Designing a multidisciplinary preclinical subject on the ecology of disease using alignment models

by
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Abstract

An action learning project was conducted to design a new level 3 undergraduate subject on the ecology of disease for students in biological and biomedical sciences. It was envisioned by stakeholders as a holistic interdisciplinary subject consolidating preclinical concepts and incorporating analytical tools. Goals and objectives were identified through needs assessments, core content through concept mapping, resource issues through components analyses, desirable graduate attributes through outcomes analyses, and best teaching and learning practices through procedural analyses. A constructive alignment model was then used to link curriculum objectives with relevant instruction activities and assessment criteria addressing skills, attitudes, concepts and knowledge. Teacher and student expectations were reconciled through class questionnaires, personal interviews and focus groups to maintain unity of vision in the multidisciplinary environment.

Background

Curriculum review should be entrenched in all courses and programs in modern universities. Client demands and perceptions vary with time and changes must be planned, resourced and actioned. Over the last two decades, The University of Queensland has nurtured its reputation as a research-intensive university. Faculties recruited academic staff with strong research performance in specific disciplines. This was conducive to the formation of several small boutique departments with light teaching loads, many third level subjects having enrolments of less than twenty students. Over the last three years, economic rationalization and a competitive marketplace led many Faculties to review their operations and restructure; in particular, to identify core activities and allocate resources accordingly. In the Faculty of Biological and Chemical Sciences, ten Departments were progressively amalgamated into three Schools; namely, the School of Molecular and Microbial Sciences (comprising Biochemistry, Chemistry, Microbiology, and Parasitology), the School of Biomedical Sciences (comprising Physiology, Pharmacology, and Anatomical Sciences) and the School of Life Sciences (comprising Zoology, Entomology, and Botany).

The Faculty undertook intensive curriculum review and implemented a rolling reform of all undergraduate subjects (level 1 in 1999, level 2 in 2000, and level 3 in 2001). The rationale for change was to better utilize finite resources, reduce wastage, promote areas of strength, and support staff during workload intensification. Faculty reduced the number of subjects offered by 40%, developed programs and course plans in consultation with prospective employers, and encouraged staff development activities. Service teaching to other Faculties (Natural Resources, Agriculture and Veterinary Science, and Health Sciences) is currently undergoing similar review. Faculty determined that most traditional scientific disciplines could be based on a selection of foundational subjects as many contemporary disciplines had overlapping boundaries and shared technologies. This fostered interdisciplinary collaboration which was also perceived to be vital for the establishment of centres of excellence. Core subjects were introduced at junior levels and multidisciplinary fields of study (including dual majors) were encouraged at senior levels.

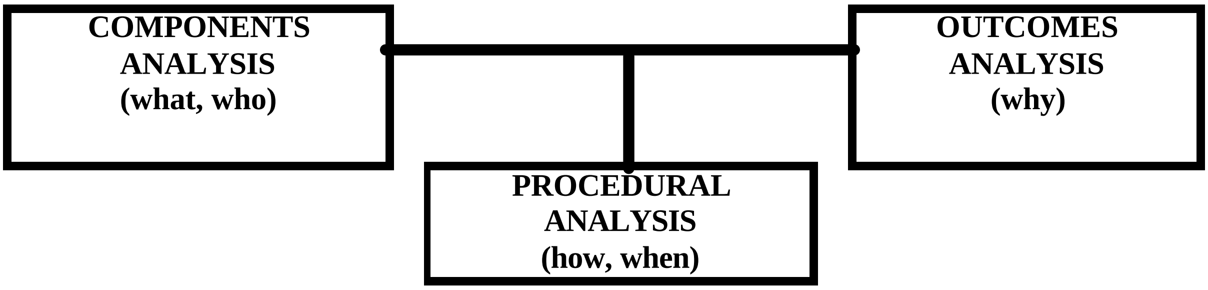
One proposal was that an umbrella subject on the ecology of disease be developed to span disciplines and strengthen links between Departments, Schools and Faculties. The University had identifiable strengths in the topical fields of ‘Infectious Diseases’ and ‘Ecology’ and wished to promote them throughout the pan-Pacific education market. There was also a perceived need to reconstruct Nature; that is, to bring specialist disciplines back together into a holistic subject relevant to the biomedical community. Practitioners wished students to reinforce their preclinical conceptions prior to vocational immersion, particularly ‘pre-med’ students seeking entry to the Graduate Medical Course. Curiously, medical teachers wanted greater emphasis on animal diseases while biologists wanted to extend coverage to human diseases. Both wanted a quantitative science incorporating analytical tools for epidemiology and disease prediction. The subject is available to undergraduate biomedical and biological science students as well as postgraduate students undertaking coursework Certificates, Diplomas or Masters degrees (estimated total annual enrolment of 120 students). It is offered within four degrees and eleven named fields of study and has been affiliated with relevant professional, industry and government agencies to demonstrate relevance, application, utility and prospective employment. The subject area is topical, contemporary and undergoing rapid growth as evidenced by the recent creation of a central Institute for Molecular Bioscience in partnership with industry and government as well as nationwide support for three new CRC proposals in the fields of Ecology, Water Quality and Emergent Diseases.

