

Augmenting engineering undergraduates' generic competencies aligned with ABET outcomes 3 and 5

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ABSTRACT: In this article, the author has explored the initiatives and methods that engineering institutions could practise in preparing undergraduates to be competent in the generic skills aligned with the ABET EAC student outcomes 3 and 5. The generic competencies augment the specific competencies of the profession and the resulting amalgamation of both these competencies enhances employability. The second aspect presented in this article deals with the most frequently employed technique for assessing the communication, problem-solving, critical thinking, teamwork and leadership skills of engineering undergraduates. The author has attempted to back the findings by studying the methods adopted in the Faculty of Engineering at Rabigh Branch (FER), King Abdulaziz University (KAU).

Keywords: Profession specific competency, generic competency, ABET EAC, assessment

INTRODUCTION

The demanding and evolving competitive and globalised work culture compels engineering institutes to equip their undergraduates with generic or soft competencies along with profession-specific competencies to make them marketable [1]. For a proper development of these much-needed generic competencies, the engineering undergraduates should develop these competencies as part of their academic learning [2].

Undergraduate programmes worldwide aim to prepare efficient, competent and autonomous future engineers. They do this by regularly updating and remodelling their curricula, tailoring training programmes to the latest demand and fostering generic competencies among their students [3-5].

Generic competencies refer to employability skills, 21st Century skills or *soft skills*, such as those in communication, time management, team management, leadership, problem-solving and critical thinking. These soft skills, as well as the profession-specific competencies are much sought after [6][7].

All organisations are now seeking these additional generic competencies among their employees to gain competitive advantage. As stated above, these additional generic competencies encompassing work-related skills, including those of leadership, teamwork, communication, attitude and values beyond the disciplinary knowledge, are presently in great demand [8].

It has now become the norm for engineering professionals to not only acquire these generic competencies, but also to hone them to keep abreast of the needs of the global working environment, hence enabling them as global citizens and effective members of modern day society [9]. The best way to equip engineering undergraduates with these necessary generic competencies is at the undergraduate level through a variety of means discussed by Sadler [10]. Most of the academic programmes consider these competencies to be part of their learning outcomes.

The Accreditation Board of Engineering and Technology (ABET) is a USA-based acclaimed accreditation agency, which has become the main external accrediting body for the Associate, Baccalaureate and Masters level programmes at most Saudi universities, with 153 programmes accredited by 1 October 2019 [11]. The newly approved ABET EAC (engineering accreditation criteria) for the Baccalaureate level programmes has reduced 11 student outcomes (a-k) to seven (1-7), viz an ability to:

1. identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics;
2. apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors;
3. communicate effectively with a range of audiences;
4. recognise ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental and societal contexts;
5. function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives;
6. develop and conduct appropriate experimentation, analyse and interpret data, and use engineering judgment to draw conclusions;
7. acquire and apply new knowledge as needed, with appropriate learning strategies.

Generic competencies, such as communication skills, personality development, teamwork, team management, time management and leadership skills can be assessed through the EAC outcome 3 (earlier g) and 5 (earlier d). The ABET has placed emphasis on development of the generic competencies by explicitly defining EAC outcomes 3, 4, 5 and 7 (see above), which are related to generic competencies only. The generic competencies form an important component of the skills required by the labour market at present. In this article, only the generic skills aligned to EAC outcomes 3 and 5 are considered at length, whereas the other generic competencies aligned to EAC outcomes 4 and 7 are excluded, to comply with the title and length of the article.

The purpose of this article is twofold. First, to describe the means and methods adopted at the Faculty of Engineering, Rabigh Branch, King Abdulaziz University (FER-KAU), for developing and assessing the generic competencies defined by EAC outcomes 3 and 5. Second, to report on the surveys undertaken to measure the perception of the FER-KAU undergraduates about their skills in communication, teamwork and leadership, problem-solving and critical thinking.

METHODOLOGY

This is the methodology adopted at the FER-KAU for developing and assessing the generic competence defined by the ABET EAC student outcome 3 (previous student outcome g). The achievement level of a student in student outcome 3 will give substantial information to the faculty about the student's communication ability, both written and oral. The FER-KAU is committed to adopting and following all feasible approaches to improve the communication skills of the students. Various initiatives were adopted over the years to realise the objective of improved communication skills at the FER-KAU and the process is ongoing. The various means suggested to improve communication skills include the techniques in Table 1.

