Assessment of A Bilingual Programme in Engineering at the University of Technology, Jamaica

Nilza Jústiz-Smith, PhD
Chemical Engineering Programme Director
University of Technology, Jamaica, Kingston, Jamaica, W.I. e-mail: nsmith@utech.edu.jm

G. Junior Virgo
Chemical Engineering Subject Leader
University of Technology, Jamaica,Kingston, Jamaica, W.I. e-mail: gvirgo@utech.edu.jm

ABSTRACT

In November 2005 the University of Technology, Jamaica (UTech) graduated its first batch of chemical engineers. This was also a landmark event because it involved the first set of graduates to have completed their course of study in two languages: English and Spanish. This study focuses on a longitudinal evaluation of the 4-year full time bilingual programme in chemical engineering using an assessment matrix approach developed by Olds and Miller. This research was born out of the necessity to meet the criteria for the Accreditation Board for Engineering and Technology (ABET), the Engineering Professional Accreditation Committee (EPAC) and the University Council of Jamaica (UCJ). The cross referencing of the objective criteria of the various accrediting bodies featured prominently in the approach as did a statistical analysis of the feedback interviews of the recently graduated professionals. The performance of the chemical engineering cohort was also compared with those of the students from other engineering disciplines in an effort to establish a relationship between knowledge of a foreign language and

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Bilingual, Assessment, Engineering

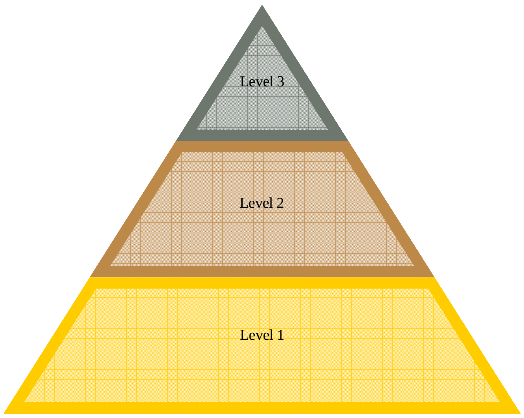
INTRODUCTION

The a 4-year full time programme in chemical engineering at The University of Technology, Jamaica (UTech) was launched in September 2001primarily to provide formal education for students in the field of chemical and biological processes. Sspecialisation courses are offered in the areas of process, biotechnology and environmental engineering.

The students are taught in both English and Spanish in order to prepare them for effective careers in the Caribbean and Latin American arena. The programme is designed around a minimum of 135 credit-courses. Students are prepared for fluency in technical Spanish via a minimum of 18 credit-hours in school/ specialization courses taught in Spanish at both UTech and other accredited Spanish speaking universities [1].

The programme is encompasses three levels of instruction (Figure 1). Years 1 and 2 covers the first level, where the fundamentals of chemical engineering are expounded while building on the applied sciences of chemistry, physics, mathematics and biology. Level 2 takes in year 3 and deals with integration, building on the first level by emphasing the principles and practices of chemical and biological engineering as well as an introduction to equipment and experimental designs. Fourth year courses constitute the third level of the programme and include process engineering plant design, process control and dynamics and a number of specialisation courses. Finally, courses in engineering management and engineer in society serve to expose engineering students to the responsibilities that a professional has to the wider community.

Three courses in Spanish communication which are taught in the first two years speak to language proficiency and is enhanced by a minimum of 270 hours of oral Spanish along with 45 hours of technical Spanish. The English component is delivered in Jamaica and the Spanish, to some extent, via immersion at accredited Latin American universities such as the “Jose Antonio Echeverria” Polytechnic Institute in Cuba. Here, Unit Operations (theory and laboratory), Electrical Technology and industrial practical experience are the the main focus of the programme.



Level 1: Fundamentals. Level 2: Integration.
Level 3: Chemical Engineering Specialisation.

