

The Bachelor of Civil and Environmental Engineering/Bachelor of Business and Commerce: an innovative 4MAT-based five-year unique Australian double degree programme

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ABSTRACT: The purpose of the present paper extends beyond providing students with the traditional teaching of a double degree. The goal is to train students to think, learn and to exercise competent judgement using 4MAT formation while they are getting the double degree. This summarises the need for the present paper. Consequently, in the paper, the authors integrate civil, environmental, business and commerce teaching in a 4MAT system in relation to the newly established Bachelor of Civil and Environmental Engineering/Bachelor of Business and Commerce programme at Monash University, Australia.

INTRODUCTION

Worldwide, there are plenty of five-year Bachelor of Civil Engineering/Bachelor of Business and Commerce undergraduate double degree courses, as well as plenty of five-year Bachelor of Environmental Engineering/Bachelor of Business and Commerce undergraduate double degree courses. In addition, there are plenty of five-year Bachelor of Civil Engineering/Bachelor of Environmental Engineering undergraduate double degree courses worldwide. However, there is only one five-year Bachelor of Civil and Environmental Engineering/Bachelor of Business and Commerce undergraduate double degree course offered worldwide that has a 4MAT strategy built into its teaching components, which is the subject of the present paper.

Consequently, the purpose of the paper is to introduce to the international engineering education community a new, innovative five-year unique Australian 4MAT-based course, namely the Bachelor of Civil Engineering/Bachelor of Business and Commerce undergraduate double degree programme offered at Monash University, Australia [1][2]. The programme is the first of its kind in the international education arena, to the best knowledge of the authors. Graduates of this programme are prepared for employment in a business environment in which a background of civil and environmental engineering is an advantage, or in pursuits where a blend of business and engineering backgrounds is desirable.

COURSE ANATOMY

The multidisciplinary 4MAT-based course entitled the Bachelor of Civil Engineering/Bachelor of Business and Commerce Undergraduate Double Degree (hereafter abbreviated as BCivEnvEng/BBusCom) has been designed to attract students who are interested in civil engineering,

sustainable development and business management [3]. The business and commerce component will equip students with in-depth knowledge and skills in at least one chosen business discipline, combined with a broad knowledge of all the major areas of business. Students must complete 18 units (108 credit points) from the Faculty of Business and Economics as follows:

- Completion of six compulsory units (36 credit points):
 - AFW1001 Introductory Accounting A;
 - BTW1200 Business Law;
 - ECW1101 Introductory Microeconomics;
 - ETW1102 Business Statistics;
 - MGW1010 Managing People and Organisations;
 - MKW1120 Marketing Theory and Practice.
- A major of at least eight units (48 credit points) in a discipline from the Faculty with at least two units at each second and third-year level. All units taken as part of the major are limited to units taught by departments of the Faculty on the campus delivering this programme.
- A maximum of eight (48 credit points) first-year units.
- A minimum of four units (24 credit points) at the third-year level from those offered by the campus delivering the programme.

The civil and environmental engineering component provides a broad-based capability for the design, implementation and management of civil engineering solutions in an environmental context. The following points are pertinent to the civil and environmental engineering component of the course: Students must complete 24 units (144 credit points). Level one includes basic sciences such as mathematics and chemistry, as well as an introductory engineering unit and an introduction to environmental science. The engineering unit provides a basis for civil engineering studies and will overlap with similar units offered at the main campus of Monash University. Its content

will be supplemented with material associated with environmental engineering.

At level two, students will undertake studies mainly in the areas of civil and environmental engineering. These include geomechanics, structures, hydrology and water supply, as well as environmental modelling. Basic mathematics will also be continued. The civil engineering units will overlap with similar units offered at the main campus of Monash University and will have material associated with environmental engineering added to supplement them. Level three and four units further extend studies in civil and environmental engineering design and analysis with increasingly complex tasks, as well as providing more advanced studies in transport, environmental management and environmental technology.

ATTRIBUTES

Monash University developed this programme following the establishment of a Gippsland Engineering Review Committee by the University Council, and this included external stakeholders from the Latrobe Valley, Victoria, Australia, whose recommendations shaped the resulting BCivEnvEng/BBusCom course. One of those external stakeholders became a foundation member of the programme's Industry Advisory Committee. The Committee consists of members from power, mining, paper, water, environmental, and traffic and transportation industries, in addition to local government and business organisations. The Waste Management Association of Australia classified the programme as one of the *Waste Management/Environment Courses Available in Australia* [4][5].

The accreditation panel of Engineers Australia has already accredited the course [6][7]. The next accreditation visit by Engineers Australia' accreditation panel will come after the course's first students graduate, as per Engineers Australia's accreditation rules.