Project definition

The objective of this project was to design a new preclinical subject on the ecology of disease for biomedical and biological sciences using contemporary educational models to identify and link subject content, delivery and assessment. The problem was to avoid superficial coverage while maintaining unity of vision in the diverse multidisciplinary environment.

The need for a subject on the ecology of disease was identified by Faculty predominantly on the basis of internal factors (such as resource rationalization, content logic, interdisciplinary networking and perceived client demand) and to a lesser extent on external factors (such as vocational demand, community benefit and society need). Various curriculum development models recommend that this process be formalized and that parametric “needs assessments” be conducted with stakeholders (Walker, 1971; Oliva, 1976). Walker (1990) lists the five major conceptions of curriculum as: subjects offered for study; educational activities; intended learning; students experiences; and learning outcomes. Teaching and learning must be considered together, if not in parallel then in series.

Teaching and learning models range from transmissivism (whereby knowledge is transmitted to students) to constructivism (whereby students construct meaning) (cf. Dawson, 1994). These polar models were used to identify three areas requiring analyses. From the teaching perspective, I conducted a “*components analysis*” to define subject content (What?) and identify teaching staff (Who?). From a learning perspective, I conducted an “*outcomes analysis*” to identify desirable attributes students will acquire (Why?). The connecting link is operational so I conducted a “*procedural analysis*” to identify best practice (How and When?). These three areas essentially represent *input*, *output* and *process.*



I believe these areas are comparable with those identified by Walker (1990) in his definition of curriculum as "referring to the *content* and *purpose* of an educational program together with their *organization*." Research on the content, purpose and organization of a specific subject cannot be achieved by any single methodology due to their disparate natures (dominated by objects, attitudes and actions respectively). Multiple approaches must be used to acquire, analyze and interpret data.