Figure 1: Programme levels’ of instruction

In the final year of the programme students are expected to undertake an integrated project in wherein they apply their knowledge and skills to either produce a process design for a production facility or to investigate a particular aspect of chemical engineering theory. They are then required to defend their projects before a panel of assessors from within a pool of academic staff and industry personnel.

ASSESSMENT RATIONALE

Having witnessed the first batch of graduates from the programme it is incumbent upon us to investigate the degree to which the initial objectives of the programme have been realized and how our engineering students would match up against other graduate from within the School of Engineering. This study, therefore, focussed on a longitudinal assessment of the programme to-date, using a matrix approach that was tempered by specific criteria for the Accreditation Board for Engineering and Technology (ABET)[2], the Engineering Professional Accreditation Committee (EPAC)[3] and the University Council of Jamaica (UCJ)[4]. Olds and Millers’ assessment matrix was designed to “help faculty develop an assessment plan” of their programme of studies [5].

The contribution of chemical engineering to the Jamaican industrial landscape has undergone continuous reviews consistent with the evolution of chemical processes in response to the changing needs of the society. The B. Eng. (CHE) programme should address these changes and help to guarantee industrial renewal in Jamaica and the wider Caribbean region, through training of a cadre of proficient chemical engineers, the development of new and improved courses, enterprise incubation with associated research, design, development and consultancy [6]. Further development and improvement of the program is a direct function of the assessment of learning outcome and continuous curriculum improvement. One benchmark for such achievement is the meeting of specific criteria for the Accreditation Board for Engineering and Technology (ABET).

PROGRAMME EVALUATION

The evaluation of a programme performance usually involves an assessment of performance followed by some amount of feedback and further assessment based on the information gleaned from the feedback [7]. Olds and Miller [8] believe that the evaluation of engineering education programmes is a necessary prerequisite for any change that targets the competition in what has become a “*global high-technology market*” [1]. It is for this reason that Felder, et al [9] and

Smith et al [6] studied the performance of engineering students in an introductory chemical engineering course and use the results as a basis for predicting students' performance.

The curriculum design of the University of Technology Jamaica [1] outlines explicitly, the assessment methods that are acceptable for the various programmes offered. However, we chose to evaluate the programme with an assessment matrix approach developed by Olds and Miller [5] since it is designed to satisfy specific criteria for ABET. The importance of satisfying these criteria is supported by work done earlier by Davis and Oliver [11]. It is therefore, imperative that we examine the various methods of formative assessment used by other educators with a view to justifying our selection of that particular matrix.

Newberry and Farison [12] wrote that the systematic and careful application of well developed assessment instruments to most educational programmes is an excellent tool for identifying weaknesses in instructional methodologies and further improving learning outcomes. However, the forms of assessment can be many and varied and are often specific to the type of learning outcome that is being assessed.

Payne [13] defines educational assessment as "Interpretive integration of application tasks (procedures) to collect objectives-relevant information for educational decision making and communication about the impact of the teaching-learning process". He further suggests, as do Meighan and Siraj-Blatchford [14], that the assessment process should not end with data collection but must include an understanding of the meaning of the information so gathered. Wiggins [15] in concurring with this definition further stated that assessments should both teach as well as measure learning outcomes by providing meaningful feedback to teachers and students, alike. He further express that assessment should focus mainly on improving performance rather than act as a kind of audit procedure. This, he predicates on the premise that "*First, assessment should be deliberately designed to teach (not just measure) by revealing to students what worthy adult work looks like (offering them authentic tasks). Second, assessment should provide rich and useful feedback to all students and to their teachers, and it should indeed be designed to assess the use of feedback by both teachers and students*". Gronlund [6] also subscribes to the feedback nature of assessment and wrote, "*Assessment results provide information useful for evaluating the appropriateness of the objectives, the methods, and the materials of instruction*".

The assessment methodologies were taken step further by Pappas et al [16], when they analyzed the performance of students of an advanced engineering communications programme. They use feedback information from industrial based alumni that directly correlated course objectives with coverage of the ABET Engineering Criteria [2]. The methodology used involved feedback from the industry as well as direct input from the alumni regarding their views on how the engineering curriculum prepared them for the problems they faced on the job. Pappas et al [16] used the information from their assessment analysis to identify and correct areas that needed specific attention and reinforcement.

