International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 4 Issue 6 ǁ June. 2016 ǁ PP. 58-68

Developing an Engaging Engineering Programme in A New Military College and Assessment of Two Years Performance

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ABSTRACT: This paper examines the integration of engineering programmes with training need analysis under reformed/modified structure, suitable for a new military college. It presents the monitoring of the results of assessment, quality assurance and monitoring of the programme during the first two years of its implementation. The Military Technological College, Muscat is the first of its kind in Oman. It offers military and academic training, and runs engineering degrees that have been validated by the University of Portsmouth (UoP), UK since September 2014. The engineering programmes were tailored for integration of Training Need Analysis (TNA) modules to fulfill the military's service requirements. The core building-blocks of the MTC BEng (Hons) programme are, problem-centered learning, upside-down' curriculum, mathematics in context, design orientation, combined simulation, training and laboratory studies. The strategy adopted in designing the programme is suitable for providing the students with lifelong transferable skills.

Keywords: Engineering programme; Military Technological College; Integration of |Training Need Analysis; Quality assurance monitoring.

I. INTRODUCTION

The Military Technological College (MTC), Muscat, Oman, is a new institute that was established in 2013. MTC's vision is to develop and adopt internationally recognized engineering programmes with high caliber education that will meet the requirements of specific services such as the Royal Oman Army, Royal Navy of Oman, and Royal Air Force of Oman, as well as assist the development of Oman in general. The academic leadership of the college embarked on the development of an engaging engineering programme that would enable graduates to deal successfully with the challenges of the future [1].

MTC is to be the leading centre in Oman, and in the wider Middle East region, for advanced training, education and professional formation in engineering. Its programmes are designed to enable students to compete and to contribute to the economic and social development of Oman. The College's focus is on achieving the highest international standards and local relevance. The aim of the College is to:

- develop an educated technical elite capable of assuming leadership in the Military, industry, education and the government;
- develop a faculty capable of sustaining and growing MTC.

The institute is also supporting research, enterprise and knowledge transfer undertaken by both faculty and students. This is central to its mission and is essential to its sustainability. In addition, the College is to become a national resource, contributing to the broader transformation of military and civilian education in Oman in accordance with national priorities.

According to Godfrey [2, 3] the awareness of the role of culture as engineering reform has taken hold on an international scale. Elisabeth [4] has discussed the importance of promotion of a culture of inquiry in engineering education amongst all faculty. For many decades the engineering schools in Oman have been providing a steady, reliable, and quality multidiscipline engineering education to Omanis. These efforts however, have been focused at the undergraduate level and largely based on traditional male knowledge and skills with little emphasis on effects of technological solutions on people. This has resulted in a culture in which many people including women feel uncomfortable and have chosen not to participate in or contribute to the extension of the engineering profession demands [5, 6]. The role of future engineers in the technical developing Omani society is becoming even more challenging due to globalization and engineering practice.

Another concern that has been raised, is that we are attempting to educate 21st century engineers with 20th century curriculum taught in 19th century institutions [7].The requirements of engineers for current century engineering are i) engineers must be technically competent, ii) innovative, iii) globally accepted, iv) culturally aware, v) entrepreneurial, vi) flexible and mobile [8]. In order to meet these requirements and to prepare engineering graduates to fulfil armed forces services requirements, the engineering programme must respond to new technological challenges by incorporation of i) approach of multidisciplinary, ii) more holistic approach to

address social needs and priorities, iii) linking of economic, environmental and legal considerations with technological design and innovation, and iv) link to Training Need Analysis (TNA).

II. METHODOLOGY

2.1 Academic framework

The academic framework of MTC dictates that the college will develop engineering programmes capable of sustaining and growing MTC and develop an educated technical elite capable of assuming leadership in industry, education, and the government. The MTC programmes will not be teacher-centric, but learner-centric, in which generic competencies, include i) ability in abstract thinking, ii) ability to apply knowledge to practical situations, iii) ability to identify, pose and resolve complex problems, iv) team work, and v) communication skills. The four year B. Eng. (Hons) program is mapped to the UK SPEC shown in appendix 1 and 2, and will lead the award of chartered engineer/incorporated engineer. This will entail the students achieving the B.Eng. of the University of Portsmouth (UK) award.

MTC uses the Grade Point Average (GPA) system to allow Omani students a seamless transfer of credits if they opt for scholarships in the Gulf region or abroad. MTC is equipped with resources to sustain an annual intake of 900 students and aspire to teach programmes, along with the partnership of the University of Portsmouth, which will nurture Omani's young talent in engineering research and teaching.. The core building-blocks of MTC BEng (Hons) programme are:

Problem-centered learning: In this approach, students tackle engineering projects of growing scale and complexity. The engineering projects are interdisciplinary in nature and involve students in a broad range of engineering specializations.

