

EDUCATION PEDAGOGY FOR SPATIAL SCIENCE PRAXIS

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ABSTRACT

In preparedness for work environment policy, technology and professional application challenges, professional education must enable students to determine learning opportunities that best suit their personal and professional needs. The diverse needs for professional practice within the geospatial (surveying and mapping) profession have defined a requirement for new approaches and multiple varied work oriented learning opportunities.

The Spatial Science profession is embracing needed change to reflect specific changes imposed by the current and perceived future professional practice and social environment (Young, 1994 and Young, 2004). The University of Southern Queensland has a unique suite of undergraduate study options from which individuals can choose to enter the spatial science profession. The opportunity to choose on-campus and off-campus delivery modes of study, and to move freely between these modes and different qualification levels, realises the dilemmas facing emerging and future professionals and employers. Similar opportunities are also available for higher degrees candidates, other professionals and continuing professional development.

This paper will concentrate on examining the major criteria and benefits of the new user-defined technical and professional education Spatial Science programs developed at the University of Southern Queensland. The praxis of these programs will emphasise a particular effective teaching pedagogy that strongly motivates learning and inculcates desired problem solving techniques, lateral thinking, teamwork and communication attributes. The paper will also demonstrate the application of the graduate's professional skills in meeting the challenges in spatial science.

BIOGRAPHY OF ASSOCIATE PROFESSOR FRANK YOUNG

Associate Professor Frank Young completed nine years the Royal Australian Survey Corps, experiencing geodetic and topographic surveying, photogrammetry and cartography, with a further three years teaching in these disciplines. Following three years lecturing in Papua New Guinea, he commenced lecturing at the University of Southern Queensland in 1982 where he is now the Head of surveying and Land information. His main professional interests are now with the cartographic and GIS/RS spheres and educational pedagogy. His major responsibilities are undergraduate and post-graduate supervision, Discipline management, lecturing, and the development of distance educational material.

INTRODUCTION

The spatial science profession is initiating changes to reflect diverse current and perceived future professional practices and imposed social environment needs (Young 1994 and 2004). Similarly, education pedagogy and choice should evolve to empower students to determine learning opportunities to suite their personal and professional needs in preparedness for these new approaches and the opportunities in multiple and varied work environments.

The University of Southern Queensland has a unique suit of undergraduate study options, from which individuals can choose to enter the spatial science profession, that enable graduates to fit and develop with spatial science practices and trends. The opportunity to choose on-campus and off-campus delivery modes of study and to move freely between these modes, different qualification levels and the surveying and GIS majors realises many of the dilemmas facing emerging and future spatial scientists. Particular teaching pedagogy developments to inculcate desired problem solving techniques, lateral thinking, application possibilities, teamwork and communication attributes will further motivate learning and interest in professional studies and developing a more useful graduate.

This paper will concentrate on the undergraduate spatial science programs researched and developed by the University of Southern Queensland for the spatial science industry. It will also demonstrate how study can be *user-defined* and how the application of the graduate's professional attributes melds to the varied challenges facing spatial sciences practice.

BACKGROUND

The formation of the Spatial Sciences professional body is embracing changes that reflect recent and continuing political, social environment pressures and professional practices which include modern technology, increased teamwork environments; an increasingly diverse range of work situations and individual's workplaces; job mobility; accountability and a more intense legal environment.

Spatial science education needs to both reflect these changes and anticipate future needs. This requires providing a stimulating and relevant learning environment to generate enthusiasm and good learning and encourage more students to enter the spatial science profession in one of the variety of work modes. As a starting point, the University of Southern Queensland (USQ) provides a variety of learning and educational strategies for prospective students with varying backgrounds, locations, work environment needs, forms of access and levels of learning. These options also encompass employers and government's demands for specific graduate attributes and qualification or certification that establishes competence and meets society's quality requirements. Different levels of educational qualification, with the option to upgrade to a higher degree levels, need to be available to address different work practices, workplace changes or personal convenience. Industry wide research has identified the the needs of different levels of employment require a multifaceted education and training structure.