METHODOLOGY

Analysis of ABET/UCJ and UTech Programme criteria.

Taking into consideration the four main elements that compose a curriculum, objectives, content, method and evaluation [17], during this planning and evaluation of the programme more consideration was given to objectives and evaluation. For this matter criteria objectives provided by ABET and UCJ documents [2,4] were used to build the assessment matrices. The matrices included ABET, UCJ and UTech programmes' objectives and were used to facilitate the analyses.

The other matrix columns recognise various elements to measuring how well chemical engineering graduates meet the requirements for each criteria and objective [5]. Individual courses were selected that were instrumental in helping to meet the particular objectives in conjunction with various assessment methods. Each assessment level included a series of activities that should be carried out by academic staff during the continuous evaluation of the programme

Matrix Design and Evaluation

In essence, after a curriculum is designed and implemented students' performances for all courses are systematically measured by department heads to identify weakness, using mainly the passing score percentages. A representative sample taken from a total of 12 objectives contemplates in the curriculum for the bachelor in Chemical Engineering degree, was selected to carry out this study. Students' performances for three years were used to evaluate both matrices: the one designed to meet ABET/ UCJ criteria and the one currently being used at UTech. During this study both matrices were compared based on aim, content, feedback and expected results.

A representative sample taken from a total of 12 objectives contemplated in the curriculum under analysis was selected to carry out this study. Students' performances for three years were used to validate and evaluate the matrices.

RESULTS AND DISCUSSION

A total of 7 out of 12 objective samples were used in the construction of the matrix for the bachelor of engineering programme. These objectives were matched to the corresponding objectives of ABET/UCJ criteria.

Table 1 shows the objective set up to deal with its respective ABET criteria 3(a) "an ability to apply knowledge of mathematics, science and engineering" [2] and the UCJ, objective: "have a sound foundation in mathematics and other requisite science" [3]. The department agreed to use four courses namely: Statistics and Probability, Physical Chemistry, Material Science and Unit Operations I (Transport Phenomena) as a part of the implementation strategy. The first three of these courses are taught by other departments and are related to levels 1 and 2 of this curriculum (years 2 and 3), that deals with the fundamentals and integration types of courses. The knowledge gathered from these course will impact on other courses and consequently on the accomplishment of other objectives in the curriculum. The table also illustrates ABET criterion 3e "an ability to identify, formulate and solve engineering problems" [2]. The grade of achievement, for example in the Unit Operations I course (introduced into the matrix by the previous criterion) will play a pivotal role in the expected results for this criteria and in the students' performance for all the courses selected as part of the implementation strategy for this objective. In addition to the process of building the assessment matrix the interaction of various courses and their location during the learning pyramid relationship shown in Figure 1, was also taken into consideration.

Students' formative testing processes were included along with summative tests as part of the assessment method column. In general, most of the UTech courses included high weights in summative tests (60% of the overall grade of the course). The timeline was also considered, dedicating 50% of the time for testing during the semester to individual formative testing and 80% to cooperative learning by using group work assignments. The students were expected to perform at about 60% average mark with overall pass of 80% in the course. The performance criteria vary for some objectives as a function of the relationship between courses and level of instruction within the curriculum. Consideration was given to courses that constitute prerequisites or knowledge basis for other courses such as, Fluid Mechanics, Heat Transfer, Mathematical Modelling and Process Design and economics. Statistics & probability is also a very versatile course that helps to build students' skills in data analysis, experimental design, simulation and modelling and any further engineering work related to data collection and analyses.

