Educating the Engineering Associate

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***Abstract**: The Associate Degree in Engineering (Defence Systems) addresses the educational requirements of the Engineering Associate or Officer, one of the members of the Engineering Team. The degree is an 'industry' based degree rather than a 'discipline' based degree and caters to the educational needs of experienced tradespeople looking to move into engineering management at the implementation or practical level.*

This degree is a response to 2006/7 survey results of the skills needs of the South Australian defence industry which identified the need for 'para professionals' in the industry. Further work articulated the need, the history behind the skills shortage and fleshed out a suitable curriculum in association with the defence industry.

While the degree is now in its second year it remains a work-in-progress. Curriculum changes are being implemented and adaptation for eLearning delivery is underway.

Accreditation by Engineers is planned and is currently being sought.

This paper addresses the formation of the degree program, the characteristics of the target group, the progress with implementation and lessons learned along the way.

Introduction

The Defence and Systems Institute (DASI) is a unit of the University of South Australia which conducts research, consultancy and education in Systems Engineering. It has about 40 faculty and is part of the Division of Information Technology, Engineering and the Environment (DITEE) and of the School of Electrical and Information Engineering (EIE).

Background

Late in 2006 (updated Jan 2008) the SA Centre for Economic Studies (SACFES) reported on a study into the workforce needs of the Defence Industry in South Australia[iii]. The study, commissioned by the SA Government among others, was driven by the significant growth in the Defence industry in the State consequent on the award of major contracts to SA based companies. Of particular note was the contract for the construction of 3 Air Warfare Destroyers, valued at some $10B over time.

Among the growth areas identified by the study was one relating to a category of employee labelled 'para-professional'. The report concluded that future year-on-year growth in this particular category was about 11%, exceeding by a significant amount the State's compound average growth rate over the past 10 years of 1.1%.

A more detailed study of this requirement, conducted through interviews with Defence industry employers, individual employees, TAFE Institutions, VET Industry Skills Boards, the Defence Teaming Centre and the Recruitment industry, showed that the term 'para-professional' embraced a category of engineering support staff often variously referred to in the past as Senior Technical Officers (STO), Engineering Associates and Engineering Support Officers.[iii] This group of employees came from a trade background (electrical, electronic, metals, IT) and, over time and with additional training in trade skills and in engineering management, turned into Engineering Associates. The military called them Warrant Officers and Chief Petty Officers.

Such people were, and still are, essential elements of all technology based enterprises. Among many things, they undertake installation tasks, lead multi-disciplinary teams of tradespeople on implementation tasks, organise and run repair facilities, write logistics, repair and maintenance manuals, control production schedules, mentor graduate engineers and younger tradespeople, undertake project management, commission new facilities and so on.

In the past, the professional growth of Engineering Associates occurred principally in public utilities such as the PMG's Dept, Dept of Civil Aviation, DSTO, Electricity and Water Utilities, and Railways among many. These organisations had three important characteristics – an institutional mentoring culture, a training and education culture and a promotion structure which permitted entry as a telegram boy to a gold watch as General Manager. When Governments privatised and corporatised these organisations they stopped training in the public interest as not being bottom-line effective. The supply of surplus trainees to industry at large dried up and existing employees are now retiring; hence the emerging shortage of Engineering Associates.

While the radar of the SACFES survey identified a requirement in the Defence industry, incidental enquiries with the Energy Networks Association (ENA) and the International Centre of Excellence in Water Resource Management (ICEWARM) showed evidence of the same need in these industries. Work by the National Institute of Labour Studies[iv] showed similar gaps in the projected demand and supply equation for Technical Employees in the resources industries. Notwithstanding the present recession, the nation appears on the edge of a serious, systemic problem[v].

One anecdotal symptom of this shortage is the shift to employing graduate engineers in roles which in the past have been undertaken by Engineering Associates.

Clearly, both the need and the opportunity existed to craft a Program of education and training which would transform experienced tradespeople into practical, engineering support managers in, in the first instance, the growing Defence industry.

The Role of the Engineering Associate

The role of the Engineering Associate is one of planning and implementation in an engineering and technology intensive environment[vi]. It is not detailed design, though some level of design may be undertaken. More often, it is the implementation of a design undertaken by more senior and experienced engineers; all this in a multi-disciplinary team structure.

The Engineering Associate operates in the transition zone between the 'shop floor' and the 'design shop'. Effective performance in this role requires a mindset shift from that of the tradesperson to that of the engineer. It is a challenging proposition.