The USQ curricula must account for a heterogeneous student cohort (national and international - Transnational) where 75% of students study by distance education (McDougall et al. 2003) because work, family or personal reasons prevent them from attending campus during normal hours. While the majority of students reside throughout Australia, many of the students have been recruited offshore from one of approximately 50 countries. Hence there is a diversity of pre university education and experiences, plus ongoing different experiences, to be considered. One example concerns Australian school leavers: Schools are responding to their own pressures and offering a greater breadth of education at the expense of depth in specific areas, a problem also experienced in New Zealand (Hannah 2004). The student cohort generally has a broader integrated approach to knowledge and skills and their application, but lack a deeper learning and understanding abilities, compared to students from alternative routes (work place, mature age, overseas experience, TAFE, etc), in material pertinent to commencing university studies in spatial science. A specialised assimilation process to accommodate this heterogeneous student cohort is an increasing pressure, within our globalization and Australian professional accreditation context, to ensure each student realizes his or her best potential.

The USQ's spatial science program's development and re-accreditation retained or enhanced existing valued attributes and institutional supporting facilities. The option of a fourth *professional* year of study in geographic information systems (GIS) was introduced into the new integrated and articulated suit of programs incorporating identified changes required to meet the needs of prospective students, society and the spatial science profession employment.

Society and government are also increasingly scrutinising professional activity and expect higher levels and breadth of technical abilities, reporting, analysis, evaluation, assessment, conceptualisation and synthesising. Our applications of these professional practice processes must be contextualised and related to any impact on society and government thinking i.e. has social spatial connectivity. Hence, professional practice education should provide skills to enable graduates to be proactive, innovative and have lateral thinking or entrepreneurial skills. Although conclusive knowledge of future expertise is not possible (Young 1997; 2004; and Hannah 2004), new graduates entering professional praxis will need to have:

- Good communication skills;
- Current technical competence;
- A high level of conceptual and thinking skills;
- A capacity for innovative thinking, good judgements and analytical and critical evaluation;
- An ability to adopt and adapt;
- A spatial science's technology literacy and numeracy;
- A spatial connectivity ability;
- A capacity for contextual understanding of their work environments;
- An ability to discriminate between and use information sources;
- Administrative, management and human relations abilities;
- A capacity to synthesize knowledge for solving problems and decision making;
- Knowledge of individual responsibilities and accountability;
- Skills to manage projects within time and resource constraints;
- An ability for future independent and lifetime learning; and
- A suitably developed attitude, motivation and behaviour focus in accordance with the profession.

While most of the USQ's spatial science program's courses incorporate problem based learning (PBL), recently introduced specific PBL courses have been integrated into the curriculum to assist in meeting the needed changes in graduate attributes. In particular, PBL aimed to address the University's explicitly listed graduate attributes of teamwork, communication skills and problem solving: early feedback shows students and employers both appear to support the PBL concept. The specific PBL courses were designed for both on-campus and off-campus distance education (national and international - Transnational) students, who are of different ages and have diverse cultural, experience and education backgrounds, and are studying in a large range of spatial science and engineering programs. The specific PBL courses deal with solving a case or a situation in a team environment with tutorial support from a staff coordinator or facilitator. These courses are discussed in detail later in this paper.

SPATIAL SCIENCE CURRICULUM OPTIONS

As an integral part of the Faculty of Engineering and Surveying, the Surveying and Land Information Discipline offers its own unique spatial science degree programs but shares some individual courses (subjects) with pertinent engineering programs. These programs form a new articulated suite of different undergraduate degree levels (Table 1) of offerings that enable students to progress to their highest potential in the major of their choosing.