The assessment matrix designed also reflects ABET criterion 3e "an ability to communicate effectively" [2]. The matching curriculum objective expressed "communicate effectively using graphical, written and oral methods in both Spanish and English" [1], taking into consideration one of the goals of this curriculum to develop in the students the capability to communicate technically in a second language. To this aim the programme included technical courses such as: Optimization, Process Engineering, Unit Operations laboratory I, Material Science and Chemical Reaction Engineering which were all offered in Spanish. The performance criteria for these courses were set at 70% with an average pass mark of 70% (B). Since the programme started there have been discussions within our Engineering School generating various questions as to the students' proficiency in technical Spanish. Specifically whether s/he was able to present and discuss chemical engineering problems before an audience and at what level? The Chemical Engineering department considered various approaches for testing the performance of this objective. This is one of the advantages of this type of assessment matrix, since course interaction can be addressed to improve efficiency, thus ensuring a higher quality product, and facilitating the accomplishment of the curriculum objective, of the ABET/UCJ criteria for accreditation.

Student will be submitting an executive summary of their Major Research project in Spanish as part of their deliverables to complete their programme of study. Most of the accreditation bodies assess these reports. The UTech matrix do not include any possibility to address the level of research or engineering design work that the students should undertake in order to graduate as engineers. The matrix designed in this study includes, as assessment methods, a continuous evaluation of the research/design work during the entire year. The report will be assessed by the department language lecturer and project supervisor. The Mini Viva will be conducted also in Spanish, with a final project presentation before a panel of academic and industry personnel in English.

In general the university's assessment matrix includes information about passing percentage, average score, and course difficulty index. This difficulty index is calculated using the sum of the highest and lowest grades per total number of students sitting the course. However, this parameter is most suitable for assessing individual testing items rather than an entire course.

The UTech assessment matrix is based only on individual course scores and ranking performance. It does not evaluate the performance objectives include in the curriculum. Table 2 shows some of the results for level 1 and 2 of this curriculum. Observe students' performance and its correlation to Course Difficult Index (CDI) for each course. A high score in a course reflects a high CDI value. What does this result actually mean? How can the department address a problem without properly identifying the cause of failure or the relationship between one level of instruction and other and the proper planning of the assessment? Can we say that a particular course is an "easy" course, because at every sitting all students are promoted or vice versa?

For example, in the fourth semester of the programme, (Table 1), the course of Mathematical Statistics included performance criteria of 70% students passing the course and with an average mark of 60%. Based on the results reflected in Table 2 for the same course 83.3 % of the students passed, with an average rank of 60.8%. Nevertheless, the CDI was 5.06. How can this result be interpreted in light of the fact that this is a tests instrument index?

Table 1: Assessment Matrix

ABET Criteria	UTech Objective	Performance Criteria	Implementation Strategy	Method Assessment	Timeline	Feedback
No. 3a	No. 1	70% students will pass the course average work of 60% (C+)	Completion of STA2005, CHE2001, ENG3001 CHY2018	Formative & Summative testing. Group work	Weeks # 7 & 15. Week#13.	Subject Leader Advisory Committee Students
No. 3e	No. 2	70% students will pass the course. Average work of 65% (B-)	Completion of CHE2004, CHE3004, CHE3008, CHE3001, CHE3004, PRJ4005, CHE2003, CHE3005	Formative & Summative testing. Group work Presentations. Laboratory assessment.	Weeks # 7 & 15. Week#13 Weekly	Subject Leader Advisory Committee Students
No.3c	No. 9	70% students will pass the course Average month of 65% (B-)	Completion of: CHE3001, CHE3004, CHE3008, CHE4001	Formative & Summative testing. Group work Presentations.	Weeks # 7 & 15. Week#13	Subject Leader Advisory Committee Students
No.3g	No. 4	70% students will pass the course Average month of 65% (B-)	Completion of: CHE2004, CHE3003, SPA3003 ENG3001 CHE3006	Formative & Summative testing. Group work Presentations.	Weeks # 7 & 15. Week#13	Subject Leader Advisory Committee Students

