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Achievement of Engineering Students in their Specialization Fundamentals—An Evaluation*

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Evaluation is an integral part of our everyday activities including educational activities conducted in an educational institution. The authors recently carried out a study in the College of Engineering, King Abdul Aziz University, Jeddah, Saudi Arabia to evaluate the academic achievements of their undergraduate students. In this study, an objective type achievement test consisting of multiple choice test items was used as the tool for evaluation. Senior students from the major departments appeared in the test. The test named General Test in Engineering (GTE) was constructed locally and comprised of two parts. The first part (GTE I) was meant for evaluating the achievements in the Engineering Basics and the second part (GTE II) was for the departmental fundamentals. The results of GTE I were presented earlier. This paper presents the results of GTE II and their analysis.

INTRODUCTION

EVALUATION of achievement levels plays an important role in any academic institution. It provides feedback concerning the quality of education. This helps to assess the degree to which the current academic programs/curriculum of an institution are effective in meeting the needs of the students, potential employers and the society as a whole. It also aids the institution to revise and improve its present curriculum. The importance and need of evaluation in education is reflected from the formation of national committees on educational evaluation in different countries as well as from the studies published in different national and international journals and books [1–11].

The principal developments that have contributed to educational evaluation today have occurred since 1900. Palmer [12] in his article made an appraisal of evaluation in education. The author listed four steps in evaluation and illustrated each. The steps are (a) the formulation of the objectives, (b) the determination of how their attainment can be measured, (c) the recording of their attainment level, and (d) the interpretation of these records. LeBold [13] reported an investigation in which 85 engineering companies were asked to give their opinions regarding the contents and duration of engineering curricula. The views were about equally divided on specific training of undergraduates for particular job categories, as contrasted with training in a common program for all job categories. The replies indicated that respondents were also equally divided between the 4-year and 5-year undergraduate programs. Hawkins *et al*. [14] conducted a study among the graduates of Purdue university in U.S.A. who were awarded B.S. degrees in Engineering from 1911 to 1956 inclusive, to get their opinion on educational objectives and engineering curricula. Gammel [15] reported on the expectations of the employers from the young engineering graduates. Rogers [16] identified gaps between the statement and achievement of objectives in the education of an engineer. McAuley [17], on the basis of responses from 227 engineering graduates of metropolitan New York engineering colleges and 175 supervisors of both large and small companies from all over the U.S.A., concluded that the engineering college curricula were inadequate in preparing the graduates for the work for which the company hired them. Lipowicz and Hughson [18] conducted a survey of 4759 practising chemical engineers and came up with the recommendation that the engineering graduates need more preparation in practical engineering skills.

Conscious of the fact that evaluation of achievement levels is very useful and needed in education, an exercise in this respect was carried out recently by the authors in the College of Engineering, King Abdul Aziz University, to evaluate the achievements of their undergraduate engineering students. In this exercise, an objective-type achievement test

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was used as the tool for evaluation. The test consisted of two parts, the first part covered the basics in engineering, while the second part covered the departmental fundamentals. This paper reports the results of the evaluation of achievement of the undergraduate engineering students in departmental fundamentals only. The results of the evaluation in engineering basics have already been reported [19]. The management experience gained from the study and suggested recommendations for conducting such exercise have also been reported earlier [20].

ENGINEERING PROGRAM AT KAAU

The College of Engineering at KAAU which was established in 1975, awards bachelors and masters degrees in a number of engineering disciplines. The requirements for obtaining bachelors degrees from most departments is the completion of 165 credit hours comprising a common core of 71 credit hours and a departmental program of 94 credit hours. The core which is common to all departments comprises subjects related to engineering basics whereas the departmental program which is different for different departments consists of some required and some elective courses.