The BCivEnvEng/BBusCom was designed with the following philosophy in mind:

- The BCivEnvEng/BBusCom programme was designed with the specific needs of accreditation in mind, and informal advice was sought from Engineers Australia in that process.
- The course is structured specifically to address the essential elements of a professional engineering programme and to identify how the generic attributes of a graduate would be achieved, and related the course objectives directly to the achievement of the generic attributes, showing how the methods of teaching and learning and the methods of assessment would contribute to this outcome.
- The Education Committee and the Faculty Board of the Faculty of Engineering, Monash University, Australia, approved the course.
- The Faculty of Business and Economics at Monash University was fully consulted at all stages of the course's development, and its Education Committee considered the structure and content of the course to ensure that the units offered in the programme by that Faculty were consistent with the Faculty's long-term strategy.
- Any changes to the programme pass through the normal approvals processes of the Faculty of Engineering at Monash University, and are considered by the Faculty of Business and Economics at Monash University through

the provision of information for noting by its Education Committee.

- Every course approved within Monash University must include a clear statement of its objectives. These objectives take the form of statements of the knowledge and understanding, professional skills and the attitudes and behaviours that a graduate is expected to have acquired upon successful completion of the course of study. The specific objectives of the BCivEnvEng/BBusCom are:
 - To develop skills and knowledge for the design and management of sustainable civil and environmental engineering infrastructure and solutions;
 - To develop an ability to carry out such engineering activities in a manner that minimises or eliminates negative environmental impacts;
 - To equip students with the knowledge and skills base to identify and implement civil and environmental engineering solutions to minimise the use of the earth's resources, drawing on both the business, commerce and engineering technologies, together with the relevant management and regulatory frameworks;
 - To develop an appreciation and knowledge of business, commerce and engineering strategies for identifying and mitigating any negative impacts;
 - To develop appropriate skills in analysis, synthesis, design, project coordination, evaluation and communication.

The BCivEnvEng/BBusCom programme complies with the recommended Engineers Australia distribution [5]. In summary, the BCivEnvEng/BBusCom distribution is as follows:

- Engineering basic science: Overall, the programme consists of 40% science and 60% civil engineering units. Several of the civil engineering units, particularly the level 1 and 2 units, have a science component. The basic science component is, therefore, approximately 42% in the double degree.
- Engineering design and projects: The project-based learning approach relies heavily on design projects and most units have a design component. This accounts for 22% of the double degree.
- An engineering discipline specialisation: The major disciplines are water, geomechanics and transport engineering; these make up the bulk of the engineering component of the programme and amount to about 26% of the double degree.
- Exposure to professional engineering practice: Several units will be taught with input from engineers from industry, and all the engaged engineering staff members have links with the consulting industry. This component comprises 10% of the double degree.

4MAT INNOVATION

Interdisciplinary Teamwork

The BCivEnvEng/BBusCom double degree course aims to prepare students to be readily adaptable at a professional level for civil and environmental engineering practice that requires knowledge of modern business techniques, or to a chosen business environment in which a background of civil and environmental engineering is an advantage, or in pursuits where a blend of backgrounds is desirable. The programme has been designed; in particular, to meet the needs of the Gippsland region

in Victoria, Australia, but its 4MAT based multidisciplinary approach will be attractive to any student with an interest in civil engineering, sustainable development and business.

The civil and environmental engineering component provides a broad-based capability for the design, implementation and management of civil engineering solutions within an environmental context. The business and commerce components of the course equip students with a level of knowledge and skills in at least one major study, chosen from accounting, business law, economics, human resource management, international business, management or marketing, combined with a group of five introductory core units from a range of business disciplines.

The course has a policy of encouraging the involvement of guest lecturers at appropriate points in the teaching of individual units. This occurs in all areas of the civil and environmental engineering with an appropriate business and commerce flavour as much as possible. The course's Industry Advisory Committee is extremely helpful in securing industrial site visits and organising guest industry tutors. The programme utilises the final year project as a mechanism to strengthen its links with industry by encouraging students to undertake a project jointly with local industrial partners. The target is to have 50% of all projects jointly supervised by an academic and a professional engineer from local industry.

Students are assessed through a combination of summative and formative assessment, including formal examinations, practical reports, essays, fieldwork reports, management plans, oral presentations and individual projects. This mix varies with the particular unit. Final examinations typically carry 60-70% of the overall assessment in lower level units. Many laboratory-based units require satisfactory completion of both theory and practical components in order to obtain a passing grade. Formative assessment includes online tests with rapid feedback and review exercises designed for self-assessment based on supplied detailed solutions.

4MAT Quadrant One, Right Mode (Type One Learners)

The key objective of the quadrant is triggered by students' involvement in the generation of ideas related to the concepts of the integration of disciplines. Its key elements are as follows:

- Student learning is connected directly to the course's objectives in an investigative way, Internet literature survey and general literature survey;
- An interdisciplinary (civil, environmental, business and commerce) learning experience is constructed that allows for diverse and personal student responses; the formation of multidisciplinary cooperative teams of students are also facilitated at this stage;
- General concepts that are familiar to students first used; this builds on what they already know and then zoom in on topics;
- At this phase of the course, a group discussion/activity is initiated regarding the interrelation of activities of the course's components.