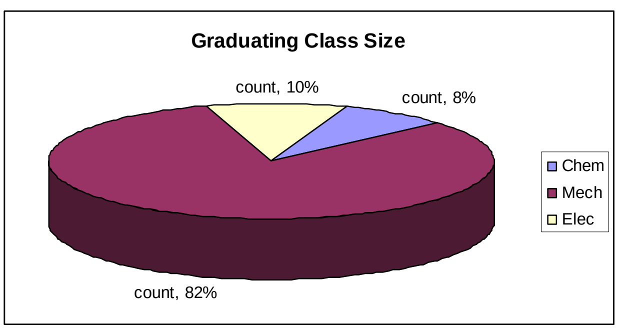
Table 2: UTech assessment matrix

Course code	% Passing (score ≥ 50)	High mark (%)	Average mrk (%)	CDI
SPA3003	90.9	85	64.4	5.86
CHE2001I	87	87	64.2	5.58
CHE3001	91.3	79	61	5.57
STA2005	83.3	85	60.8	5.06
CHY2018	91.7	77	63.8	5.84
CHE2002	91.3	85	64.2	5.86
CHE2003	100	97	84.9	8.49
CHE3004	100	92	72.7	7.27
CHE3007	91.3	80	58.3	5.32
CHE3008	95.7	85	63	6.03
CHE3002	82.6	90	61.4	5.07
ENG3001	100	88	73.3	7.33
Average				**6.56**

The assessment matrix has been tested since the 2001/02 academic year. During this assessment a correlation was done comparing performance criteria for various courses within the fundamental levels using formative, summative and students' overall pass grades. For example a correlation of the final grades for foundation course CHE2001 showed a positive coefficient with respect to all the chemical engineering integration courses such as, CHE3004 and CHE3008. This supports our selection of CHE2001 as a prerequisite for the integration level courses.

A summary of the chemical engineering group's assessment performance is compared with that of the other engineering groups in the tables below. Data summarised from the assessment of the performances during levels 2 and 3 formed the basis of these tables. Figure 2 is a breakdown of the population from which the data is assessed. The mechanical engineers constitute the largest of the groups while the electrical engineering students earn the opposite distinction of being the least in numbers. Table 3 compares the accumulated grade point averages of the different groups as a means of

Figure 2: Distribution of students within the three engineering disciplines.



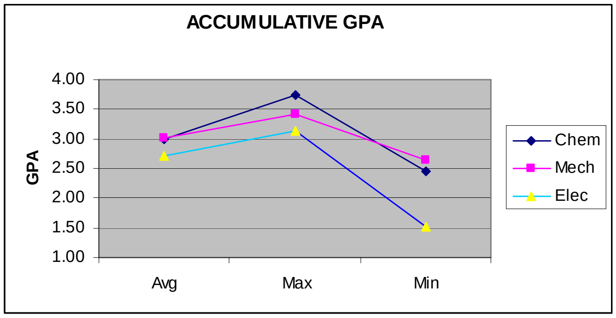
evaluating the chemical programme. This information is illustrated in Figure 3 from which it is evident that the chemical

Table 3: Accumulated Grade Point Average Comparison

	Chem	Mech	Elec
Avg	3	3.01	2.72
Max	3.74	3.41	3.13
Min	2.46	2.64	1.53
Range	1.28	0.77	1.61

engineers achieved marginally higher GPA's than the mechanical and electrical engineers.

Figure 3: Cumulative GPA Comparison



When the data is further discriminated on the basis of programme levels the chemical engineers again showed better performance than the other two groups.

Table 4: Level 2 Grade Point Average Comparison

	Chem	Mech	Elec
Avg	2.77	2.75	2.60
Max	3.69	3.26	3.23
Min	2.06	2.20	1.99
Range	1.63	1.06	1.24

This is supported by the data shown in table 4 and charted in figure 4. Here, although the average GPA is similar for both the chemical and mechanical groups the former had the highest maximum value at 3.69.

