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Assessing Epidemiological Learning Amongst Undergraduate Students

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Abstract
Increasingly, students from a range of undergraduate health courses are required to study epidemiology. This is, in part, due to the use of evidence-based frameworks and workforce competency programs. Resources to guide the selection of content and development of teaching strategies are available. However, there is paucity of published research on how to best assess epidemiological knowledge and skills.

Using recent experience and a review of the current evidence on best practice in assessment, this paper outlines how the key principles in assessment can be used in epidemiology to encourage students to learn and apply epidemiological skills in their professional practice and promote interprofessional learning and co-operation.

Keywords: assessment, university teaching, epidemiology, research methods

Introduction
Epidemiology is the study of factors affecting the health and illness of populations (Last 2001), and serves as the foundation and logic of interventions made in the interest of public health and preventive medicine. It is a cornerstone of evidence-based practice and policy, providing the mechanisms for identifying risk factors for disease and injury, and determining optimal management approaches to clinical practice (Dawes et al 2005). Increasingly, students in a range of undergraduate health courses are required to study epidemiology or research subjects that include epidemiological concepts. For example, medical practitioners, nurses, pharmacists, physiotherapists, and other allied health professionals are required to use evidence-based frameworks to inform their practice (Australian Medical
Council, 2008; Australian Nursing and Midwifery Council (ANMC) 2005, Australian Physiotherapy Council 2006; Pharmaceutical Society of Australia 2006). This need for epidemiological knowledge and skills is also reflected in a range of workforce competency documents for various professions including public health (Public Health Association of Australia (PHAA) 1990, PHAA 1993, PHAA 1995, NSW Department of Health 2000), speech pathology, (Speech Pathology Association of Australia 2001), environmental health (Australian Institute of Environmental Health 2004), health promotion (Shilton et al 2002) and nursing (ANMC 2005). In addition, a review of the Bachelor of Public Health program at La Trobe University found that skills learnt in epidemiology were judged as relevant and applicable to practice by both recent graduates and potential employers (School of Health Sciences, 2004). Information to assist academic personnel who are required to teach epidemiology is therefore both timely and important. Resources to guide teaching strategies and the selection of content in epidemiology for medical and other undergraduate and postgraduate students are available (Saracci and Trichopolous 2001, James, et al 2006). However, none of these include recommendations and guidelines for assessment, and there is a paucity of published research on how to best assess epidemiological knowledge and skills.

Effective pedagogy aligns assessment tasks with learning objectives and teaching activities. It also promotes students taking responsibility for their own learning. Biggs (2003) refers to this as constructive alignment. This approach to teaching and learning promotes higher order skills such as synthesis, interpretation and understanding (deep learning) instead of the ‘regurgitation’ of facts without any real understanding of what the material means (surface learning) (Biggs 2003). Constructive alignment (see Figure 1) incorporates assessment strategies that maximise deep learning and minimise surface learning. Many academics will be familiar with the surface learning student(s) who have the attitude ‘I just want to pass this unit’ and as identified by Ramsden, (2003) students often work ‘backwards’ and focus on the assessment requirements to determine the specific material they are required to learn in order to pass. Biggs (2003, p.141) refers to this as

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Teacher perspective: objectives ➔ Teaching activities ➔ assessment 
Student perspective: assessment ➔ Learning activities ➔ outcomes
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Figure 1: Teacher and student perspectives on the role of assessment in curriculum content (Biggs 2003) (p 141)
"backwash" which is generally viewed negatively (Crooks 1988). This can be exacerbated if summative assessment is the only evaluation of student learning. In this case, assessment is conducted after teaching is completed and does little to contribute to student learning. In contrast, formative assessment is directly linked to teaching as it provides the student and the teacher with feedback during the teaching period (Biggs, 2003). When a range of assessment tasks that are linked to learning objectives and teaching strategies are used, backwash can be positive; promoting deep learning on the part of the student and enabling both student and teacher to effectively evaluate learning over time.

The aim of this paper is to provide practical strategies to effectively assess epidemiological learning by undergraduate health sciences students. These strategies are based on a review of the current evidence on best practice in assessment and on our experience of assessing undergraduate epidemiology students from a range of health professions at two universities. The paper describes six criteria:

1. Link assessment to professional learning objectives
2. Provide a range of assessments
3. Build on prior knowledge
4. Provide a balance between theoretical and practical assessment tasks
5. Communicate assessment criteria
6. Include bi-directional feedback

that are key principles in assessment in higher education (Crooks 1988, Biggs 2003). This paper describes how teaching and learning in epidemiology can be improved by adhering to these principles.