The spatial science programs have also been structured to accommodate the diverse avenues by which individuals enter the university: this includes Transnational applicants from Year 12 (or equivalent), another discipline, change of major specialisation, mature age situation and another institution. Year 12 students can enter any of the undergraduate programs of their choice, restricted only by their level of achievement at school: from a lower degree level they may progress to higher degree levels based on their university study achievements. Potential students from other programs and other institutions are offered credit on previous studies to reduce the time and cost to achieve their aims. USQ offers a Tertiary Preparation Programs that enable individuals, without the minimum year 12 matriculation or an inadequate language or mathematical abilities or no other tertiary studies achievements, to achieve a suitable tertiary entrance standard. This program can be completed on-campus or off-campus without leaving a current work place or home. These student options also enables employers to manage opportunities, including cadetships, scholarships or time release, while still accommodating workplace needs.

COMMON COURSES			ELECTIVES		RESIDENTIAL SCHOOLS		STUDY TIME	
	Total courses	Common/ Core + major courses	SVY	GIS	SVY	GIS	F/T	P/T
ADSS	16	9 + 7	1	1	2	2	2 years	4 years
BSST	24	13 + 11	2	2	4	3	3 years	6 years
BSPS	32	19 + 13	3	4	6	5	4 years	8 years

CODES:

ADSS - Associate Degree in Spatial Science
 BSST - Bachelor of Spatial Science Technology
 BSPS - Bachelor of Spatial Science

SVY - Surveying
 GIS - Geographic Information Systems
 F/T - minimum full-time study duration
 P/T - minimum part-time study duration

Table 1. Course commonality of undergraduate programs.

Figure 1 depicts all the available spatial science programs, their interrelationship and the optional graduate exit points. These options are particularly pertinent for past graduates seeking further qualifications or continuing professional development.. However, this paper will concentrate only on the research outcomes that provide the undergraduate options and interrelationships, as they address the pedagogy that empowers emerging professionals entering the spatial science profession

In Figure 1 the two major spatial science study options depicted are surveying and GIS. For both there is the four (4) year Bachelor of Spatial Science degree, the three (3) year Bachelor of Spatial Science Technology degree and the two (2) year Associate Degree in Spatial Science. The study paths of each major are hierarchical with seamless articulation between each degree level. The high course commonality between these majors, vertical articulation and articulation between majors, and various exit and re-entry options will be discussed in the following sections. Free movement between the surveying and GIS majors enables students to smoothly correct an initial wrong career decision. It is the interrelationships between the programs that help provide students with multiple options while satisfying the diversity of the spatial science profession's needs or development within employment.