The 'upside-down' curriculum: This approach moves material on engineering applications to the earliest stages of education in order to motivate, more strongly, the students' interest in fundamental Mathematics and Science that can otherwise seem dry and indigestible.

Mathematics in context: The teaching of engineering mathematics by engineers is presented in an applied setting.

Design orientation: The design of the course will be aligned with the service discipline the student is enrolled into. The term 'design', as set out by professional bodies, is to comply with the UK guideline specifications provided by UoP.

Combining simulation, training and laboratory: The laboratories and workshops facilities at MTC will provide the ideal setting to engender student confidence and creativity in simulation of expensive prototype experimentation.The academic framework provides guidance on engineering modules, teaching spaces, timetabling, teaching loads, innovative early training through 'Make Space' lab, and research capacities.

Quality Assurance (QA) framework

The key processes which comprise of the framework and are adopted at MTC are:

- Five-yearly department review,
- Annual monitoring,
- Five-yearly programme review,
- Teaching and learning strategies,
- Programme specifications,
- Student feedback through questionnaires,
- External examiners,
- Teaching observation and evaluation,
- The department steering committees with board of studies responsibilities.

MTC pursue an explicitly academic-led approach to QA, a reflection of the college's recognition that active and critical engagement of its academic staff is central to the fulfillment of its mission. The key features of the framework are: i) discussion of policy development and major decision making by the academic community through a committee system, ii) peer review by academic staff active in research and teaching, iii) design of processes to promote constructive dialogue between academic staff and where relevant, students, rather than mechanical compliance-testing. The QA structure and processes are appropriate to MTC's mission and context and i) meet external regulatory or legislative requirements and expectation, ii) meet the college internal needs, comply with MTC partner institute, local and international requirements, iii) maximize efficiency without compromise on effectiveness, iv) strike an appropriate balance between trust and accountability, with

processes which seek to deliberate the respective responsibilities of staff and bodies at department and college level, and v) include, where appropriate, external evaluation, guidance, review and monitoring.

III. COMMONALITY OF THE PROGRAMME

The accreditation bodies, such as ABET (Accreditation Board for Engineering and Technology) Engineering Criteria (2010) [9], IMechE, IE etc., explicitly requires that the engineering programme demonstrates that the graduates possess communication, multidisciplinary teamwork, and lifelong learning skills; and the military services of Oman requires that their graduates also possess TNA competencies promulgated by the armed forces through the TNA department. This challenging objective was met by careful design of the engaging engineering degree programme to be compliant with internationally-agreed standards and to transform its education culture from one that is teacher-centered, to one that is learner-centered, in which generic competences, such as: ability in abstract thinking; ability to apply knowledge to practical situations; ability to identify, pose and resolve complex problems; team working; communication skills, are as equally important as subject-specific competences and so was accounted for in the programme design. In this way, the aspirations of MTC to become a world-leading centre of education excellence, with modern, internationally-comparable degree programmes, can begin to be realised and the needs of the country will be met.

To meet these objectives, an innovative curriculum of systems-based education combined with specializations, the curriculum for the four departments namely Systems, Aeronautical, Marine and Civil Engineering with overall twenty pathways is shown in Figs. 1 and 2. It shows that the BEng (Hons) degree is comprised of a common eighteen months to begin with, followed by a department common eighteen months, then finally a specialized twelve months.

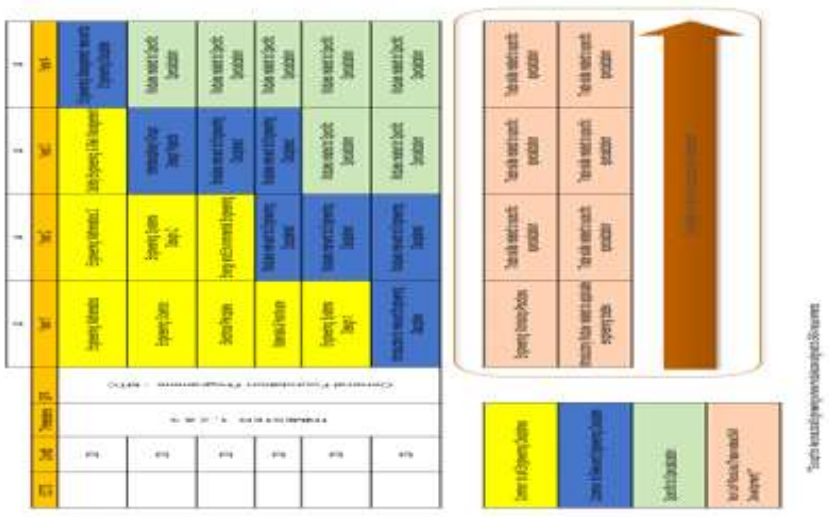


Fig. 1 BEng (Hons) programme structure with TNA modules.