Table 1: Various means suggested by the FER-KAU to improve communication skills.

• Reports, projects, presentations	• Debates and group discussions
• Interviews/ <i>viva voce</i>	• Augmenting more courses with projects, reports
• Summer training programmes	• Internal orientation programmes
• Introducing proficiency courses in English	• External training programmes and internships
• Establishing an academic liaison and language support unit	• Assignments to improve communication skills

Summer training provides the opportunity for students to communicate with people from different cultures/ethnicity, nationality and religion. Introducing proficiency courses in English aids students in the development of communication skills. Table 2 depicts the means by which the achievement level of students may be assessed in communication skills.

Table 2: Means to assess the achievement level of students in communication skills.

• Summer training course - supervisor feedback	• Students' grades in the <i>Technical Writing</i> course
• Internship programme - supervisor feedback	• Alumni feedback
• Students' feedback	• Employers' feedback
• Faculty observation	• Achievement in outcome EAC 3 (g)

Methodology for Developing and Assessing EAC Student Outcome 5

The achievement level of a student for EAC student outcome 5 will give substantial information to the faculty about the student's ability to work in a team, recognise participant roles in a team setting and fulfil appropriate roles to assure

team success, take leadership roles and exercise problem-solving skills. The FER-KAU is committed to adopting and following all feasible approaches to improve the ability of the students to work effectively in a team.

Various initiatives and means were adopted over the years to enable students' ability to work in a team. The process adopted to realise this objective is dynamic, growing and improving continuously. The various means suggested by the FER-KAU for further improvement of the students to work in a team include the techniques given in Table 3.

Table 3: Developing skills for students to function effectively in a team.

• Laboratory work - assignments for a team	• Events' organisation and management
• Reports, projects, presentations	• Establishment of academic liaison and language support unit
• Students' chapters and clubs	• Designing contents in courses that seek students' teamwork
• Industrial visits	• Teaching the importance of individuals' roles in a team
• Extracurricular activities, such as football matches	• Showing case studies/anecdotes on the importance and advantages of good teamwork
• Summer training programmes	• External training programmes and internships

Table 4 lists techniques to assess the achievement level of students in their abilities to work effectively in a team.

Table 4: Assessment techniques for the ability to function effectively in a team.

• Recording team meetings by making videos of them for assessment
• Taking written statements from the students about their contributions and about their team members
• Feedback of the instructors and TAs about individual students' contribution in a team
• External supervisors' judgment during summer training and internship programmes
• Web-based peer evaluation

The achievement levels for outcomes 3 and 5 serve as a means of measuring the communication, leadership, teamwork, and employability skills of the undergraduate students. The performance levels of the students can be better determined by analysing the performance data of previous years and the actions identified for the improvement of non-performing students.

The faculty at the FER-KAU assess the communication skills, teamwork and the leadership skills of the students directly in the courses through their achievement levels in EAC student outcomes 3 and 5. Based on these assessments, the faculty at the FER-KAU suggest plans for improvement. One such plan was to implement an increase in the number of core courses assessing student outcomes 3 and 5 from autumn 2019 onwards, for all five programmes of the Faculty.

The courses were chosen from different programme levels: low, intermediate and high, to continuously develop competencies. Assessment techniques such as projects, reports, presentations, seminars and case studies were introduced. Depicted in Figure 1 and Figure 2 are the number of courses targeting outcomes 3 and 5 before and after autumn 2019.

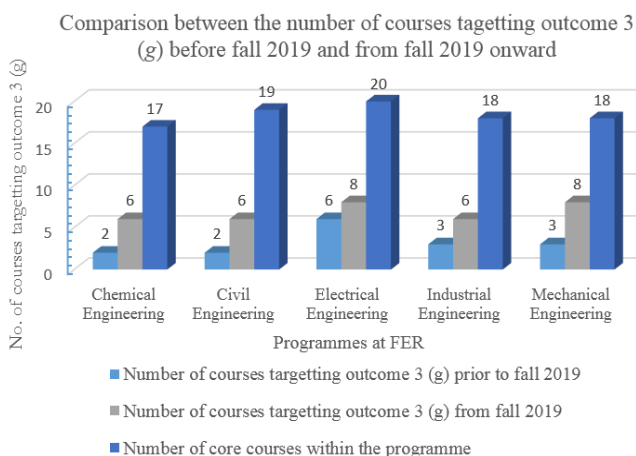


Figure 1: Number of courses targeting outcome 3 (g) from autumn 2019 for the five programmes within the FER-KAU.