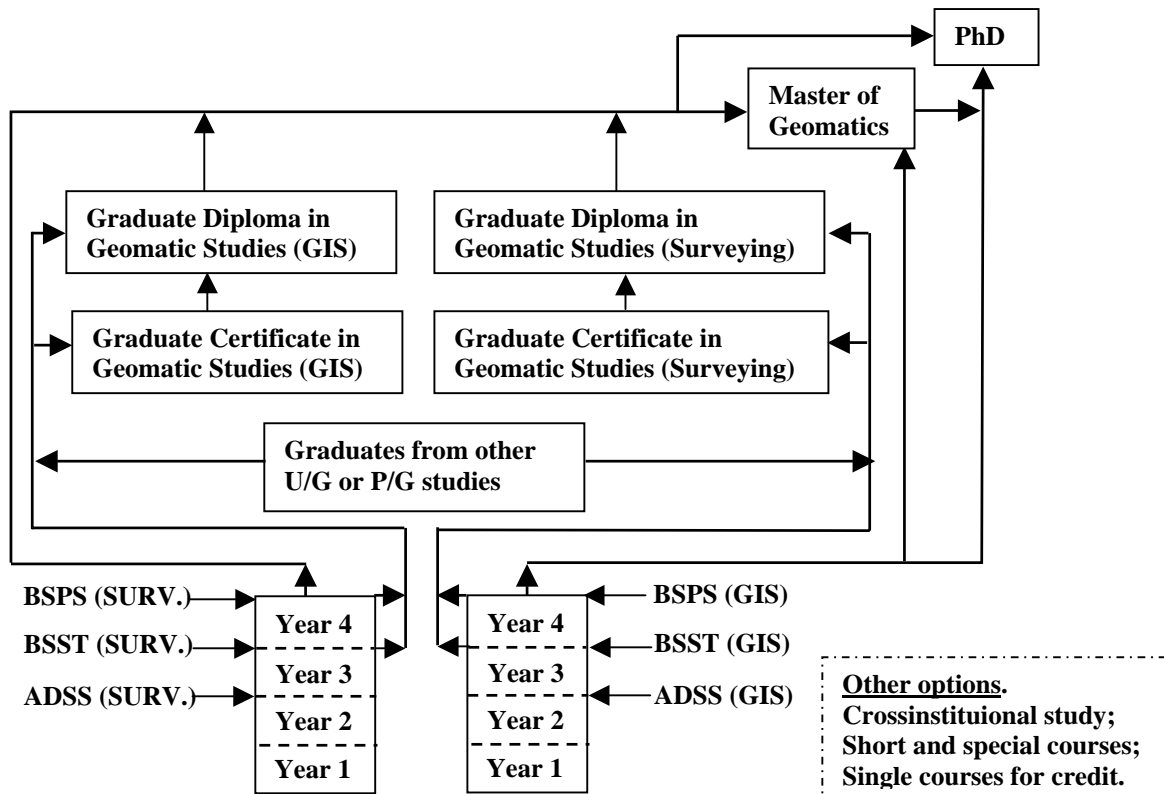


Figure 1. Spatial science program's interrelationships and entry and exit options.

The hierarchical structure and seamless articulation of the programs were developed specifically to address the following cognitive stages of professional development appropriate to a student's needs and different practice levels within the spatial science profession:

- First-year courses assimilate students into the profession and its role. It also establishes basic technical competence; technical knowledge; organising; communication and problem solving abilities.
- Second-year courses provide a higher technical competence and applications knowledge and ability for graduates to lead a small field party or complete more complex technical tasks under supervision.
- Most of the highest technical competence and understanding is achieved with the completion of the third-year courses. Graduates can independently conduct, report on and manage technical tasks.
- The fourth-year courses are largely professional and project management skills oriented but include higher 'academic' research studies. This year prepares graduates to meet professionalism and management demands, the intellectual challenges of continuing professional development, and address higher level technical and innovative application needs. The capstone Research Project, which integrates all the knowledge and skills of the enabling courses, incorporates the major professional standard report writing and verbal communications outcomes.

Student Empowered Study Options

By choosing one of the available six degree options, in either the off-campus or on-campus study mode, students select a program that best suits their financial, workplace, technical or professional and personal needs (McDougall et al. 2003; Young 2002). If they enter at a 'lower' level degree they are able to progress, or later return, to a higher degree program with full credit of their previously completed studies. Similarly, if a bachelor program is unable to be completed, a student may revert to a lower level program and, with sufficient course credits, graduate with a recognised qualification.

Figure 2 separately displays each of the degrees and the two major (surveying and GIS) study options for the Bachelor of Spatial Science degree, Bachelor of Spatial Science Technology and Associate Degree in Spatial Science: Figure 3 combines the degrees to demonstrate the commonalities. The colour coding in the *Common/Core* section depicts the courses common to the different degree levels and both the majors. Certain courses are studied in each degree: the difference between degrees is the inclusion of courses not studied at the lower levels. There is also course commonality across degree levels within both of the majors in the *Majors* section. Within the majors specialisation courses a number of electives allow individuals to further choose preferred or workplace needed specialisation.