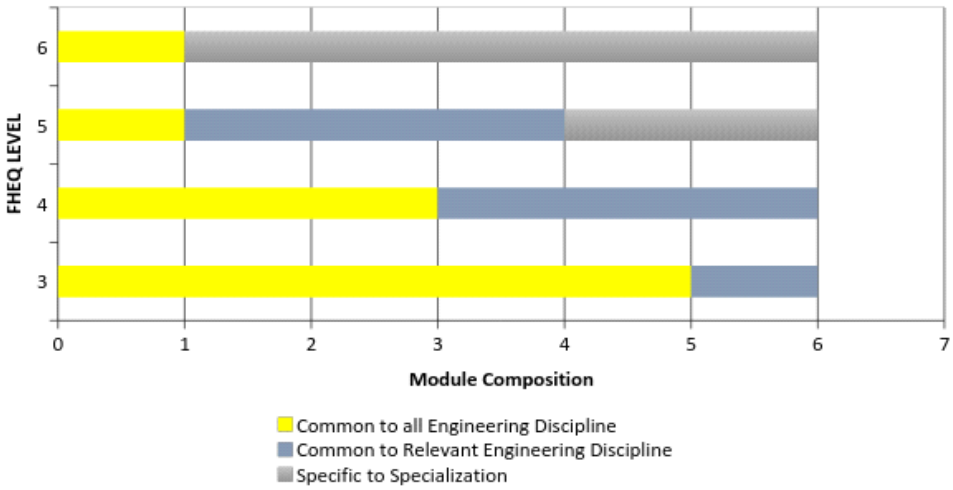


Fig. 2 Module composition for all engineering disciplines.

IV. TRAINING NEED ANALYSIS

It is widely known that the first phase in the development of a training programme, particularly a training programme for the military armed forces, is the identification of the needs for such a programme within an organization [10, 11, 12, and 13]. Training Needs Analysis (TNA) is the starting point where the organization's needs are identified, forming the foundation for an effective training effort. TNA identifies what kind of training programmes are needed, who needs to be included, conditions under which training will occur, and criteria to guide programme evaluation. TNA needs to be viewed as an on-going process of data gathering in order to determine the training needed so that it can be developed to help the organization accomplish its objectives. Only when there is a match between training needs and the content of training, can outcomes that are beneficial for organization's performance be realized [14].

A study of different Training Needs Analysis models [15]reveals that over the past 40 years, many TNA models have existed and that each differs in terms of its levels of concentration. However, during this time, the TNA models have not seen significant changes, in terms of both in theory and in practice. This study considers the O-T-P model because in academic literature, it is believed to be the core framework for a needs assessment and the framework on which most of the models developed since, have been based, despite first being published in 1961. In addition to this, Saeed [16]states that most firms do not assess the training needs and those which assess actually do not assess. Most managers view the planning of training programmes as simply telling the training department that training is needed, showing little understanding of the importance for the assessment of training needs. Furthermore, the literature on TNA shows that, most Arab countries have difficulty in identifying the training required for their employees. Studies in how TNA is actually conducted illustrate that ad hoc processes remain the norm and there continues to be a gap between recommendations from researchers and what is being actually practiced [17]. As O'Driscoll and Taylor [18] recognized, while there has been much discussion of the theory-practice gap in TNA, few direct empirical investigations have actually been conducted. Arthur et al. [19] remarked that studies conducting needs assessments represented only 6% of the data within their meta-analysis of training effectiveness. Eduardo Salas and Cannon-Bowers [20] further emphasized that there is a shortage of research in their review of the field of training. Moreover, existing literature regarding TNA shows that most studies conducted on organizations' training/TNA practices have been undertaken overseas (UK, Europe, the USA and the Far East). Due to cultural and national differences, however, these findings might not reflect the TNA practices in the Middle East, specifically in the UAE. Of the studies that have been conducted in Middle East [21, 22], none has focused particularly on TNA and the organizations used as case studies were limited to the manufacturing and service sectors. For example, the Louisiana state government in the US has adopted a large-scale performance-driven TNA project, designed to identify the performance improvement training needs of its employees [23]. The state of Idaho has also applied TNA to develop a comprehensive management development programme [24]. In Africa, the Government of Somalia has applied TNA at the Ministry of Agriculture and its constituent agencies, and three Egyptian public organizations have adopted TNA to identify leadership training and development needs [25]. In the Far East, the public administration in Taiwan has implemented a more systematic approach to TNA, the organization-task-person (O-T-P) model in the Taiwan Coast Guard [10]. The Pakistan Chapter One: Introduction 2014 - 7 - corporate sector has also adopted TNA to identify the managers' training needs [26]. It is true that some studies have emphasized the importance of TNA in the planning and design of training programmes [27, 28], but these studies lack clarity about how the TNA process shown in Figs. 3 and 4, could be managed effectively and leveraged for business advantage.