Figure 4: Level 2 Grade Point Average Comparison

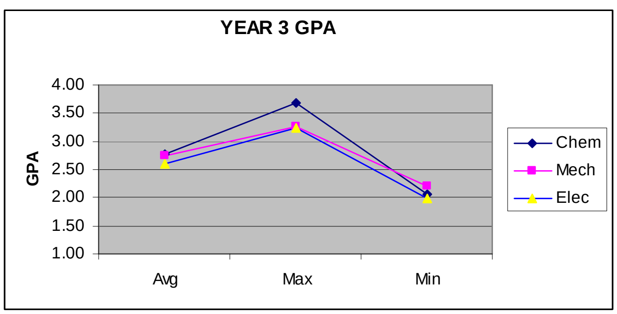
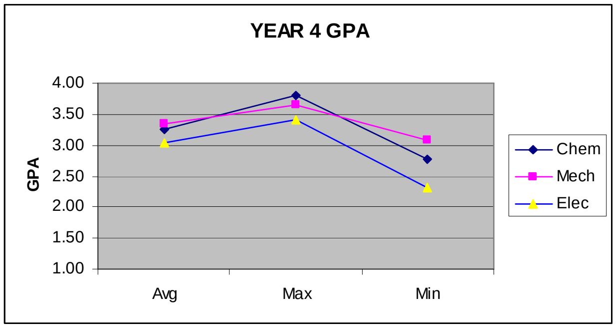


Table 5 compares the performance of the groups during their final year assessment. The data is better illustrated in figure 5 which shows the chemical group on par with the mechanical group but with better performance than the electrical group.

Table 5: Level 3 Grade Point Average Comparison

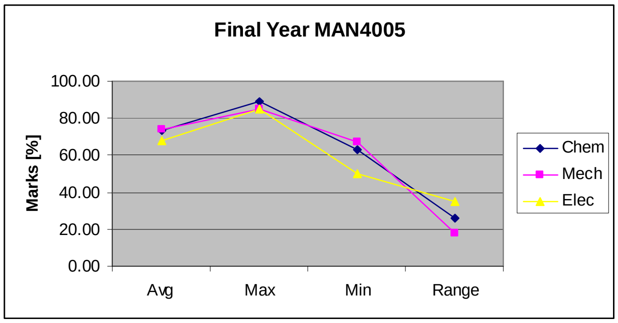
	Chem	Mech	Elec
Avg	3.26	3.34	3.05
Max	3.80	3.66	3.41
Min	2.78	3.07	2.32
Range	1.02	0.59	1.09

Figure 5: Level 3 Grade Point Average Comparison



The average GPA of three of the final year courses that are common to all three groups were tabulated and charted below.

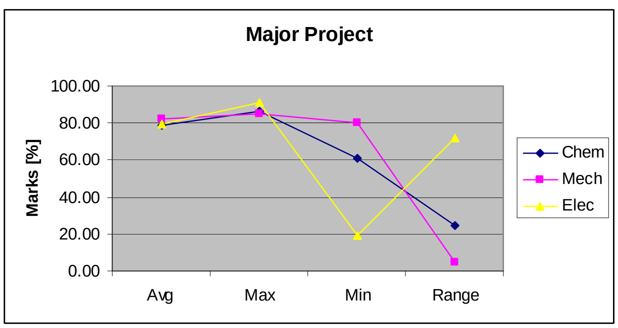
Figure 6: Comparison of Average MAN4005 scores



From figure 6 it is evident that the chemical group scored higher in Management for Engineers which is a course that is common to all the engineering groups.

Figure 7 compares the average scores for the major design project. Again the group average for the chemical engineers

Figure 7: Comparison of Average PRJ4005 scores



was no worse than that of the other two disciplines which further attests to the comparatively favourable performance of these students.

CONCLUSION

The designed assessment matrix resulted in a very effective instrument for planning and projecting students expected learning outcomes for various courses with respect to programme specific objectives. However, further work needs to be done on the correlation of the core courses with the integration and specialization level courses.

The matrix has proven to be a valuable tool in assessing and predicting the performance of engineering students at various levels of the programme.

Although the data for the entire programme could not be accessed for the study, the available information suggests that the chemical programme is characterized by better student performance in comparison to the mechanical and electrical engineering programmes at the University of Technology, Jamaica.

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