TEST AND THE EVALUATION SCHEME

The objective-type achievement test which was used for the evaluation was developed locally by a committee of professors drawn from different disciplines of the college. All the professors had a long experience of teaching and had also been teaching at this college since its establishment. They prepared tests pertaining to their respective areas of specialization and consulted their senior colleagues in the departments. The decision to construct the test locally was taken because no standardized achievement test suited to the evaluation objectives was available even after letters of enquiry were sent to various organizations and test publishers. The test was prepared in English and consisted of multiple-choice type questions with four choices to each test question. The first part which covered the basics in engineering related to the courses in the college core and was named 'General Test in Engineering, Part I (GTE I)'. The second part titled 'General Test in Engineering, Part II (GTE II)' included materials from the departmental required courses only. GTE I was common for all students irrespective of their specialization while GTE II was different for different departments. The test was initially administered on a trial basis to a group of graduate assistants and graduating students. Based on the feedback obtained from a trial run, some of the test items and answer options were revised. The total number of test items were also revised such that they could be answered within the stipulated time. Some sample test items of GTE II for Civil Engineering are given in Appendix A.

GTE I had 98 test items while GTE II in Civil, Electrical, Industrial and Mechanical Engineering had 75, 72, 78 and 72 test items respectively. The time allotted for each part was 90 minutes. The grading was done by assigning one mark for every correct answer and zero mark for a wrong answer or no answer. The test was eventually given to a randomly selected group of senior students from four major departments (Civil, Electrical, Industrial and Mechanical Engineering) of the college.

The test standards (the desired performance in GTE II) for different subject areas were set between 50 and 60. Standards were based upon the considered judgement of the investigators and the test preparation committee who are intimately familiar with the environment related to the characteristics measured by the test, the difficulty level of test items and the talent of the group of students tested.

TEST RESULTS AND ANALYSIS

As mentioned earlier, this paper presents the results and analysis of GTE II only. Although the test was given to students from four major departments, the results of the Electrical Engineering students were not considered for the present analysis as their attendance in the test was not sufficient for any meaningful analysis. The present analysis is based on the results of the students from the other three departments.

Descriptive statistics for different departments

The total number of students who appeared in GTE II was 94. Out of these 35 students were from Civil, 30 from Industrial and the remaining 29 from Mechanical Engineering. The mean of the undergraduate point average (GPA) of all the students who appeared in GTE II was 3.118 out of a maximum of 5. The mean GPA of CE, IE and ME students were 3.38, 2.94 and 2.98 respectively. The descriptive statistics for different departments is given in Table 1.

Distribution of students by test scores

The distribution of students by test scores for different departments is shown in Fig. 1 with the help of three relative frequency histograms, one each for CE, IE, and ME. Figure 2 shows the cumulative distribution of students by test scores for the three departments.

Civil Engineering. As can be seen from Fig. 1, the distribution for CE is symmetric. Maximum percentage (34%) of the students scored between 50% and 60%. 31.5% of the students scored above 60% (see also Fig. 2). 25% of the students scored below 46% and 50% of the students scored below 54%.

Table 1. Descriptive statistics for different departments

Statistics		Civil Engineering	Industrial Engineering	Mechanical Engineering
No. appeared		35	30	29
GPA	Mean	3.381	2.94	2.987
	Std. Dev.	0.716	0.466	0.623
Test score in %	Mean	54.32	48.63	44.68
	Std. Dev.	11.86	7.89	8.86
	Highest	78.67	74.36	58.33
	Lowest	29.33	38.46	27.78

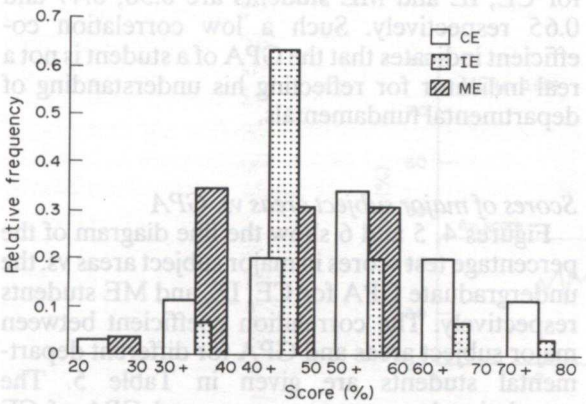

Fig. 1. Distribution of students by test scores.