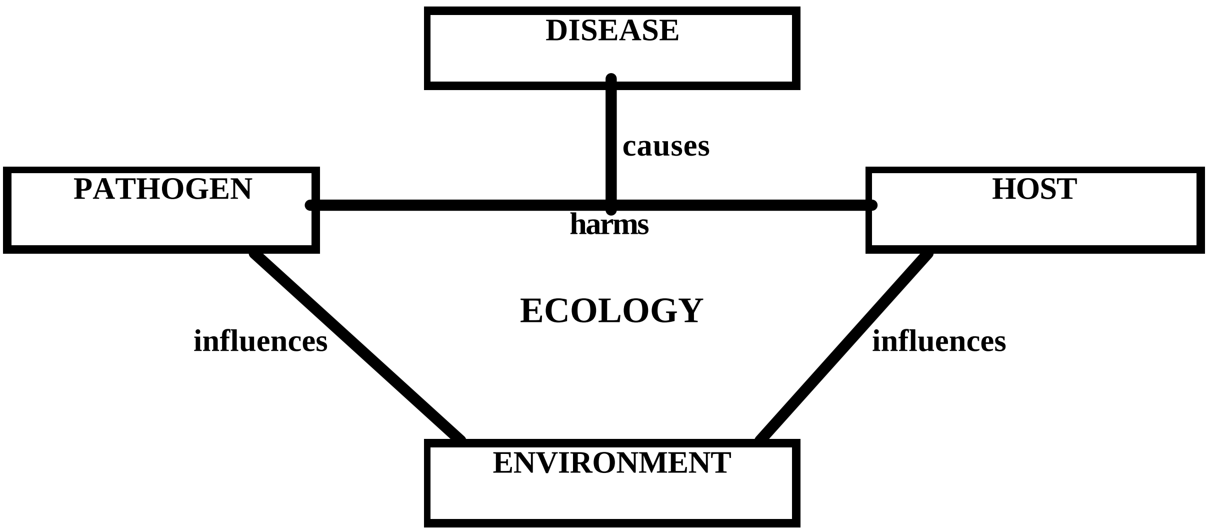
Data acquisition

The three basic principles of experimental design are that an intervention be conducted, that controls be included for comparison, and that experimental bias be negated by randomization. The latter two are difficult to implement in design studies. Education is about affecting change and it would be ideal to measure the degree of change in students before and after an educational intervention or alternatively in one group of students given specific learning opportunities compared to another group denied those opportunities. Subjects should also be selected at random from a larger population and data collected after random allocation to treatment or control groups. These tenets could not be enforced in this study. Information was gathered from both teacher and student groups who were prospective participants in the subject. Teachers (n=10) were nominated as content specialists by cognate departments while students (n=50) were undergraduate volunteers who were interested in taking the subject thereby probably imparting an inherent bias due to motivation levels. The student group was not homogenous and included level 2 students who had not previously studied allied subjects and level 3 students who had recently completed studies in relevant subjects. The teacher group was also heterogeneous and ranged from senior staff expert in subject content and accomplished in delivery through to novice lecturers new to tertiary teaching. The experiences, opinions, attitudes and expectations of the participants were therefore varied which was considered vital for multi-perspective representation.

Data was acquired by triangulation using questionnaires, personal interviews and focus groups. Information was gathered in the two broad categories of subject content and process; including concepts, core content, supportive anecdotes, syllabus, class types, activities, resources, self-directed learning, problem-solving, graduate attributes, assessment criteria, feedback and subject evaluation. All participants were given a questionnaire containing open and closed questions to generate qualitative and quantitative data on process and content. Each participant was personally interviewed to gauge their opinions on content, objectives, activities and assessment. Focus groups were then established to promote discussion and develop consensus on specific issues. Qualitative data was categorized and narrative summaries composed whereas quantitative data was analyzed to determine strongest correlations.

Components analysis

Scientists seldom have difficulty in documenting content particularly in their area of expertise. However, it is often done in an intuitive fashion which is not transparent to others. For this reason, subject content was examined through the process of concept mapping as advocated by Novak & Gowin (1984). Teachers and students were asked to develop individual concept maps and focus groups were asked to develop consensus maps for consideration by the design team. Most respondents defined the ecology of disease as the scientific study of the interactions between pathogenic microorganisms, their hosts and the external environment to explain disease occurrence and distribution. It was perceived as an integrative multidisciplinary subject attempting to reconstruct natural relationships from relevant microbial, organismal and environmental sciences. Pathogens interacted with their hosts causing disease while environmental interactions affected morbidity, mortality and transmission patterns. A consensus map was derived which was essentially pyramidal with core components forming the base, the apex indicating disease, the faces comprising interactions and the whole body representative of Ecology.



Outcomes analysis

Educational imperatives for the subject include extrinsic social factors such as vocational competencies as well as intrinsic student-centred attributes such as active learning, autonomy and accountability (Elliott, 1998). Specific outcomes identified by teachers could be aligned with content with an emphasis placed on application skills. For example, specific learning outcomes included the ability to differentially diagnosis infections, deduce transmission cycles, assess risks and hazards, plan surveillance programs, predict distribution patterns, devise management strategies, collect and analyze relevant parameters, and critically interpret data. In addition, higher order attributes were identified similar to those listed in The University of Queensland Teaching and Learning Enhancement Plan (2000-2002) which included communication, IT competency, problem solving, critical thinking, scholarship, and interdisciplinary perspective. Desirable learning outcomes could be allocated into the three domains of education recognized by Bloom (1956-1964); namely, cognitive (knowing), affective (attitudes) and psychomotor (doing). Six categories are recognized in the cognitive domain (knowledge, comprehension, application, analysis, synthesis and evaluation) and five in the affective domain (receiving, responding, valuing, organizing and characterizing) (cf. Walker, 1990). While no formal categories have been proposed in the psychomotor domain, generic research behaviours, manipulative skills and technical competencies were identified as most desirable and practical.