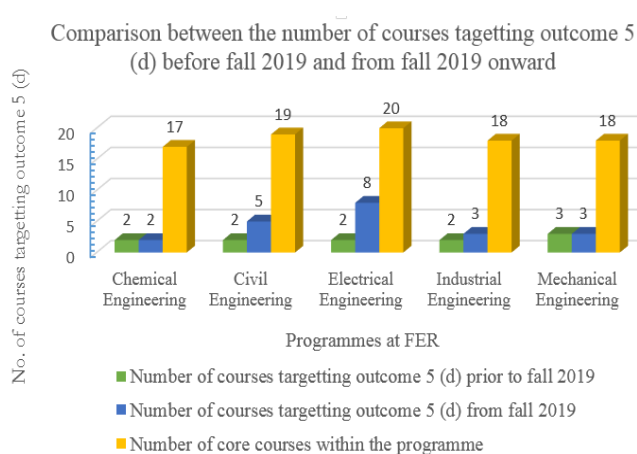


Figure 2: Number of courses targeting outcome 5 (d) from autumn 2019 for the five programmes within the FER-KAU.

Shown in Figure 1 is an increase in the number of core courses assessing generic skills aligned with outcome 3 for all the programmes within the FER-KAU, from autumn 2019. Out of the five programmes at the KAU-FER, only two did not take initiatives to increase the number of courses mapped to outcome 5 (see Figure 2).

Apart from the direct assessment of student outcomes 3 and 5 through course work, the indirect means of assessing students' abilities against the communication and teamwork skills is through feedback from the students, employers, alumni, instructors, faculty, internship supervisors and summer training supervisors.

Restrictions on the length of this article and constraints on the inclusion of too much subject matter has meant the author has deliberately abridged the article to discuss the indirect assessment techniques through students' feedback only and the remaining techniques could form the subject matter for future studies. Moreover, out of all the means available for assessing students' achievement level in student outcomes 3 and 5, the most commonly adopted technique is through self-report surveys in the form of feedback questionnaires [12] assessed on the Likert rating scale of 1 to 5.

STUDENT FEEDBACK

Students' achievement levels in some of the specific generic skills were indirectly assessed through the two questionnaires the templates of which are shown in Tables 5 and 6 in the Appendix. The Faculty's Quality and Accreditation Committee at the FER-KAU designed the questionnaires taking into account the needs of the professional world.

The questionnaire in Table 5 was designed for the students on the summer training programme, whereas the questionnaire in Table 6 was targeted at the international internship students. The main purpose of these questionnaires was to assess the level of achievement in generic competencies by the students, which are among the learning outcomes of the ABET accreditation system. The assessment results of both these surveys against various generic skills are shown in Figures 3 to 9.

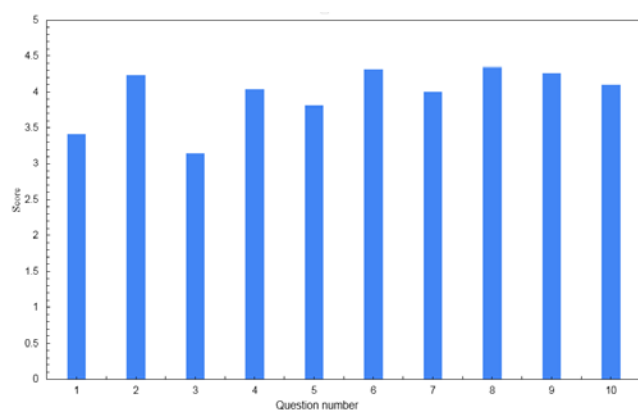


Figure 3: Communication skills.

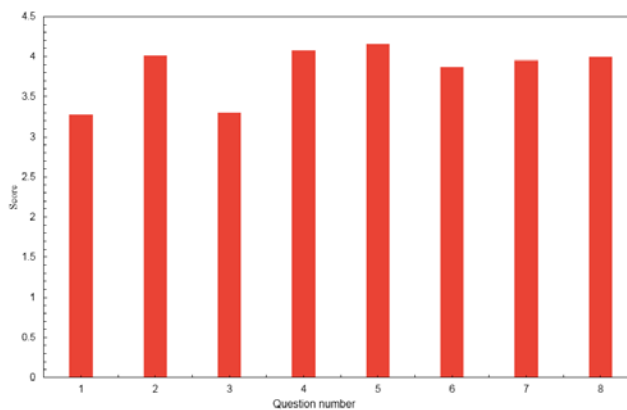


Figure 4: Leadership skills.