**Best Practice in Assessment**

We use data from staff and student evaluations of epidemiological teaching at La Trobe and Deakin Universities to exemplify the application of pedagogical theory to the practice of assessing epidemiological knowledge and skills in the following undergraduate programs.

1. Epidemiological concepts are taught to 3rd year pharmacy students at the Bendigo campus of La Trobe University, Victoria. The Bachelor of Pharmacy (BPharm) at Bendigo commenced in 2000 and includes a strong research methods program.

2. Epidemiological concepts are a core component of a 3rd year unit taught to public health students in the Bachelor of Public Health (BPH) program offered at the Bendigo campus of La Trobe University, Victoria. The BPH program provides education and training for the health promotion and environmental health workforces.

3. Epidemiology skills are taught as part of a 1st year online Health Information and Data unit at Deakin University, Victoria. The unit is core for all students in the Faculty of Health, Medicine, Nursing and Behavioural Sciences and so includes undergraduate students enrolled in public health, health promotion, health sciences, nursing, psychology, occupational therapy, science and exercise, and nutrition science.

4. Epidemiology and biostatistics skills are taught to 2nd year Bachelor of Public Health and Health Promotion...
(BPHHP), Bachelor of Public Health and Health Promotion/Bachelor of Commerce and 3rd year Bachelor of Nursing/Bachelor of Public Health and Health Promotion students at Deakin University. These programs provide students with training for the public health and health promotion workforces.

Overall, the assessment in these programs includes: retrieval and interpretation of data, critical appraisal of quantitative epidemiological papers, class presentations of epidemiological concepts that are relevant to professional practice, practice-based scenarios of study designs and basic epidemiological calculations, multiple choice online ‘quizzes’ and formal examinations that include long and short answer questions. Different assessment tasks are assigned different weightings, so that there is, on average, three pieces of assessment per unit.

1. **Link assessment to professional learning objectives**

Selection of assessment tasks is a key component of constructive alignment (Biggs 2003). Good teaching means that unit aims and objectives are articulated in and linked to the assessment requirements (Biggs 2003, Prosser and Trigwell 1999, Ramsden 2003). It is not realistic to assess every topic that has been included in a unit. Instead, the emphasis in assessment tasks should be on key goals for learning and where appropriate, these should be linked to professional competencies. These priorities help students focus their learning on key concepts and skills and also assist academics in ensuring that degree programs are based on professional needs and workforce competencies. This also contributes to the quality assurance cycle and external accreditation by ensuring that teaching is relevant to practice. For example, the BPH (Environmental Health) curriculum is accredited by Australian Institute of Environmental Health (Talbot et al 2007).

Students studying epidemiology and related biostatistical concepts often have high levels of anxiety in relation to assessment that can be exacerbated by over reliance on summative assessment (Boyle, 1999). So, instead of setting assessment tasks in isolation from curriculum content we use the assessments to assist in facilitating student motivation to learn specific topics and tasks. This approach is supported by several authors (Biggs 2003, Ramsden 2003) including Crooks (Crooks 1988 p.2) who stated that ‘work which is assessed, and particularly work which counts towards a final grade, often is undertaken more seriously and diligently than work which is not assessed’ (Crooks 1988). We address this issue by beginning each semester with an outline of the assessment requirements and how this is linked to the unit outcomes and course content (see Figure 1).

We place a stronger emphasis on some objectives that are linked to professional requirements and these are covered more thoroughly in both teaching content and assessment. For example, in the BPharm program, one of the learning objectives is: “Understanding epidemiological principles and evidence-based practice and using these to critically evaluate health research.” This objective includes several concepts and skills so
the assessment focuses on enabling students to demonstrate deep learning skills via analyses and evaluation. The students are required to critically appraise pharmacy relevant peer-reviewed articles using epidemiological principles. This objective and linked assessment is a professional requirement (Pharmaceutical Society of Australia 2006) and so assists the academic in prioritising learning outcomes. Similar objectives are used for the Deakin University Health Information and Data unit "read, interpret and critically reflect on peer-reviewed health research articles" and the Epidemiology and Biostatistics unit "be aware of, and able to apply, the key issues in critically appraising health research literature."