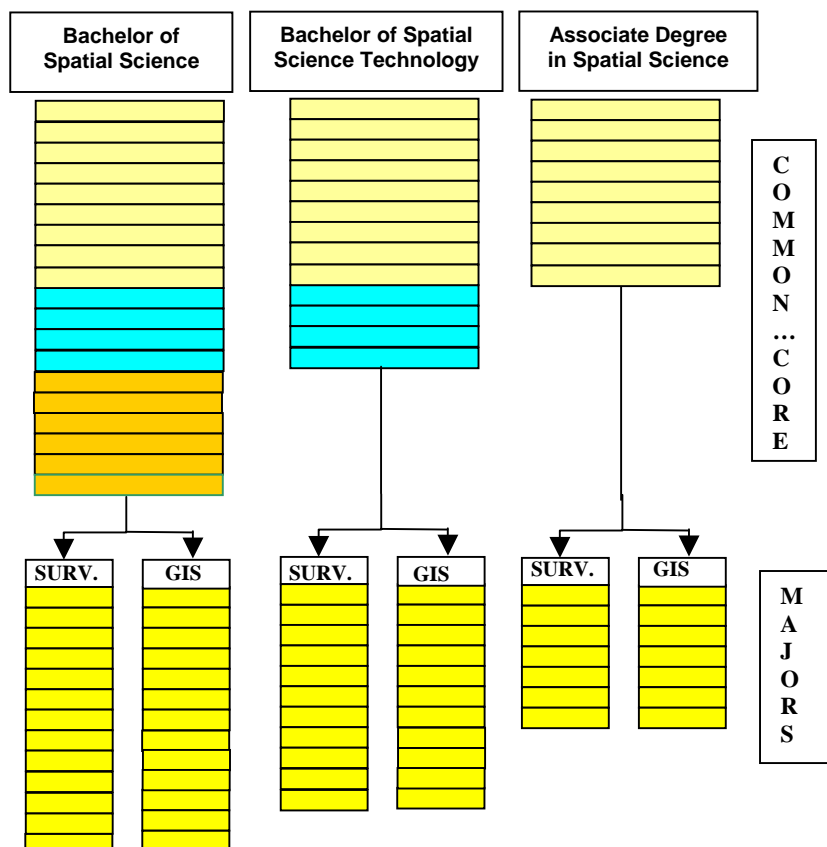


Figure 2. Suite of degree programs options.