4MAT Quadrant One, Left Mode (Type One Learners)

The key objective of the quadrant is to examine the course concept and its pyramids of disciplinary sub-components. Its key elements are as follows:

- Explore with students the needs to understand the spine units of the course;
- Encourage students to share their perceptions of such needs with industry;
- Summarise and review similarities and differences in basic concepts of sub-disciplines;
- Establish an understanding on the objectives of the course;
- Clarify the reasons and importance of learning the relationships of the course's sub-components;
- Guide students' thinking to synthesise the civil, environmental, business and commerce aspects of the course.

4MAT Quadrant Two, Right Mode (Type Two Learners)

The key objective of the quadrant is to connect what students already know at this stage to what students ought to be taught in a traditional double degree course with an emphasis on engineering judgement, engineering modelling and business strategic aspects. Its key elements are as follows:

- Establish a wider view of the course;
- Emphasise the connection between the civil, environmental, business and commerce aspects of the course and its relationship to students' professional activities;
- Relate what students already know to what the literature survey has found.

4MAT Quadrant Two, Left Mode (Type Two Learners)

The key objective of the quadrant is triggered by defining the units' theories in a traditional lecture and checking students' understanding. Its key elements are as follows:

- Emphasise the most significant aspects of the course;
- Present the units of the course in a systematic and well-organised way.

4MAT Quadrant Three, Left Mode (Type Three Learners)

The key objective of the quadrant is to set exercises based on the reinforcement and manipulation of civil, environmental, business and commerce related problems. Its key elements are:

- Assignments are set to check for thorough understanding of concepts and skills required in the course by Engineers Australia;
- The set units' assignments provide avenues for students to practice new learning in their chosen sub-discipline;
- The set assignments and field trips are driven by high expectations of the quality assurance of skills;
- The quality assurance of skills is set to determine if there is a need to go back to re-lecturing a (previous) quadrant.

4MAT Quadrant Three, Right Mode (Type Three Learners)

The key objective of the quadrant calls for additional assignments and site visits to be designed to extend students and encourage them to tackle advanced ideas. Its key elements are as follows:

- Tutorials and exercises, and Internet-based laboratory experiments, are set up in a way where students have to find information not readily available (or not available at all) in their textbooks;

- The opportunity for students to design their own open-ended skills developments is an integral part of this quadrant.

4MAT Quadrant Four, Left Mode (Type Four Learners)

The key objective of the quadrant is to evaluate assignments' usefulness and industrial applications. Students must reach the ability to refine the problem. Its key elements are as follows:

- Students are encouraged to develop their own further development of educational refinements and patterns;
- Students must maintain high expectations for the detection of educational refinements and patterns;
- Students must explore their own mistakes as systemic mechanisms for learning enhancements;
- Students must be able to evaluate their own cumulative experience.

4MAT Quadrant Four, Right Mode (Type Four Learners)

The key objective of the quadrant is triggered by transforming the gained knowledge into an integrated understanding with a total quality assurance of skills. Its key elements are to:

- Highlight the new advances in relation to civil, environmental, business and commerce;
- Allow students to practice new educational problems patterns of a civil, environmental, business and commerce nature;
- Share students' learning experiences by relevant industries for comprehensive feedback;
- Create an enthusiasm on the part of students to handle future forthcoming applications of problems that have an interdisciplinary nature;
- Promote the eagerness of students to integrate learning into their future professional work.

CIVIL-ENVIRONMENT/BUSINESS-COMMERCE CROSS-FERTILISATION

One of the advanced features of the BCivEnvEng/BBusCom is the course's adaptively dynamic and well-rounded emphasis on the process of modern civil-environment/business-commerce cross-fertilisation of applications and Problem-Based Learning (PBL). This is achieved in a consultative way, among staff teaching in the course, pertaining to ongoing suggested engineering and business applications relevant to the programme's units.

DISCUSSION AND SUMMARY

Feedback from current students and industries has been overwhelmingly supportive, as reported by Engineers Australia during their course accreditation visit. The immediate lesson that has been learned from industry is to introduce industry-based projects and practices in learning and teaching. The biggest challenge that had to be overcome was to successfully implement the 4MAT-based cross-fertilisation between

engineering and business subjects. In order to achieve this, seminars had to be introduced for academic staff in order to show them how to *look over the fence*, outside their discipline's boundary, and implement such integration in their subjects.

CONCLUDING REMARKS

Ref. [8] shows the URL location for Australia's skill shortage lists. The lists incorporate information on specialisations in shortage in particular states. Information about the extent of shortages, whether they are state wide (S), regional (R) or metropolitan (M), is provided. The lists also make use of the concept of recruitment difficulties (D) where *skill shortages* are not evident, but some employers have experienced recruitment problems. Monash University's BCivEnvEng programme is at the heart of such skill shortage in terms of S, R, M and D classifications. The *lists* show that civil engineering tops the list of skill shortages of all engineering disciplines. At present, and as a rule of thumb, environmental aspects cost 40% of any civil engineering project. This makes the BCivEnvEng the leading engineering sustainability course in Australia directly distanced to fill the national Australian engineering skill shortage. Information on, and reports from, the industry-led skill shortage working groups, managed by the (Australian Federal) Department of Education, Science and Training (DEST), is also available on the Web [9].

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