Whilst there is a multitude of skills that an epidemiologist may consider important to undergraduate education, these may not be reflected in professional competencies. For example, an epidemiologist might suggest that it is an important learning activity for undergraduate health promotion students to calculate direct and/or indirect standardisations. In contrast, health promotion workforce competencies (Shilton et al. 2002) indicate that it is important for students to know about standardisation but it is not necessary for them to be able to complete the calculations. In undergraduate programs, where students are often undertaking introductory epidemiology units, professional competencies can assist academics in setting learning priorities as opposed to the 'optional extras' (Crooks 1988). For example, the Deakin University Health Information and Data unit teaches students to understand and interpret results of statistical tests often reported in peer-reviewed papers, such as correlations, odds ratios, p-values and confidence intervals. However students are not required to be able to calculate the various statistical tests.

2. Provide a range of assessments

Formative and varied assessment tasks provide a more accurate picture of each student's achievement and enhance assessment reliability (Foley 2000, Ramsden 2003, Edwards and Thatcher 2004). In these epidemiological units, assessment includes: group presentations, critical appraisals, data collection analysis and interpretation, multiple choice/short answer tests and longer exams. Typically, assessment includes content material and the skill or competency that is required to be displayed (Crooks 1988). The choice of assessment format should reflect consideration of multiple factors including the type of skills to be assessed (and how these link with the unit aims and objectives), time constraints (for both the academic and student), student familiarity with the assessment format, and the degree of choice available (Crooks 1988).

Traditional summative assessments such as examinations often promote surface learning (Ramsden 2003). However, used in conjunction with other methods of assessment throughout the unit, examinations can provide a valuable assessment tool provided that the questions are appropriately devised to assess understanding and not just recall. By way of illustration, BPH students complete a long answer examination; a scenario is derived from a recent popular media report that is relevant to public health practice. This
might be a question concerning a recent food-poisoning outbreak investigation, and require students to outline the steps involved in investigating the outbreak, given the circumstances described. Students were then required to calculate and interpret the relative risk of developing a particular outcome (for example, a disease). These questions required students to actively transform their knowledge and to make use of their knowledge through reflection and application to real-life situations (Biggs 2003, Ramsden 2003).

 Whilst the use of multiple assessment tasks is endorsed, care must be taken to ensure that both teaching staff and students do not become unreasonably burdened by assessment tasks. In order to avoid some of these problems, we ensure that assessment is regularly spaced throughout the semester and in planning the unit, other year level unit co-coordinators are consulted to ensure that students are not unnecessarily overburdened at any particular time throughout the semester. Smaller assessment tasks are often less daunting for students and diversity in assessment means that there are several opportunities to motivate students who have different learning styles (Ramsden 2003). This is also an important consideration in the weighting of allocated marks for assessment tasks where it is important to ensure that students with different learning styles are not disadvantaged. We balance this by ensuring that the 'key' unit objectives are spread across the assessment tasks and that this is reflected in the weighting of allocated marks. Students in the BPharm, BPH and BPHHP second year students are provided with a greater range of assessment activities than those students in the online subject. Online units can create challenges in assessment due to the increased opportunities for cheating and difficulties in accessing/managing the technology (Roach 2001, Kippen et al 2004).

 Teaching staff need to be able to develop flexible assessment tasks that meet the learning needs of students. This also includes meeting the needs of students with disabilities and accessing resources in order to effectively do so. As our units include students from a range of disciplines, we consult widely with course co-coordinators, prior to the commencement of the unit, to determine if there are any students that will need additional support in assessment.

 3. Build on prior knowledge

 One of the principles of adult learning is building on prior knowledge (Knight 2002). Constructive alignment is closely linked to students' previous experiences (Biggs, 2003) and so utilising students' prior knowledge should decrease anxiety and enhance the learning experience. High levels of student anxiety often mean that students are attracted to surface learning (such as recall) instead of the deep learning (such as understanding, analysis and interpretation) that is required in epidemiology. In each of the units, via teaching and assessment, we frequently advise students that memorising and verbatim reproducing of unit content will not contribute to success. We keep to a minimum the amount of assessment that focuses on recall alone as assessment that focuses on deep learning enhances
the learning of all skills including recall (Crooks 1988). For example, we use multiple choice questions to require students to recall or recognise key information such as epidemiological definitions (as in online weekly quizzes for first year students). Alternatively, students in the first year online unit complete an assignment where they are expected to briefly describe the main limitations of an epidemiological paper. This requires an understanding of key epidemiological concepts prior to answering the question. In this way we assess both recall and understanding.