Fig. 3 TNA review process

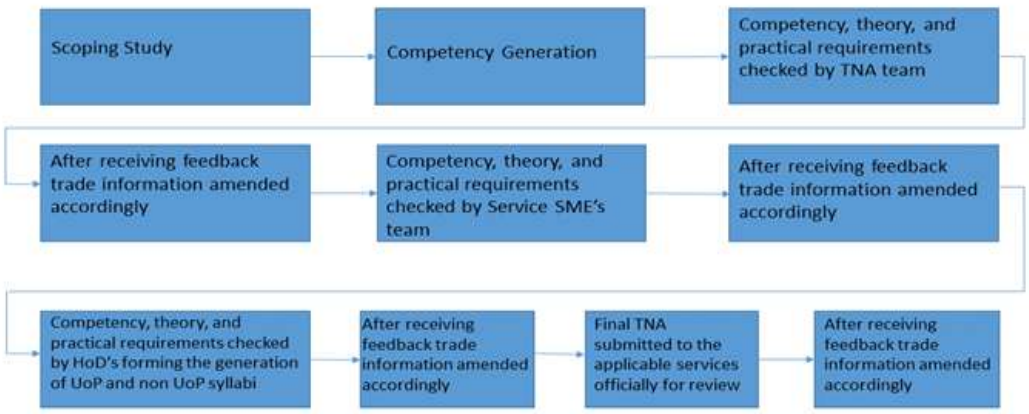
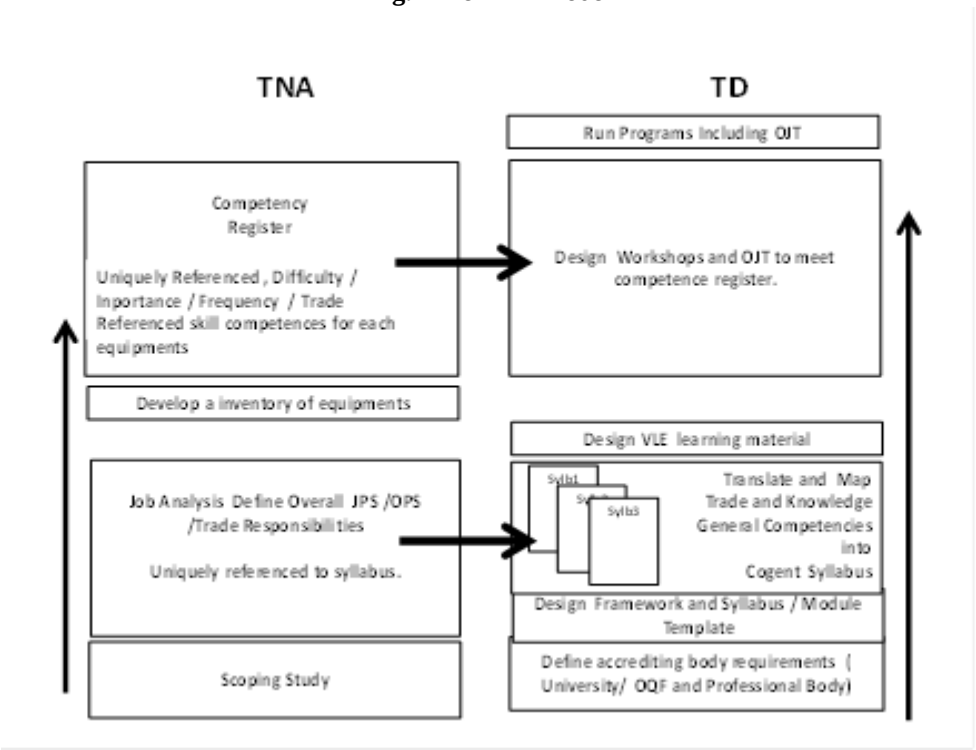


Fig. 4 The TNA Model



As part of the process for ensuring that MTC becomes a "Centre of Excellence", TNA is embedded in the strategic plan to ensure that MTC meet the requirements of the Ministry of Defense (MOD). Effective training or development depends on knowing what is required for the individual, the department and the organization as a whole. With limited budgets and the need for cost-effective solutions, all organizations need to ensure that the resources invested in training are targeted at areas where training and development is needed and a positive return on the investment is guaranteed. TNA is particularly vital in today's changing workplace as new technologies and flexible working practices are becoming widespread, leading to corresponding changes in the skills and abilities needed. Analyzing what the training needs are is a vital prerequisite for any effective training programme. TNA enables organizations to channel resources into the areas where they will contribute the most to employee development, enhancing morale and organizational performance.