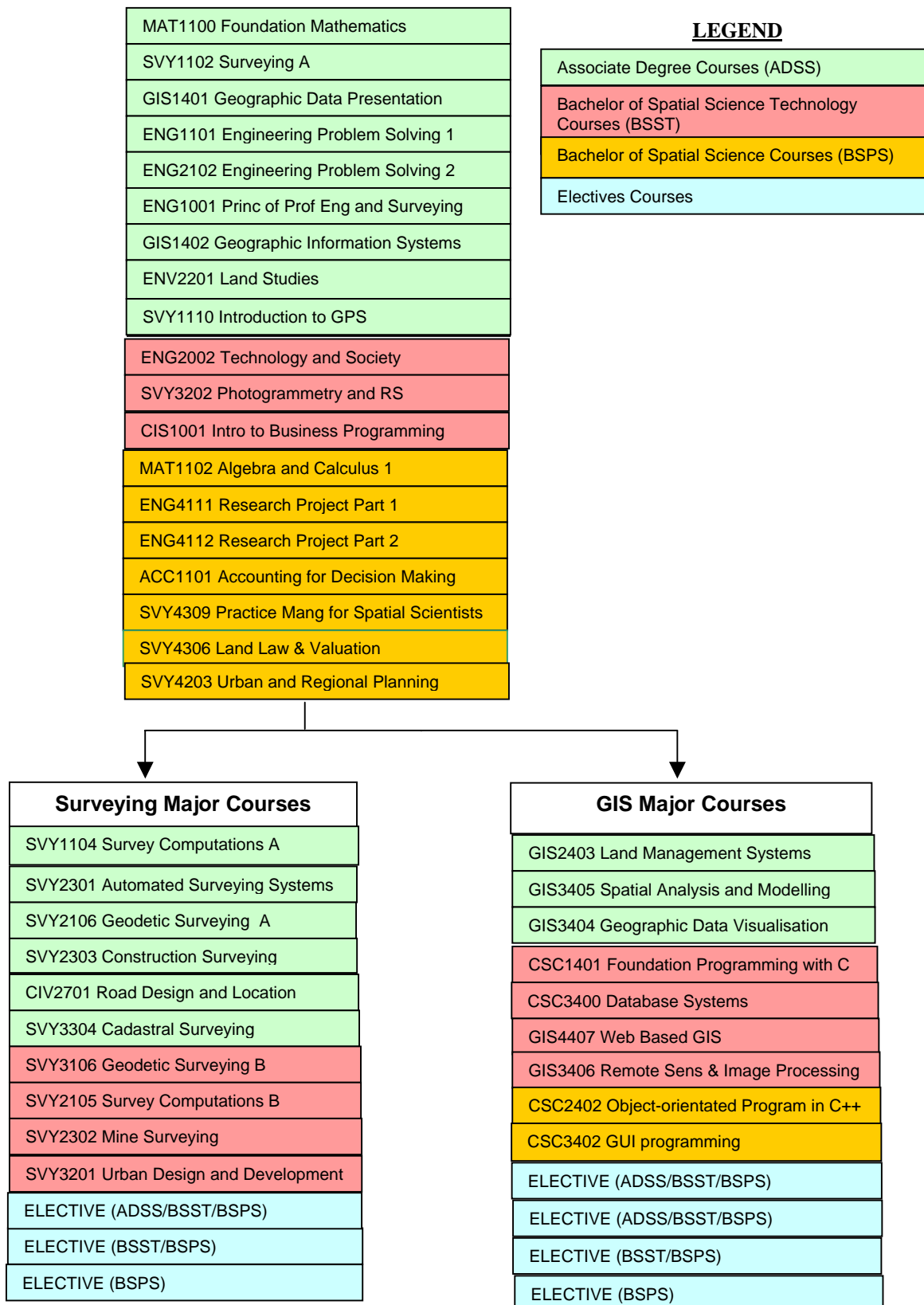


Figure 3. Commonality between programs and content of degree levels

User defined education works best when the user can choose from a range of appropriate and substantial student support. Administrative, distance education and academic staff are all contactable through a variety of mechanisms including: email; telephone; facsimile; post; Outreach (a specialised student support service); regional centres; the on-

campus international Office; offshore agency offices; and through the *USQConnect* student web portal. Students select which of these services they require to assist in pedagogical aspects pertinent to individual needs.

The majority of the courses have customised study materials developed by the staff. These may include an introductory book (assessments and administration and study information); study book; book of readings; and multimedia enhancement materials (hardcopy, CD/DVD or web based). The first two chapters of each study book are accessible via the web to enable student to commence before the study material arrives through the post. This allows off-campus students to better manage their own time and provides a near equivalent teaching and learning experience and information access to that of the on-campus student. The communications and material support assists students to better balance their work and study commitments.

PEDAGOGY FOR EMERGING SPATIAL SCIENCE PROFESSIONALS

The USQ curriculum includes foundation courses that ensure appropriate fundamental technical, mathematical and science abilities, plus personal and interpersonal skills, are learnt early. These contextualised competencies focus on the diversity of practices in the spatial sciences profession: the different major study options provide the specialisations' competence and knowledge depth. Specific task oriented Practice Courses further consolidate technical skill learning in individual courses within the programs. Practice courses are conducted as on-campus residential schools (all of one week duration: refer table 1) for the off-campus students for: practical training; face-to-face contact with staff; assessment; and to experience the university ethos. Other practical *assignment* assessment is completed off-campus. As students in the work place they have an advantage of continuous on-the-job team work experiences, technical practice and verbal communications development.

Not all workplace needs are technical or professional specific applications. Specific problem based learning pedagogy in all courses is playing an increasing role to *realistically* prepare graduates for the challenges faced in a team workplace praxis.

The Need For Problem Based Learning

USQ's Transnational student cohort continue to use multiple pathways to enter both the para-professional and professional program levels: 75% of these students are studying from a distance with no chance (other than residential schools) of face-to-face meetings. We are also unable to depend on all commencing students having prerequisite knowledge and equitable educational standards. In admitting a diverse student population into programs there is a duty of care to ensure that they all have a reasonable chance of success with no particular innovative or traditional education background being a disadvantage. The concept of problem based learning aims to use the unique student experiences diversity and abilities in a collaborative and co-operative based learning environment to the advantage of all participants.