Procedural analysis

Numerous models have been proposed for curriculum development (objectives versus process models), providing instruction (scope, sequence, schedule models), conducting assessment (measurement and standards models), undertaking evaluation (intuitive versus systematic approaches) and performing educational research (process, product, learning and causal paradigms) (cf. Oliva, 1992). Traditional theory-practice models gave rise to a number of objectives models which specify educational aims and subdivides them into behavioural objectives (statements of intended learning outcomes). (cf. Elliott, 1998). Several prescriptive models have been described whereby objectives are selected from students, society and/or subject matter (Taba, 1962; Tyler, 1949; Oliva, 1976; Saylor *et al*., 1981) and some descriptive models have advocated deliberation to resolve curriculum issues (Walker, 1971). Critics of objectives models suggest that this standardization of learning outcomes engenders student passivism and promotes individualistic learning. They advocate process models which view discovery learning as cultural induction and more conducive to the development of social competencies and affective dispositions (Stenhouse, 1975). Both types of models profess to being able to respond to social change through reform.

I considered the design of this new subject to depend on developing clear vision statements particularly since several disciplines are represented which may have divergent views. This mandated the use of an objectives model but consideration was given to operational parameters. A strategic design model was adopted (cf. Foster, 1993) which considered mission (purpose), goals (attributes), objectives (operational), structure (organizational) and evaluation (criteria). Goals were given as statements of purpose in general terms without criteria of achievement whereas objectives were stated in specific measurable terms (cf. Walker, 1990). This model was similar to the systematic model of Oliva (1976) but lacked preliminary contemplation of philosophical and psychological principles of education. The strategic model was also compatible with business planning models familiar to many administrators (an advantage for future promotion and marketing exercises).

However, curriculum has various meanings in relation to action. Five categories have been defined as envisioned, developed, enacted, assessed and learned curriculum (Butler, 2000). This project was concerned with the planning categories (envisioned and developed curriculum) whereas research on operational categories (enacted, assessed and learned curriculum) is scheduled as part of regular review processes. The translation of curriculum from theory (planning) to practice (operation) involves interactions between many component parts, including instruction, assessment and evaluation. Different relationships between curriculum and instruction have been described in dualistic, interlocking, concentric, cyclical and spiral models whereby content and action exhibit no, partial, total, continuous or periodic dependence respectively (Oliva, 1992; Harden & Stamper, 1999). Integrative approaches have recently been taken a step further with the formulation of the constructive alignment model (Biggs, 1999) which brings together curriculum, instruction and assessment.

CONSTRUCTIVE ALIGNMENT MODEL (Biggs, 1999)

TEACHING/ LEARNING ACTIVITIES	CURRICULUM OBJECTIVES	ASSESSMENT TASKS
a **b**	**A** **B**	**a'** **b'**

This model aligns curriculum objectives with teaching and learning activities as well as relevant assessment tasks. Objectives are defined in clear measurable terms, activities are chosen to realize those objectives, and assessment criteria address particular objectives. This makes the system transparent to both teachers and students and fosters engagement and reflection. I adopted the constructive alignment model as the basis for developing learning outcomes. Partial alignment models have previously been used in physical, biological and earth science curriculum development, including the FAST model (Foundational Approaches in Science Teaching) aligning interdisciplinary foundational concepts and methodologies with formal and informal evaluation mechanisms (Brantley *et al.*, 1983). Evaluation, however, is not assessment. It focuses on program efficacy rather than student performance.

Student assessment may be formative (process-oriented) or summative (content-oriented). In the past, heavy emphasis has been placed on summative assessment tasks to measure learning rather that formative assessment to support learning. Summative assessment has traditionally been facilitated by 'measurement' models which rate individual performance against population normal distributions rather than by 'standards' models which criterion-reference higher cognitive level performances (Taylor, 1994). Five hierarchical levels of understanding are recognized within Bloom's SOLO (Structure of Observed Learning Outcomes) taxonomy (cf. Biggs & Collis, 1982; Biggs, 1999); i.e. prestructural, unistructural, multistructural, relational, and extended abstract. Desirable learning outcomes should involve higher order understanding and assessment tools should evaluate cognitive, metacognitive and social competencies and affective dispositions (Dochy *et al.*, 1999). In this project, I used the SACK alignment model (acronym for Skills, Attitudes, Concepts and Knowledge) which was developed to link curriculum, instruction and assessment with the cultural and learning experiences of students (Sappier, 1996).