Teaching activities that encourage students to work on problems that are used as a model for short answer questions in the class test are employed. For example, in the BPharm and Health Information and Data units, students are given an activity where they are asked to develop a research question on a topic of their choice and to provide a study design that will answer the question. The foundation for this activity is to encourage the students to think critically and make judgments when applying the unit content to their existing knowledge.

Student interest in a topic also promotes deep learning (Ramsden 2003). Throughout our teaching in the BPH and BPharm programs we use a range of relevant scenarios from the popular media to highlight different epidemiological principles. This challenges the student to use their critical appraisal skills in a 'live' setting where evidence-based practice is sometimes challenged by popular media reports. Drawing on students' prior knowledge and experience of teaching strategies is one way to reduce anxiety in assessment. In the short answer section of the class test, BPharm students are given pharmacy-based case scenarios which provide the basis for questions on study designs, interpretations of quantitative results and other epidemiology concepts such as confounding and standardisation.

4. Provide a balance between theoretical and practical

One of the challenges in promoting the relevance of epidemiology to professional practice is choosing assessment tasks that are relevant to practice. The use of practical assessment tasks is highly successful in engaging undergraduate students who do not have a clinical background (Abramson 2001). It also enables students to make a smooth transition into the workforce where their epidemiological skills are highly valued. This is best achieved by providing a balance of theoretical and conceptual understanding and practical epidemiology skills (Fraser and Greenhaugh 2001) which are reflected in the set assessment tasks. Students who can easily calculate odds ratios are not necessarily able to translate the meaning of their result when confronted with a real-life situation. Assessment tasks should require students to explain their work and describe how they would translate their answer into a lay person's language. Similarly, a theoretical understanding of confounding is not useful in practice unless the student can discuss it in terms of real-life studies and their application to practice.

We choose assessment tasks that are aligned closely with the processes used in the workforce (Abramson 2001, James et al 2002, Talbot et al. 2007). Specifically, the assessments aim to assess
students' learning and understanding of the content, particularly those competencies which are essential to practice. Whilst it can be challenging to set assessment tasks that address the needs of a range of student programs, previous research has reported that assessment in interprofessional education units highlights educational similarities rather than interprofessional differences and that common assessment that is acceptable to different professional groups can be set (Morrison and Stewart 2005). For example, in the 1st year unit taught at Deakin University, students are given a range of epidemiological papers, from several disciplines, to critique. The scope of the assessment task means that students may choose a paper that is more relevant to their specific discipline but at the same time, they are gaining skills that are generic to a range of disciplines. This strategy also ensures that assessment methods are selected because they measure the expected outcomes and not because they are favoured by one professional group. Similarly, in some of the units, students are expected to understand the concept of sensitivity and specificity. Again, students are provided with a range of examples, at least one of which is derived from highly relevant to each discipline within the unit and to their later professional practice.

Students are often surprised at the intricacies of putting epidemiological theory into practice. Public health students are provided with various scenarios and they are required to collect and interpret data from a range of websites that provide population and health statistics (see Box 1). This is a useful way to test students' understanding of underlying epidemiological definitions and concepts such as study designs, standardisation, bias and effect modification. At first sight, most students believe that this is a fairly easy task. However, invariably, later discussions in class suggest that accessing and interpreting the relevant data is not as straightforward as they had initially thought. Using common search engines, students often find a multitude of sites that include data of relevance to the topic. However, ensuring that the data that they use is both robust and relevant to the specific question being asked is not always easy. Once they have accessed the relevant data, students then find themselves reviewing definitions and texts to gain a deeper understanding of epidemiological concepts that can be applied to the question at hand. Students gain increased confidence in data interpretation when they find that they can interpret graphs, understand the differences in types of data that is reported, highlight limitations of the data and discuss related epidemiological questions.

**Box 1**

Using the Centre for Disease Control and Prevention (CDC) website, find the percentage of American males who were smokers in 2004.

Using the Australian Institute of Health and Welfare site, provide comparable data.

a. Is the definition of smoking same or different?

b. Can we validly compare the data sources? Why or why not?

(You do not need to provide the actual data.)
5. Provide assessment criteria

It is important that assessment procedures promote and reward desired learning activities and outcomes (Crooks 1988). In each of the assessment tasks, we provide clear criteria including the weighting for each criterion towards a final mark. Students are not assessed against each other, as is the case with norm-referenced assessment; rather they are assessed against the set criteria (Biggs 2003). The criterion-referenced approach emphasises the more important unit aims and objectives. For example, students in the online unit are required to 'be able to answer questions about discipline relevant articles that have been retrieved from a range of online sources' and 'understand the need for collecting population health data.' The assessment criteria stipulate that electronic data be used and so it is assumed that the students are learning about the different types of online health information.