Effective TNA involves systematic planning, analysis and coordination across the organization, to ensure that the organization's priorities are taken into account and that duplication of effort is avoided [29]. TNA identifies training needs at employee, departmental or organizational levels in order to help the organization to perform effectively. The aim of training needs analysis is to ensure that training addresses existing problems, is tailored to organizational objectives, and is delivered in an effective and cost-efficient manner.

The TNA consists of the following areas:

- Situational Analysis
- Scoping Study
- Competency Generation
- Select Equipment
- Training Gap Analysis

Integration of TNA

For structuring a curricula and courses for BEng. (Hons) and Dip.HEprogrammes in four engineering disciplines (Aeronautical, Civil, Marine, and System Engineering) to meet the objectives of the competencies list of the MOD in Oman, the integration of fundamentals and a TNA application was made within courses in such a way that exhibits the appropriate balance [29]. The order of courses was from fundamental to applications through deductive presentation and expository teaching. Another challenge was to incorporate courses to the main BEng. (Hons) program for a number of pathways in each of four engineering disciplines. This was achieved by integrating the TNA material to both main engineering courses and TNA courses (non-credit) so that the student can develop a practical understanding and a systematic way of thinking along pathway

lines in their approach to problem-solving. There was no compromise on core engineering courses or the magnitude of its linkage with TNA and development of intended lifelong learning skills.

Key features of the TNA focused BEng. programme

The Key features of the TNA focused BEng. programme are:

- The curriculum contains mathematics, science, and engineering.
- Embedding of TNA topics, both in core engineering modules and in non-credit TNA modules.
- Development of lifelong learning skills (a civilian and military requirement).
- Integration of core engineering and TNA courses.
- Hands on experience by 'Make Space' laboratories and workshop practices under instructor's supervision.
- Enhanced role of laboratories by computer based training and real experimentation.
- Coverage of multidisciplinary/cross disciplinary aspect of design projects.
- Integration of disciplinary academic and pathways knowledge.

Programme evaluation

V. BASED ON STUDENT PERFORMANCE

The students' academic performance is critical to the institution for measuring the effectiveness of the strategically planned engineering program. The students' performance can be measured using GPA distribution upon graduation or in the case of a new institute by grade distribution during first few years of study [4]. The students' performance in four common engineering modules of first year B.Eng. programme at MTC, for the academic year 2014-15, is presented in TABLES 1 and 2. The data of these tables indicate a fair normal distribution of grades. The failure rate decreased significantly in two core engineering modules that is engineering science and engineering material and hardware. However, the failure rate in Engineering Maths-I and Electrical Engineering Principles increased by 11% and 4% respectively, which could be linked to application of assignments submission through Turnitin, and online assessment of course work. The governance of the program through strict QA regulations and procedures suggests that the engineering programme is an engaging engineering programme in a new military learning environment.

Table. 1 Average and standard deviation of exam results of common modules

Academic year 2014-15			
Module	Average	Standard deviation	Cohort size
Engineering Maths-I	58.6	14.75	242
Engineering Science	66.8	10.84	242
Eng. Material & Hardware	47.1	11.8	242
Electrical Eng. Principles	61.0	9.92	242
Academic year 2015-16			
Engineering Maths-I	40.1	13.8	167
Engineering Science	63.8	14.8	167
Eng. Material & Hardware	60.1	12.3	167
Electrical Eng. Principles	56.0	10.8	167

Table. 2 Grade distribution (%)[1] in common engineering modules

Academic year 2014-15					
Module	A	B	C	D	F
Engineering Maths-I	25.6	21.1	16.9	0.4	36.0
Engineering Science	38.8	34.7	0.40	0.0	26.0
Eng. Material & Hardware	5.0	9.5	32.6	3.3	49.6
Electrical Eng. Principles	22.7	34.7	22.7	0.4	19.4
Academic year 2015-16					
Engineering Maths-I	1.8	6.6	15.56	28.74	47.3
Engineering Science	41.8	43.12	5.62	0.0	9.37
Eng. Material & Hardware	27.7	27.1	27.1	5.42	12.65
Electrical Eng. Principles	11.58	29.87	32.92	2.43	23.17

[1]A = > 70%; B = 60-69%; C = 50-59%; D = 40-49%; and F = < 40%

based on student feed back

The students'feedback in four common engineering modules of first year BEng. programme at four engineering departments of MTC (Aeronautical, Civil and Quantity Surveying, Marine, and Systems), for academic year 2015-16, is presented in Figs. 5-8. The students' responses for four statements listed below are rated between 1 (low) and 5 (high); 5 means strongly agree; 1 means strongly disagree.