Problem based learning achievements can be likened to the more commonly discussed competency attributes of professionals. A *competency is defined as a combination of attributes, such as knowledge, abilities, skills and aptitudes, underlying specified aspects of successful professional performance* (Higher Education Division 1992). While problem solving is listed as a professional competency, the problem solving courses teach the professional competencies that have been identified and include: collection, analysing and organising information; communication; planning and organising; team work; mathematics application; problem solving and using technology (NTB 1992). Competency standards are applicable to all levels of training and education, from mundane tactile tasks to the highest level of professional attitudes. Hence, problem based learning principles are of significant importance in contemporary spatial science education.

Learning from team based problem activities advances verbal and written communication skills, comprehension of group dynamics, personal and interpersonal skills and problem solving abilities. It also inculcates cultural change and awareness; create an understanding of the diverse possible solutions alternatives; assists in comprehending entire curriculum aims; and how to work in an international environment. It has also been hoped that problem based learning will further enable student's to understand their chosen career path and generate more interesting and exciting learning (Brodie and Porter 2004).

Problem Based Learning in the Program

The PBL courses are core Faculty of Engineering and Surveying courses conducted across all has nine discipline majors (surveying, GIS, civil, agricultural, environmental, electrical and electronic, mechanical, mechatronic and computer systems). The spatial science programs contain only the first two plus a core final year Research Project dissertation: other problem learning is contextualised within most courses and the practice courses. Including the multidisciplinary PBL courses in the spatial sciences programs has enhanced the attributes required by the spatial science profession through the student's involvement globally in a multicultural environment; in interdisciplinary teams; multi-skilled teams; sharing activities on an around the clock basis; utilising digital communication tools; and working in a virtual environment.

The skills acquired in the Engineering Problem Solving 1 and 2 courses are built on throughout the program as integral elements of each course to achieve professional and technical competence. Increased emphasis has also been given to communications skills through establishing a minimum of one course per year as a *communications benchmark*. This means that, irrespective of the content of a course, 30% of the assessment marks are awarded to the *professional* communication of the outcomes: a pass in the communication element is mandatory as it is regarded as a critical part of problem solving completion. The final year in the Bachelor degrees includes the final problem solving activity in the form of a double credit point independent Research Project dissertation of approximately 25,000 words: there is an associated professional conference environment presentation. This dissertation consolidates all the skills and knowledge gained from the program: it also establishes competence in researching, major report writing and professional verbal communications. Problem based learning methodology and techniques empower students to cope with the technical and non-technical demands depend of curricula content and its delivery and to more seamlessly enter the workforce with more confidence.

Core Problem Based Learning Courses

The first of the specialized non-discipline specific courses, Problem Solving 1, has "*key learning objectives of developing teamwork skills, communication abilities using electronic media, use of spreadsheets, basic statistics and physics. These objects are assessed through four separate team reports on complex, real world engineering (and spatial science) problems and an individual reflective portfolio*" (Porter and Brodie 2001).

In summary, multidiscipline problems solving in teams focuses on the following skills experienced and learnt in context:

- Planning, organising, and managing (group and personal).
- Written, verbal and visual communication.
- Mathematics, physics and statistics knowledge, application and relevance.
- Teamwork and individual contribution.
- Basic research techniques.
- Knowledge-based association with other disciplines and role or function of his/her own discipline in relation to other professions and society.

The four tasks (small projects) in this course are designed to compel student to learn and apply, within a spatial science and engineering context, fundamental computing, physics and statistics content. In addition, there is a reinforcement of study skills; research methodology; lateral thinking and application techniques; personal and interpersonal commitment; and management and responsibilities of professional practice.

The project tasks are designed to be completed within three or four weeks with each progressively more open-ended and challenging than the previous. In the first project task each team elects a team project leader (changes with each project); defines codes of conduct and co-operation measures (unique to the first project but can be developed); and determines their approach and individual member's work contribution for the initial project. Each project is structured for two weeks of research and an individual weekly report to the USQ staff facilitator. Each team has regular scheduled meeting to discuss issues and achieve a consensus for the final group report.