The assessment criteria that are given to students provide a balance between assessment validity and reliability. It is important to ensure that there is consistency of standards and results in assessment. This is commonly referred to as reliability (Ramsden 2003). To enhance assessment reliability, we also have some overlap in the objectives that are being assessed in each piece of work. For example, as in several of the other units described, the pharmacy class short-answer test assesses understanding and application of some of the objectives that have previously been assessed. This strategy means that if there is reduced reliability in one assessment task, it will be compensated for in another. Assessment validity measures performance on the aspects of the course that are important (Crooks 1988).

While it would be easy to enhance the validity of assessment by using questions for which a student need only recall information, this would not promote deep learning of epidemiological concepts.

Students are often concerned about the value of group assessment as their focus is often on the equitable sharing of the tasks and concerns that the allocated mark may not accurately reflect each student's individual contribution (Rowntree 1977; James et al. 2002). It is therefore important that any group work be supported by clear assessment guidelines and that students are supported in devising a plan that clearly outlines each individual student's role and responsibilities (James et al. 2002).

6. Incorporate bi-directional feedback

Feedback needs to be detailed, structured and timely. Crooks (1988, p.12) outlines four criteria for effective feedback:

i. feedback has to be truly informative, clearly identifying areas of strength and weakness for the individual student;

ii. ways of improving performance should be made as explicit as possible;

iii. the feedback should be delivered in such a way that it enhances rather than damages student motivation; encouragement should be given where possible and faults should be pointed out kindly and constructively;

iv. feedback should be timely because if it is too long delayed the student may be concentrating
on learning new topics and skills and thus have little time or interest to make use of the feedback.

It is good practice to utilise marking guides that make the criteria as clear and defensible as possible (Crooks 1988), and so we provide copies of such guides to students before an assessment task is due. These marking guides include a breakdown of the allocated marks and details regarding the expectations for each section of the assessment. Further, the assessment and marking criteria are clearly linked to the content objectives. Considerable effort should be devoted to defining the criteria that are to be used in assessing student performance. These criteria should then be systematically applied in the marking process (Crooks 1988).

Where there are consecutive assignments, we ensure that the due dates are timed to allow the return of marks and feedback on each piece of assessment prior to the due date of the next item. In both the face-to-face and the online units we utilise class-wide feedback sheets that summarise the main areas that students did well and did poorly. Facilitating self-reflection on feedback has been identified as influential in feedback acceptance (Sargeant et al 2008) and so we also provide general feedback verbally in class or online via discussion threads and eLive discussion. This is supplemented with targeted individual feedback on each student's work via hard copies or online. We aim to, whenever possible, provide feedback to students within three weeks of submission.

Some useful feedback can often be given by presenting a model answer and helping students identify the important differences between their answers and the model answer (Crooks 1988, p4). Online students are also given practice tests which give them immediate feedback regarding their multiple-choice response and the correct response.

Feedback from students via quality assurance (QA) processes should be incorporated into assessment selection for future years. Increasingly, QA processes require academics to collate and reflect on feedback received from students regarding teaching and learning. All of the units described here have been continually refined following student feedback. For example, in the online unit, more opportunities for practice assessments have been incorporated into the unit and clearer links between unit content, tutorial activities and assessment have been developed. Course reviews and professional accreditation processes also link into the quality assurance cycle.

**Conclusion**

The value of teaching epidemiological concepts to undergraduate students in a range of disciplines is well recognised by both academics and professionals in the field. The challenge for educators is to ensure that the assessment tasks in epidemiology units are tailored to meet the needs of students and their professional practice setting. Selection of assessment tasks is a key component of constructive alignment. The examples in this review are drawn from several courses at two higher education institutions. We acknowledge that a larger sample that includes representative
Data would have been preferable but also believe the findings of this review have application to the teaching of epidemiology in a range of higher education settings. This paper outlines how the key principles in assessment can be used to promote appropriate assessment in epidemiology that will, when used, encourage students to actively learn and apply epidemiological skills in their professional practice and promote interprofessional learning and co-operation. Further research is required to evaluate how assessment in epidemiological learning enhances professional practice.

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