm to determine its outputs. Desk checking an algorithm to confirm correctness or locate errors. (DGLO 6) Meeting deadlines.
5 Problem solving: creating solutions to authentic (real world and ill-defined) problems	Quiz 3	(DGLO 1,4,5) Identify, design and develop pre-conditions, post-conditions and assertions in algorithms. (DGLO 6) Meeting deadlines.
6 Self-management: working and learning independently, and taking responsibility for personal actions	Examination	(DGLO 1,2,4,5) The examination will at a minimum cover argument types, symbolic logic and developing an algorithm. (DGLO 6) Meeting deadlines.
7 Teamwork: working and learning with others from different disciplines and backgrounds		
8 Global citizenship: engaging ethically and productively in the professional context and with diverse communities and cultures in a global context		

Table 8 Teaching roadmap

Week	Week commencing	Topic	Related assessment criteria pass	Related assessment criteria credit	Related assessment criteria distinction	Related assessment criteria high distinction	Related assessment		Assessment due date
1	11-Mar	Introduction							
		Problem solving techniques	2a–P	2a–C			A1		
2	18-Mar	Claims, issues and arguments	1a–P	1a–C			A1		
		Two kinds of reasoning	1b–P						
3	25-Mar	Vagueness, ambiguity and generality			1a–D		A1		
		Credibility			1a–D		A1		
EASTER Friday 29 March–Sunday 7 April									
4	8-Apr	Understanding arguments using categories		2b–C	2b–D	2b–HD		Q1	
		Understanding arguments using truth-tables			2a–D			Q1	
5	15-Apr	Understanding arguments using deduction (group I rules)				2a–HD			A1–Friday 5 pm, April 19
		Understanding arguments using deduction (group II equivalences)				2a–HD			
6	22-Apr	Steps in algorithm development	4a–P	4a–C	4a–D	4a–HD	A2		Q1–Friday 5 pm, April 26
		Building algorithms	4a–P	4a–C	4a–D	4a–HD	A2		
7	29-Apr		3a–P, 4a–P	3a–C, 4a–C	4a–D	4a–HD	A2	Q2	

Table 8 (continued)

Week	Week commencing	Topic	Related assessment criteria pass	Related assessment criteria credit	Related assessment criteria distinction	Related assessment criteria high distinction	Related assessment		Assessment due date
		Building and checking algorithms							
		Selection statements	4a–P	4a–C	4a–D	4a–HD	A2	Q2	
8	6-May	Repetition statements	4a–P	4a–C	4a–D	4a–HD	A2	Q2	
		Modularisation			4b–D	4b, 4c, 4d	A2		
9	13-May	Module cohesion			4b–D	4b–HD	A2		
		Module coupling				4c, 4d–HD	A2		
10	20-May	Flow charts	4a–P	4a–C	4a–D	4a–HD	A2		Q2–Friday 5 pm, May 24
		Pre and post conditions, and assertions	5a–P	5a–C	5a–D			Q3	
11	27-May	Review–critical thinking							A2–Friday 5 pm, May 31
		Review–critical thinking							
12	3-Jun	Review–problem solving							Q3–Friday 5 pm, June 7

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