Such a role requires higher level thinking skills, as are described in Bloom's Taxonomy[vii]. Discussions with TAFESA Institutions suggest that current, Training Package based, VET Diploma and Advanced Diploma qualifications do not properly address that requirement. Gientzotis seems to support that observation[viii].

The Nature of the Candidate

The traditional launch pad for Engineering Associates is skilled trade training in electronics, electrical, mechanical and IT trades plus solid experience in the work place and exposure to engineering management practice. The candidates are mature tradespeople with people management skills and family responsibilities. They are not school leavers.

Mature engineering associates possess a wealth of life and practical work experience as well as corporate knowledge. Much of this knowledge, skill and experience is not acknowledged by today's higher education community and hence not by employers and human resource departments. This is a major, career-limiting characteristic. The most common comment in interviews with employees laments the lack of credibility arising from the lack of an under-graduate qualification.

Program Requirements

The legacy skills of experienced tradespeople require enhancement with practical engineering mathematics, higher level engineering management practice and exposure to other disciplines.

To meet the skills shortfall in the Defence Industry workforce, substantial numbers from a non-Defence background must be recruited and trained. Those not familiar with the differences between the commercial and Defence environments will require substantial familiarisation with Defence industry language and practice as is embodied in systems engineering.

While some Engineering Associates will articulate to higher degrees, most will not. Work, family demands and age are limiting factors. Many will advance to competency specific graduate certificates or diplomas with immediate workplace application in areas such as systems integration, integrated logistic support and test and evaluation. Few will seek higher degrees.

A BEng of 4 years duration full time, even with credit standing, is too long both for the nature of the individual and to meet the industry need. For the role envisaged, the BEng contains too much mathematics and engineering science. In combination with the nature of the transition from VET to Higher Education it is quite difficult for a senior tradesperson to transition from a trade to a professional environment, creating something of a 'chipboard ceiling', It is both socially and economically desirable that this ceiling be penetrated.

Alternatively, something analogous to a Post Graduate Certificate or Diploma is too short and lacks the breadth required of an industry aligned degree.

Engineers Australia recognises the Grade of Engineering Officer and has established Competencies across Stages 1 and 2. Both the Advanced Diploma and Associate Degree qualifications are accepted for Stage 1. The Training Package nature of the Advanced Diploma and the constraints associated with the Training Package approach suggest that the Associate Degree, awarded at the Higher Education level and with a greater emphasis on higher level thinking skills, is the award of choice in training Engineering Associates.

The Associate Degree in Engineering (Defence Systems)

The curriculum for the proposed Associate Degree began to suggest itself as the above factors were explored.

The By-laws of the University of South Australia require that an Associate Degree Program consist of 16 Courses each of 4.5 units. In addition, consideration can be given to recognition of prior learning through both workplace experience and training and the possibility of credit standing from earlier studies.

The language, processes and mindset of Defence materiel acquisition are embodied in Systems Engineering. To engage successfully with the defence industry a comprehensive exposure to that field is therefore essential.

Candidates also need exposure to the practice of Defence engineering in military platforms such as warships, military aircraft and military vehicles, for these are the environments in which the work that they undertake will be employed. They therefore need to understand how the Navy, Army and Air Force are organised for operations and the stresses under which men, women and equipment are required to operate. If people understand the environment in which the work they are undertaking is to be used, they will do a better job.

For the Defence industry there is only one customer. Candidates need to understand the impact of this fact on organisations and engineering practice.

Since Engineering Associates lead multi-disciplinary teams, candidates for the qualification need exposure to disciplines other than their native trade. In particular they need exposure to issues associated with software engineering.

Candidates do not need advanced mathematical skills to perform the functions of an Engineering Associate. Practical mathematical skills, project management and enhanced inter-personal

communication skills are fundamental to the management of complex engineering projects and need to form part of the Program.

Throughout the curriculum Candidates needed to be encouraged to operate at a higher intellectual level, to undertake independent thinking and research; to form their own views, define the problem, explore alternatives and to defend the choice of an option. They need to stop thinking like tradesmen and technicians.