- The module material was clear and understandable.
- The lecturer's presentation of the material was in an understandable language.

- The personal tutoring was effective and helpful.
- I received the feedback from the lecturer on time.

The average rating for Engineering Maths-I was between 2.47 and 4.26; for Engineering Science it was 2.53 and 4.00; for Engineering Material and Hardware it was 2.35 and 3.68; and for Electrical Engineering Principles it was 2.39 and 3.39. The overall rating in all modules was recorded above 2.5, which indicate that students were satisfied with the module material, its presentation, and assessment.

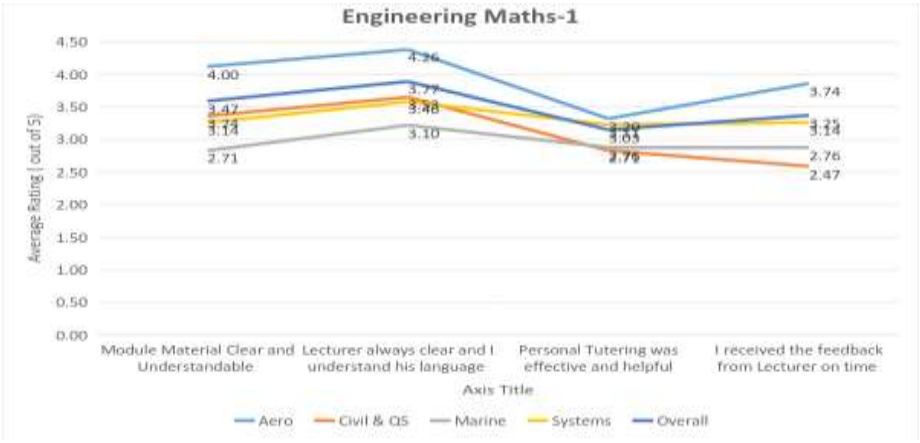


Fig. 5 The student feedback for Engineering Maths-1.

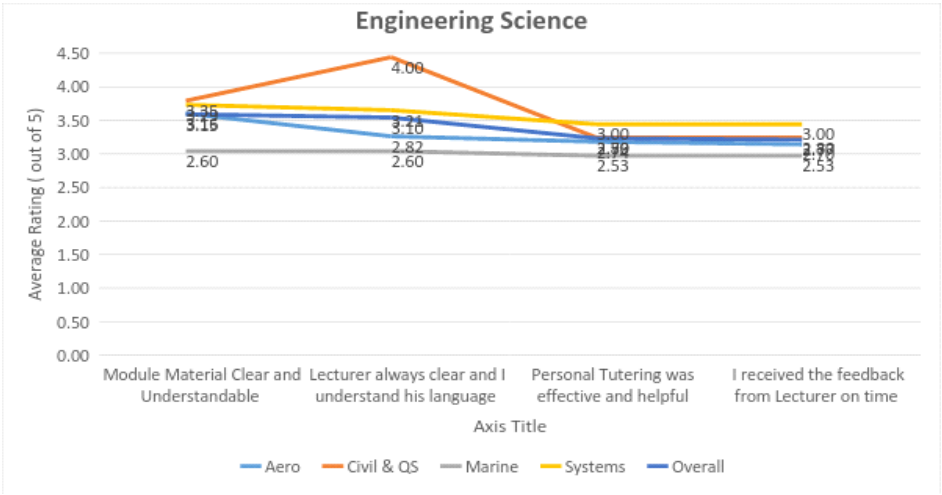


Fig. 6 The student feedback for Engineering Science.