Figure 3 shows the average (Likert scale 1-5) for communication skills in Table 5, questions 1 to 10, from the summer training programme. Figure 4 shows the average (Likert scale 1-5) for leadership skills in Table 5, questions 1 to 8, from the summer training programme.

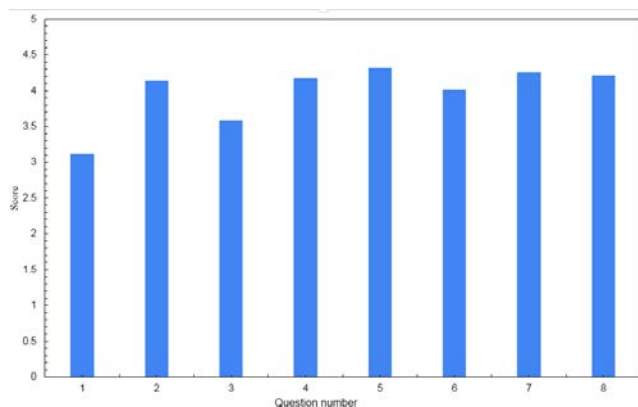


Figure 5: Teamwork skills.

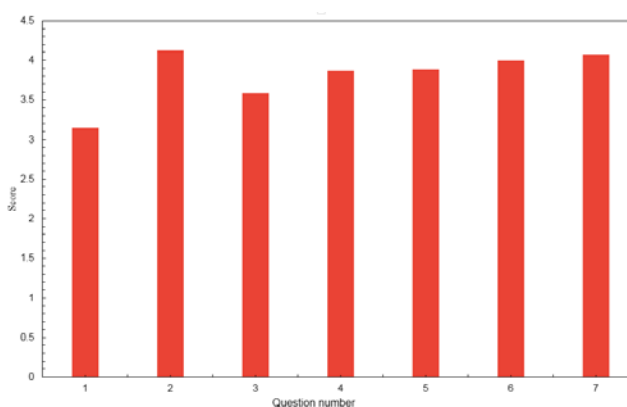


Figure 6: Problem-solving skills.

Figure 5 shows the average (Likert scale 1-5) for teamwork skills in Table 5, questions 1 to 8, from the summer training programme. Figure 6 shows the average (Likert scale 1-5) for problem-solving skills in Table 5, questions 1 to 7, from the summer training programme.

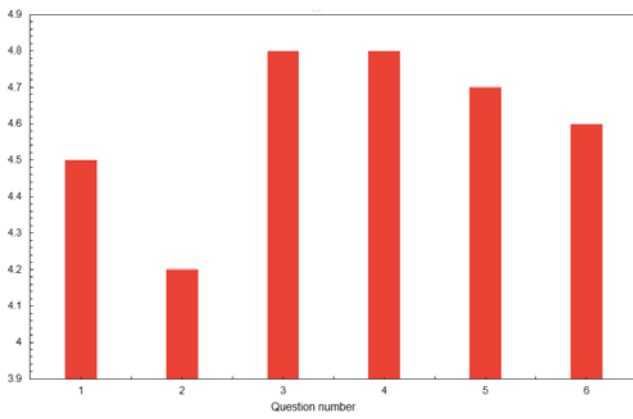


Figure 7: Communication skills.

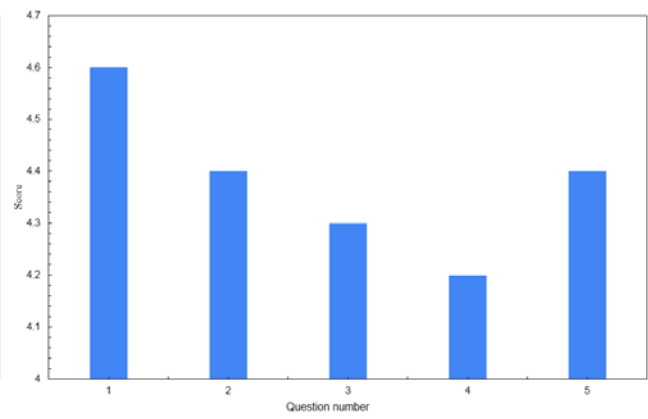


Figure 8: Problem-solving skills.