Taking these factors into account the Program contains four principle elements and their components:

1. **Engineering Management**:
    a. **Defence Culture** – to effect a cultural re-alignment from commercial to Defence industry practice by understanding how the three Services and the Defence Department worked and where the equipment and systems upon which they worked would be employed in operations.
    b. **Systems Mathematics** – practical skills to aid in decision making, statistical analysis and logistics engineering analysis – based in Excel functionality.
    c. **Communications Skills for Industry** – written and oral communications skills tailored for the language and processes of the Defence industry.
    d. **Systems Project Management** – schedule, resource and quality management in a complex military systems environment.
    e. Tendering and Contracting for Defence.
2. **Systems Engineering**
    a. **Introduction to Systems Design** – the design of complex systems.
    b. **Systems Requirements Management** – understanding and articulating the customer need.
    c. **Systems Modelling and Simulation** – tools of the trade.
    d. **Systems Integration** – bringing complex systems together.
    e. **Test & Evaluation of Complex Systems** – ensuring they meet specification.
    f. **Integrated Logistic Support** – through life management in demanding operational environments.
3. **Engineering Practice**
    a. **Elements of Mechanical Design** – appreciating the issues faced in mechanical design.
    b. **Elements of Electronic Design -** appreciating the issues faced in electronic design.
    c. **Elements of Software Design -** appreciating the issues faced in software engineering and its relationship to other disciplines.
    d. **Engineering in the Defence Industrial Environment** – understanding the practice of engineering in Defence and where it differs from other industries.
4. **Technology Applications**
    a. **Fundamentals of Military Platform Design** – understand the applications of technologies in areas such as operational requirements, logistical viability, manoeuvre-mobility, manoeuvre-situational awareness, protection, firepower, propulsion and control systems in land sea and air platforms.

Detail of the content of these Courses is available on the UniSA web site at http://www.unisanet.unisa.edu.au/programs/program.asp?Program=LTDS .

Each of the proposed Courses is largely new and, in many instances, breaks new ground. Because of the 'industry' orientation of the Program rather than a 'discipline' orientation, and because of the mature nature of the student body, the development of new material, rather than the re-cycling of old material, was considered necessary and appropriate.

Necessarily the Curriculum is a work in progress. Changes have already taken place. The military platforms course was originally conceived as three separate courses devoted to the sea, land and air environments. This proved very difficult to implement as instructors at the required level were not available in Australia or were not prepared to devote the time to the onerous task of building a new course. The replacement courses in defence contracting and defence engineering practice had already been discussed and fitted quickly into the curriculum.

It is intended that this Program be subject to the accreditation processes of Engineers Australia.

Curriculum Delivery

Delivery of the first on-campus course commenced in February 2008. The nature of the student body, mature, fully employed, family responsibilities, called for an unconventional delivery approach.

Delivery of the Program does not follow the conventional two semester, undergraduate paradigm. The 16 Courses of the Program are presented sequentially, one after the other commencing early February, eight Courses in Year 1 and eight Courses in Year 2. Only two Courses are pre-requisites – Defence Culture and Systems Mathematics. The remaining Courses can be taken in any order.

Defence Culture and Systems Mathematics are repeated mid-year to facilitate additional enrolments, to provide a fall-back for those who might struggle early and to permit fine tuning of the syllabus.

Each Course is presented over five weeks. In each week one day (Monday or Friday) requires attendance at lectures, tutorials and practicals on the Mawson Lakes Campus. These are delivered in the Distributed Systems Laboratory of the Defence and Systems Institute. Students undertake assessed individual and collective assignments where possible oriented to the defence industry workplace and which will contribute to insights and improvements in the student's workplace.

Site visits to Defence installations and industrial sites (e.g. RAAF Edinburgh) form an important component of the Program. Visiting lecturers from industry, government and the services are common.

On-line Delivery

During 2008, while the first year of the Program was bedding down, the Commonwealth asked that four courses be adapted for e-Learning on-line delivery. This was consistent with early thinking and had been approved as a future approach by the Academic Board.

The successful completion of the Project in December 2008 showed the flexibility of combined on-line and on-campus delivery and demonstrated the capability and relative simplicity of the modern generation of e-Learning tools.

With this experience to hand and with the support of the Curriculum Advisory Board, the balance of 12 courses is in process of adaptation to e-Learning mode. This will be complete by end 2009.

Industry Consultation

As earlier indicated, to better understand the industrial requirement for a Program of this nature, discussions were held with a wide ranging selection of organisations. These included:

- The Defence Teaming Centre.
- The SA Government Dept of Trade and Economic Development.
- The SA Government Dept of Further Education, Employment, Science and Technology.
- The SA Government Defence Unit.
- The Defence Materiel Organisation.

- Engineers Australia.
- The Engineering Employers Association of SA.
- The Energy Networks Association.
- The Electronics Industry Association.
- The International Centre of Excellence in Water Resource Management.
- The National Institute of Labour Studies, Flinders University.
- The Manufacturing Industry Skills Board.
- The Electrotechnology Skills Board.
- Panorama TAFE.
- Regency TAFE.