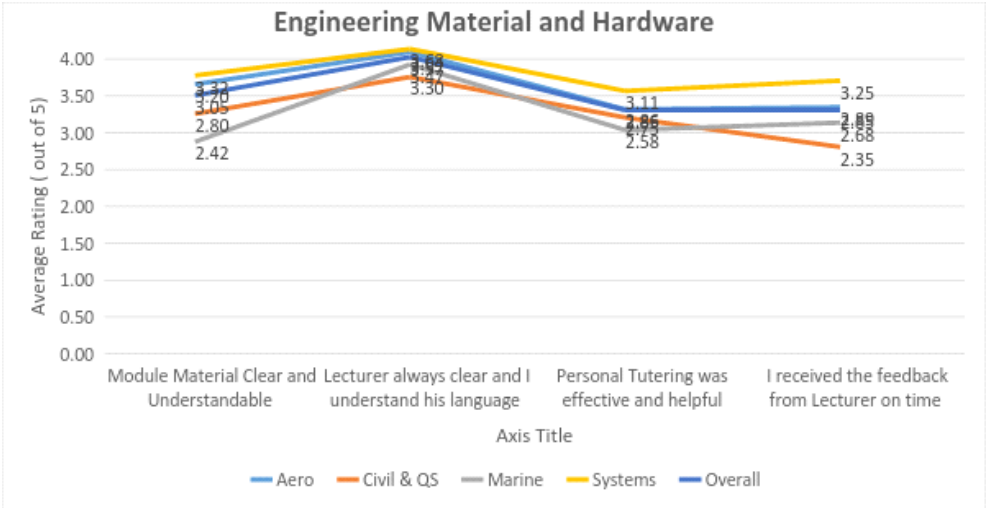


Fig. 7 The student feedback for Engineering Material and Hardware.

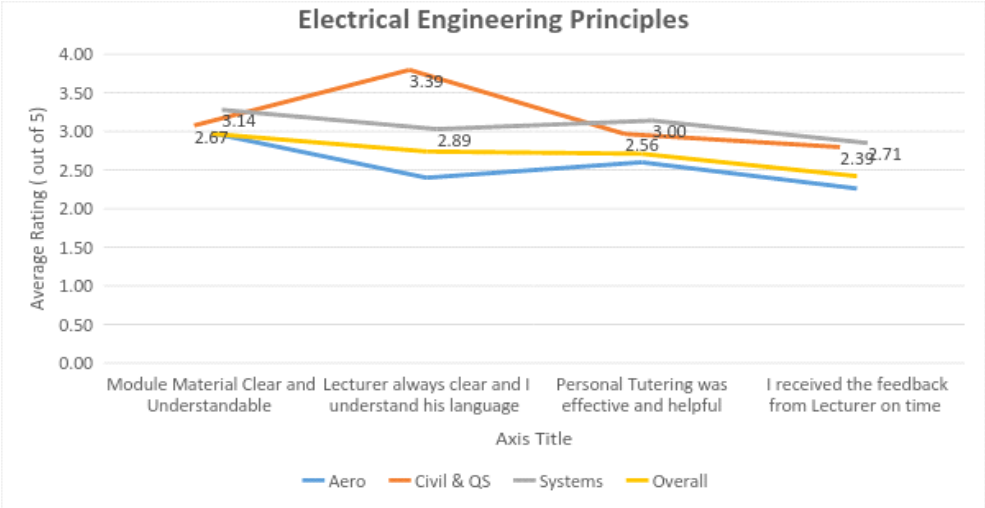


Fig. 8 The student feedback for Electrical Engineering Principles.

Based on TNA assessment

The QA analysis is based on logbook entries of laboratories and workshop sessions conducted by students for TNA modules which are verified by the modules instructors. The students and stake holder's satisfaction are the indicators of the success of the programme and appropriateness of the assessment. The positive word of mouth communication from current and past cohorts and the responses from the campus wide college faculty who have firsthand experience seeing the TNA competencies of the students, suggests that the developed programme is indeed an engaging engineering programme. For the two cohorts of students involved in this study, the instructor's investigation of the log books reveal that cooperation and group work is positively related to academic achievement of TNA competencies. The investigation results show that most students enjoy group and cooperative work. These findings are in agreement with previous studies [30] which reported that group or cooperative learning provides a classroom with a supportive environment, both academically and personally. It becomes paramount in the case of military academy. Similarly, team work and cooperation were found to be highly correlated with academic staff support and feelings of association; indicating that students value the academic staff support, which is not in agreement with the research in [31] but is in agreement with the results of Gaith [32], which states that the importance of instructor's support may vary across cultures. It should be noted that students competencies are measured from students log books, which might affect the investigation is some cases where students may underestimate or overestimate their achievement of TNA competencies. However, the sample size of cohort, ranging from 167 to 242, is sufficient to draw conclusions on QA analysis of the programme based on TNA assessment.

VI. CONCLUSIONS

The BEng. (Hons) programme was successfully integrated with the TNA modules to each of the pathways in four engineering disciplines. The objective of the engaging engineering programme was successfully achieved by mapping the TNA competencies along with accreditation requirements. The integration of the engineering programme with TNA under reformed/modified structure was found suitable for a new military college. While developing the BEng. (Hons.) Program, with the core engineering modules and TNA modules, due weightage was given to match the competencies required by the armed forces of Oman. In the BEng. (Hons.) programmes of all four disciplines, the adoption of the mixed-mode and blended learning environment presented an alternative that successfully integrated TNA and the engineering design approach in the engineering curriculum. The systematic and gradual integration of competencies identified through TNA with the academic programmes of Dip.HE and BEng (Hons) engineering degrees for all stages, resulted in a positive cultural change in the potential members of Oman Armed and Police Forces (i.e. MTC students). It has also resulted in higher engagement level of students, leading to improved progression, increased retention and advanced problem solving skills abilities. This was all accomplished within the institution's internationally compliant quality assurance framework. It is believed that the novel approach adopted for implementing the TNA requirements will have an influence on improving the understanding of current TNA practices and management in not only the armed forces but the country in general, as well as developing further the armed forces training policies and practice in this regard. The core building-blocks of MTC BEng (Hons) programme are, problem-centered learning, upside-down' curriculum, mathematics in context, design orientation, and combined simulation and laboratory. The QA monitoring of the programme suggested that the strategy adopted in designing the programme was appropriate in providing the students with lifelong transferable skills.