Integrated alignment

The constructive and SACK alignment models were combined and data gathered from participating teachers and students incorporated into an alignment matrix. The study concentrated on the relationships between objectives, activities and assessment which were most obvious from the data collected. Most information originated from the focus groups which were able to discuss specific issues and occasionally from personal interviews with individual participants. In the following table, I have not weighted or ranked any conclusions but have simply allocated them to pertinent categories or domains recognized within educational theory. The resultant model therefore represents a consensus design by prospective teachers and students aligning what most considered core content with appropriate instructional activities and relevant assessment tasks.

INTEGRATIVE ALIGNMENT MODEL FOR ECOLOGY OF DISEASE

TEACHING/ LEARNING ACTIVITIES	CURRICULUM OBJECTIVES	ASSESSMENT TASKS
	<u>SKILLS [psychomotor domain]</u>	
❑ **practical sessions (+ computer lab)** [tutor-controlled] (applied examples)	❑ **develop diagnostic and analytical skills:** e.g. • identify pathogens • characterize diseases • apply mathematical models	❑ **practicum (solve problems)** [multistructural] (describe, list, analyze)
	<u>ATTITUDES [affective domain]</u>	
❑ **tutorials (problem-based)** [peer-controlled] (clarify, reflect)	❑ **appreciate interrelationships between composite parts:** e.g. • discriminate patterns • deduce transmission • assess hazards	❑ **project report (case study)** [extended abstract] (theorize, hypothesize)
	<u>CONCEPTS [cognitive domain]</u>	
❑ **seminars (with questions)** [self-controlled] (topical anecdotes)	❑ **comprehend ecological conceptions:** e.g. • explain distribution • define delimitors • recommend control	❑ **assignment (literature review)** [extended abstract] (generalize, summarize)
	<u>KNOWLEDGE [cognitive domain]</u>	
❑ **lectures (plus readings)** [teacher-controlled] (preselected content)	❑ **categorize diseases within biomes:** e.g. • characterize infectious diseases • list hosts and vectors • define environmental factors	❑ **written exam (short answers)** [relational] (compare, contrast)

All objectives were readily categorized as Skills (psychomotor domain), Attitudes (affective domain), Concepts or Knowledge (cognitive domain). Students prioritized their learning issues in that order (S-A-C-K) while teachers ranked their teaching issues alternatively (C-K-S-A). There was heavy emphasis placed on practical applications involving diagnostic and analytical skills, particularly by students. Both groups considered that student appreciations of interactions between biological and environmental sciences needed to be re-assessed. This was regarded as essential for better comprehension of fundamental principles, especially underlying disease distribution and control. The acquisition of specific knowledge was thought to be best facilitated through the structured presentation of topical examples.

Both teachers and students were quite eclectic in their selection of teaching and learning activities, favoring combinations of transmissivist and constructivist approaches to provide variety and presumably cultivate different learning outcomes. Activities ranged from teacher-controlled lectures and recommended readings, tutor-controlled interactive practical and computer laboratories, peer-controlled problem-based tutorials, and self-directed learning through seminars on contemporary topics. Practicals were aligned with skills acquisition, lectures with knowledge transfer, tutorials with attitude modification, and interactive seminars with concept comprehension. Emphasis was placed on activities promoting skills practice, interactive discussion and problem-solving.

Multiple modes of assessment were selected by participants with most preferring progressive summative assessment with detailed documented feedback. Curiously, few mentioned formative assessment although many subsequently indicated they regarded it as integral to modern courses. Open-book and computer-assisted practical examinations were aligned with skills demonstration, verbal and written project reports with assessing attitudes, essay-style literature reviews with testing conceptions, and traditional written theory examinations with knowledge depth and diversity. Most assessment tasks required higher order understanding involving multistructural, relational and extended abstract hierarchies. Assessments were weighted differently by teacher and student groups with teachers favoring written examinations and students preferring projects and practicals. Most participants were familiar with measurements models of assessment and actively discussed marking and grading. Few, however, contemplated standards models involving assessment criteria aligned with learning objectives. Although criterion-referenced assessment was finally endorsed as university policy in 1997, it has been slow to be instituted in its correct form and continues to be plagued by misunderstandings and misconceptions by both teachers and students. The final challenge to be faced within the planning phase of this design project is to specify assessment criteria for each learning objective and define appropriate standards of performance. I take heart from the observation that there is no single right solution to any teaching and learning problem but a multitude of choices involving a multitude of educational models.

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