There was strong support from Government bodies, Industry Associations and Engineers Australia for the concept of some form of up-skilling Program for experienced tradespeople in the engineering domain. Lesser support was evident from the Industry Skills Boards and the TAFE sector who could see the emergence of a crossover Program from VET to Higher Education as a possible threat.

Industry was also widely consulted. Companies included, BAE Systems, SAAB Systems, ASC Pty Ltd, Tenix Ltd, Raytheon Australia, RLM Ltd, Gibbs & Cox Pty Ltd, EDS Ltd, Lockheed Martin Australia, AUSTAL, Pacific Marine Batteries to name a few.

As the nature of the requirement emerged from discussions it became clear that some form of benchmark or competency based description of the employee was necessary. The competency standards of Engineers Australia were an obvious and authoritative source of such a description and the Stage 1 Competencies for Engineering Associates were chosen as that benchmark. A group of six companies were surveyed to ensure that theses competencies accurately reflected their view of the employee. All agreed that they did.

A curriculum was then constructed and mapped to the Stage 1 Competencies. This curriculum was also provided to companies for comment and support. The response to the draft curriculum was positive and some adjustments were made to reflect comments.

This consultation is a continuing process and is embodied in a Curriculum Advisory Board composed of industry representatives as well as representatives from Engineers Australia and the University of South Australia.

Student Selection, Teaching and Learning

The requirements for admission into this Program, approved by Academic Board, are simple; candidates must be employed and have at least five years experience in their trade. They need to submit a CV as evidence of past employment experience and evidence of relevant trade training that they have undertaken

In its first year, 2008, 19 students were admitted to the degree program. In the second year, 2009, a further 18 students were admitted. Candidates to date have come from experienced tradespeople in electrical, metal, electronics and IT trades and from the RAAF. They are in their late twenties, thirties and forties. Most present with Cert IV, Diploma or Advanced Diploma VET qualifications plus extensive Defence Force or vendor training. Many have undertaken extensive equipment training relevant to their work – CNC programming, operation & maintenance, 3D CAD, robotics installation, programming, operation and maintenance, production planning, front line management and the like. They have led small teams of tradespeople. Some are already in managerial positions but require a higher qualification for further advancement. Some have not undertaken formal study in some years. They are ambitious and enthusiastic and prepared to work hard.

The response to this situation is to deal with each candidate as an individual, rather than a 'tick-the-box' approach. Candidates are interviewed by telephone or face-to-face to establish their level of commitment and to assess their level of ability to complete the Program. It is important that no one be set up to fail.

Student response to the curriculum has been positive while at the same time offering constructive criticism. Students are highly motivated and suggestions included:

- A greater emphasis on content specific to the defence industry.
- Greater coordination between courses to emphasise under pinning knowledge, for instance that between statistics and logistic support engineering.
- Continuing support for a high level of 'pastoral care' necessary to revitalise student connection with the learning process in a University environment.

The most significant educational issue to emerge from the first two years of operation of the degree has been the need to shift the mindset of students from that of a trained tradesperson to that of an engineer. Many, not all, students expected that lecture materials would address all situations with which they would be confronted in the assessment process, as is the case in VET training. This, of course, is not the case in engineering where problem definition, research and investigation toward option development and trade-off requirements precede the selection and justification of a course of action is the norm. The requirement to foster this change of attitude will be a major driver in the forthcoming curriculum review.

CONCLUSION

The Associate Degree in Engineering (Defence Systems) is a new degree breaking new ground. It is a work in progress with both curriculum content and methods of delivery subject to further scrutiny, change and improvement.

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[i] The Defence Industry Workforce Requirements: 2006-2010. The SA Centre for Economic Studies. Dec 2006.

[ii] The South Australian Defence Industry Workforce Update 2007. The SA Centre for Economic Studies. Jan 2008.

[iii] These terms are interchangeable and vary across industries. Terms such as Foreman and Clerk of Works might also fit the category. This paper will settle on the term Engineering Associate as being representative of the group.

[iv] Staffing the Super Cycle: Labour Force Outlook in the Minerals Sector, 2005 to 2015. Minerals Council of Australia. August 2006.

[v] World Class Skills for World Class Industries. Employers Perspectives on Skilling in Australia. Australian Industry Group. The Allen Consulting Group. May 2006.

[vi] Australian Engineering Competency Standards. Engineers Australia. 2003.

[vii] Bloom, B., Englehart, M. Furst, E., Hill, W., & Krathwohl, D. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. New York, Toronto: Longmans, Green.

[viii] Gientzotis J. Associate Degrees and the VET Sector. Presentation to the 17th IDP Australian International Education. Conference. 21-24 October 2003