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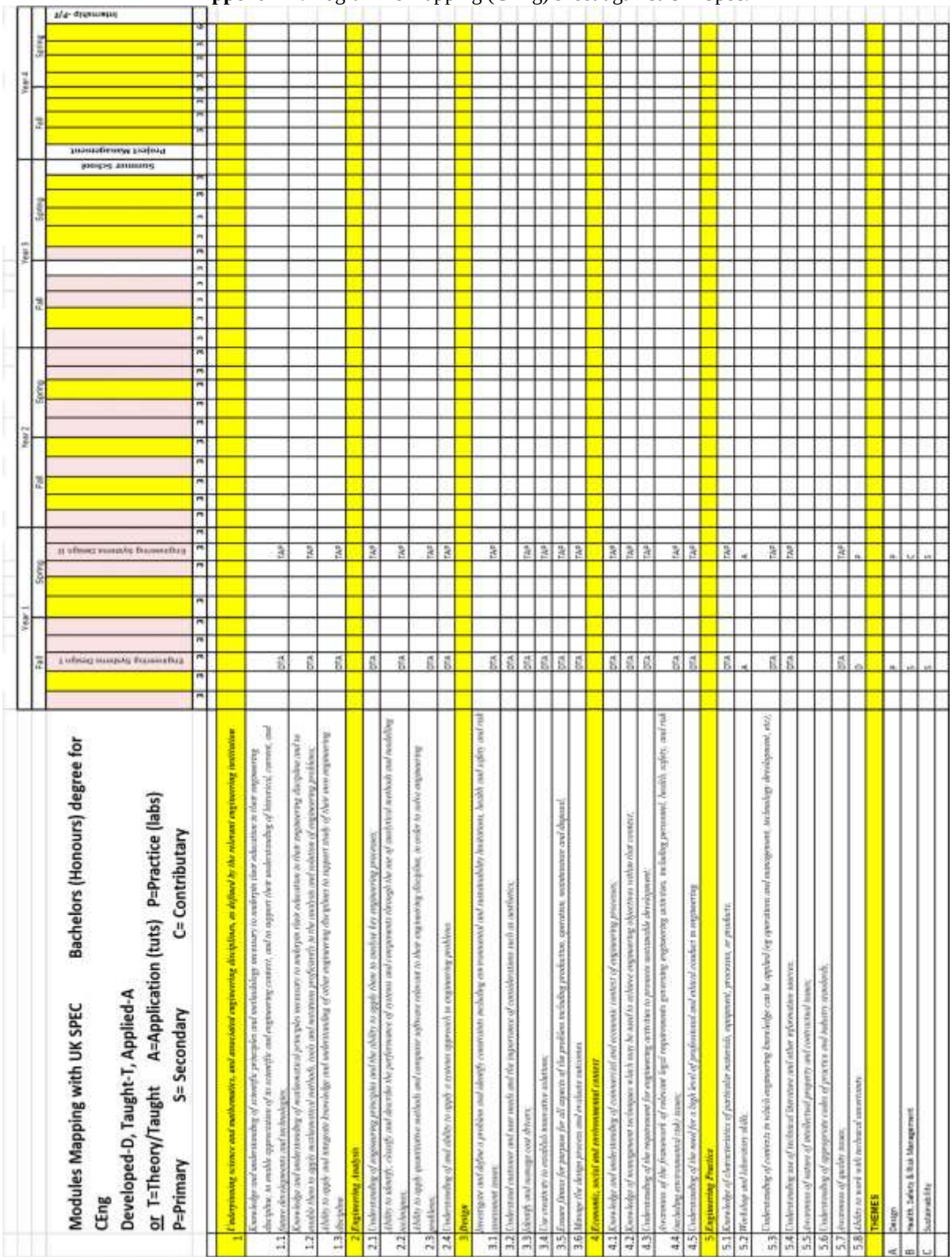
Appendix 1. Programme mapping (CEng) sheet against UK Spec.



Appendix 2. Programme mapping (IEng) sheet against UK Spec.