Figure 7 shows the average (Likert scale 1-5) for communication skills in Table 6, questions 1 to 6, from the international training programme. Figure 8 shows the average (Likert scale 1-5) for problem-solving skills in Table 6, questions 1 to 6, from the international training programme.

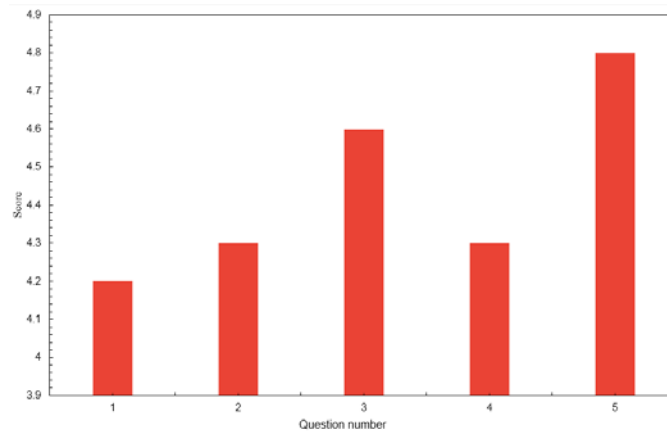


Figure 9: Leadership and teamwork skills.

Figure 9 shows the average (Likert scale 1-5) for leadership and teamwork skills in Table 6, questions 1 to 5, from the international training programme.

A close analysis of the above revealed a most interesting characteristic of the perceptions of the students about their communication, teamwork, problem-solving and leadership skills. The students of the international internship programme rated all these generic skills higher (average more than 4 on a scale of 5) than the students who attended the summer training programmes (average lower than 4 on a scale of 5). This difference in the average rating results is understandable as the internship programme was specifically targeted to improve the generic skills of the attendees. The objective of the programme was to give students an international experience, connect with industry and improve their soft skills.

The internship programme was project-based. Students were assigned a project in which they worked in teams to propose a solution. They had sessions on theory, technical visits and presentations on each topic to develop their generic skills further and, because of that, their perception of their generic skills was more positive than that of the students who did not attend this programme.

Therefore, the perception of the students attending the international internship programme was more positive than was that of the students attending the summer training programme, as is evident from the rating results. These indirect assessment results along with the direct assessment results of the courses and various feedback mentioned earlier, should be analysed further to suggest improvement plans.

CONCLUSIONS

Despite difficulties and challenges in inculcating generic skills, a planned and subtly articulated pedagogical framework including training programmes, internship programmes, field visits and international exposure aided in developing these skills among engineering undergraduates.

One of the ways to ensure the success of programmes that develop competencies is to seek assurance of the quality of the programmes from an unbiased accrediting agency, such as ABET. The review of the programmes by the ABET

programme evaluators (PEVs) provides valuable information and comments about their quality that helps the faculty and administrative management to adopt corrective and improvement measures.

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BIOGRAPHY



Abdullah A. Alshehri is an Associate Professor in the Electrical Engineering Department, Faculty of Engineering-Rabigh, King Abdulaziz University (KAU) in the Kingdom of Saudi Arabia. He received his BSc in electrical engineering in 1993 from the University of Detroit, Detroit, MI, USA. He received his MSc and PhD in electrical engineering from the University of Pittsburgh, PA, USA in 1999 and 2004, respectively. His field in research is in advanced signal and image processing, such as time-frequency, wavelet transform, neural networks and statistical signal processing. His recent research studies include learning outcomes and their assessment in engineering education. Since July 2016, he has been Dean of the Faculty of Engineering-Rabigh, KAU.

APPENDIX

Table 5: A questionnaire for assessing the generic skills/soft skills of students at the FER-KAU, and specifically for engineering students in the summer training programme.