The academic facilitator's role is to monitor this/her teams' activities and provide guidance on the USQ resources: help or interference is generally only given if there are serious administrative difficulties. On-campus students regularly meet face-to face with their team and facilitator and use electronic communications between meetings. The off-campus members of each team rely on virtual meetings via the World Wide Web and Internet as members can be in any world-wide location and time zone. Additional 'course' support, beyond the USQ text external studies material, is the Course Home Page. The interface contains resources links to verbal and written communication methods and

techniques; the team's role; generic codes of conduct and co-operations processes for organizing a team; conflict resolution tips; and dynamic 'FAQ' and notice-board pages. These facilities are part of USQ's integrated, web-based teaching environment that is available to all on-campus and off-campus students to enable students to self design their own learning experience.

Problem Solving 1 commenced in 2002 with 180 on-campus and 165 off-campus students; in 2003 it was 95 on-campus and 130 off-campus students; and in 2004 there were 87 on-campus and 173 off-campus. Each team comprised 6 to 8 students of a mixture of different backgrounds; employment situations; degree levels; and majors (engineering and spatial science).

The four projects account for 85% of the assessment marks with the remaining 15% allocated to the individual student's 'learning experiences' reflections portfolio. For equity and consistency, the team mark is moderated by the individually submitted peer assessments and nominated contribution level of each team member for each project: these submissions are quality controlled from the facilitators' observations. The control of this course is largely in the hands of the participants.

Student and staff feedback has been mostly positive (92% see the benefits with 5% uncommitted). Resistance by staff and students having to work in a team teaching situation has largely disappeared: some students who wish to be *spoon fed* remain unhappy with student centered demands of this course, but the majority of them end up extolling the virtues of the concept. It is only the minority who do not appreciate the value of the multidisciplinary learning and the holistic needs and co-operation in completing a task.

"All of these skills [covered in the course] will be applied in my future study and career, as they relate to the area of work that I wish to be a part of. I have already found that these skills have helped in other areas of study and that I have a more professional attitude towards the tasks I carry out. I have been complimented on my quality of work from my employer and since been promoted." – Student comment June 2005.

Problem Solving 2 builds on Problem Solving 1, encouraging students into self-directed learning in solving more complex real-world technical problems and systems. There is a greater emphasis on higher levels of statistical analysis, research, synthesis, evaluation, application of complex mathematical and scientific techniques, and computer skills to present results. Communication and team work dynamics continue to be a core requirement.

These courses provide a broad spectrum and skills and knowledge plus the ability for self learning. These abilities empower individual learning, interpretation, comprehension techniques and the ability to evaluate and extract the best from the professional course's content and a future work place praxis environment.

CONCLUSIONS

The USQ spatial science programs were researched, strategically planned and systematically integrated to enable an evolution for changes in current and perceived future trends. With the addition on the institutionally comprehensive student support infrastructure, there are sustainable and quality accredited programs in both off-campus distance education and on-campus modes.

The USQ's flexibility through study modes, program content, contextual learning, and interrelated undergraduate program options address student's paraprofessional and professional education needs in a cohesive, integrated and co-operative approach. This structure also addresses the social issues, work place restrictions and the general limited time and economic resources concerns of each individual participant.

Spatial science programs and courses curricula cannot be entirely market driven. The Surveying and Land Information discipline (department) has enhanced the curricula and pedagogy to maintain both professional education standards while incorporating market-place forces and accommodates participant's needs where possible. User defined quality professional education is regarded as highly desirable and has been shown to be achievable.

The introduction of non-discipline specific problem solving courses is proving successful in establishing the basis for successful professional performance. Individual students' reflective portfolios and feedback questionnaires are overwhelming positive towards these courses. There is anecdotal evidence that students are more focused, comprehending and enthusiastic towards their professional course content and aware in their work environment

The USQ's spatial science programs flexibility and options, contextualised problem solving learning and on-campus and off-campus study modes structure provides *user-defined* or *user-determined* education. It empowers students to determine learning opportunities and graduate attributes to suit both their personal and professional praxis needs.

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