Generic skills/soft skills questionnaire for engineering students						
Name:			ID:			
Department:			GPA:			
Summer training location:			Academic level:			
Soft skills can be defined as character traits or interpersonal aptitudes that affect your ability to work and interact with others. Soft skills include: communication; teamwork; adaptability; problem-solving; creativity; work ethic; interpersonal skills; time management.						
Communication skills questionnaire						
No.	Question	Score				
1	Were you satisfied with your first-year communication skills?	1	2	3	4	5
2	My communication skills have improved after I enrolled in the College of Engineering.					
3	My communication skills have improved through external training courses.					
4	My communication skills have improved through presentations in engineering courses.					
5	The number of presentations in the courses is sufficient to improve my communication skills.					
6	Teamwork on projects in some courses improves my communication skills.					
7	My proficiency in English is one of the most important factors to improve communication skills.					
8	Summer training has had an impact on developing my communication skills.					
9	Dealing with peoples from different cultures in summer training has improved my verbal communication skills (presenting ideas verbally, understanding what was heard, giving feedback).					
10	Dealing with peoples from different cultures has improved my social communication skills (negotiating to get agreement, communicating in different languages).					
Leadership skills questionnaire						
No.	Question	Score				
1	Were you satisfied with your first-year leadership skills?	1	2	3	4	5
2	My leadership skills have improved after I enrolled in the College of Engineering.					
3	My leadership skills have improved through external training courses.					
4	My leadership skills have improved through projects in engineering courses.					
5	Teamwork in projects in some courses improves my leadership skills.					
6	My proficiency in English is one of the most important factors to improve leadership skills.					
7	Summer training has had an impact on developing my leadership skills.					
8	Dealing with peoples from different cultures in summer training has improved my leadership skills.					
Teamwork skills questionnaire						
No.	Question	Score				
1	Were you satisfied with your first-year teamwork skills?	1	2	3	4	5
2	My teamwork skills have improved after I enrolled in the College of Engineering.					
3	My teamwork skills have improved through external training courses.					
4	My teamwork skills have improved through projects in engineering courses.					
5	Teamwork in projects in some courses improves my teamwork skills.					
6	My proficiency in English is one of the most important factors to improve teamwork skills.					
7	Summer training has had an impact on developing my teamwork skills.					
8	Dealing with peoples from different cultures in summer training has improved my teamwork skills.					
Problem-solving (critical thinking) skills questionnaire						
No.	Question	Score				
1	Were you satisfied with your first-year problem-solving skills?	1	2	3	4	5
2	My problem-solving skills have improved after I enrolled in the College of Engineering.					
3	My problem-solving skills have improved through external training courses.					
4	My problem-solving skills have improved through projects in engineering courses.					

5	My proficiency in English is one of the most important factors to improve problem-solving skills.					
6	Summer training has had an impact in developing my problem-solving skills.					
7	Dealing with peoples from different cultures in summer training has improved my problem-solving skills.					

Table 6: A questionnaire for assessing the generic skills/soft skills of students at the FER-KAU, for engineering students of the international internship programme.

International internship questionnaire for engineering students						
Name:			ID:			
Department:			GPA:			
Summer training location:			Academic level:			
Programme outcomes (communication skills)						
No.	Question	Score				
1	My ability to organise written materials in a logical sequence and appropriate technical style format.	1	2	3	4	5
2	My ability to make appropriate use of graphics/tables/figures/visual aids, etc.					
3	My ability to listen carefully and respond to questions appropriately.					
4	My ability to speak clearly professional language syntactically and semantically.					
5	My ability to enhance communication by maintaining proper body language/persona and clarity of speech.					
6	My ability to organise written materials in a logical sequence and appropriate technical style format to enhance the reader/audience comprehension.					
Programme outcomes (problem-solving and critical thinking)						
No.	Question	Score				
1	My ability to collect and document data for the case studies.	1	2	3	4	5
2	My ability to analyse effectively relevant data.					
3	My ability to engage, understand and resolve problem of the case studies.					
4	My ability to think and create multiple solutions to the problems.					
5	My ability to explain the major engineering systems and technologies used by the visited technologically based enterprises.					
Programme outcomes (leadership and teamwork)						
No.	Question	Score				
1	My ability to recognise participant roles in a team setting and/or fulfil appropriate roles to assure team success.	1	2	3	4	5
2	My ability to integrate input from all team members and/or make decisions in relation to objective criteria.					
3	My ability to improve communication among teammates and/or ask for feedback and/or use suggestions.					
4	My ability to demonstrate the ability to monitor team progress and/or make suggestions when needed.					
5	My ability to engage team members in problem solution.					