Industrial Engineering. From Fig. 1, the distribution for IE is seen to be skewed to the right. Maximum percentage (63.3%) of the students scored between 40% and 50%. 10% of the students scored more than 60%. Figure 2 shows that 25% of the IE students scored less than 44% and 50% of the students scored less than 46%.

Mechanical Engineering. The distribution for ME is also skewed to the right, as can be seen from Fig. 1. Highest percentage (34.5%) of the students scored between 30% and 40%. None scored above 60%. 25% of the students scored below 36% and 50% of the students scored below 44%.

Scores by subject

In order to assess the achievement of engineering students in their specialization fundamentals, only the courses belonging to the department core program were considered for GTE II. The questions of GTE II were grouped into the respective department's major subject areas. The results of these subject areas are shown below.

Civil Engineering. The questions of GTE II for CE were from three major subject areas. Table 2

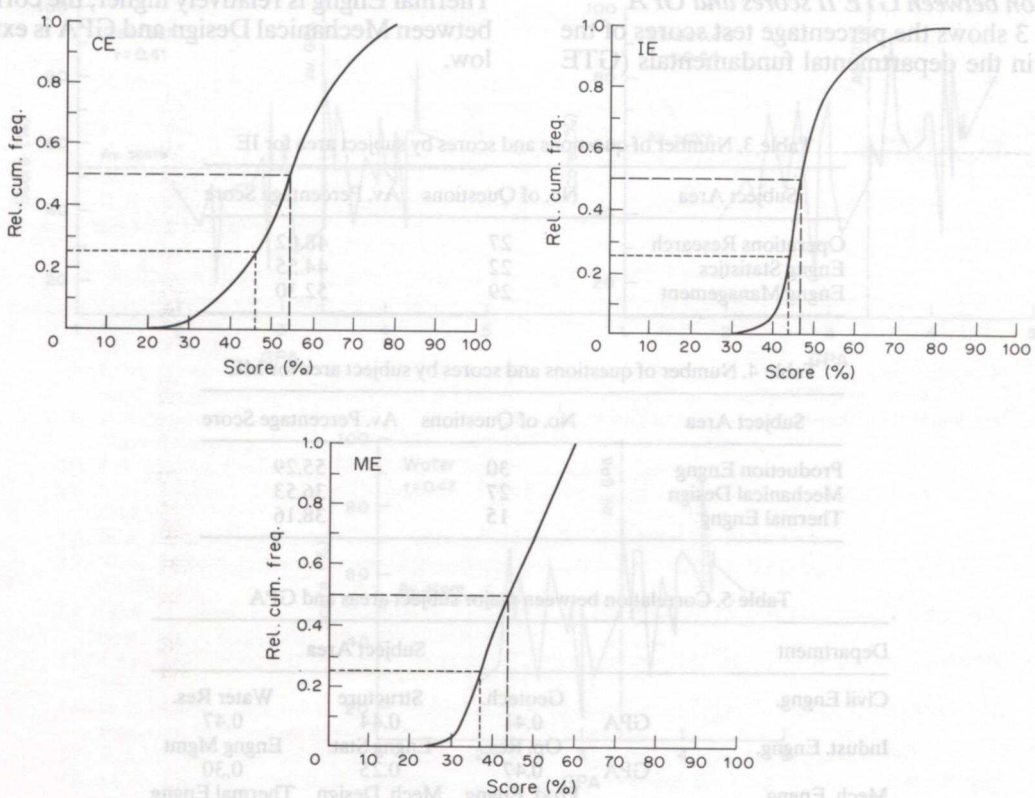

Fig. 2. Cumulative distribution of students by test scores.

Table 2. Number of questions and scores by subject area for CE

Subject Area	No. of Questions	Av. Percentage Score
Geotechnical and Transportation	25	52.69
Structural and Construction	26	57.91
Water Resources and Environmental	24	52.14

shows the number of questions and the average percentage scores in each area.

From Table 2, it can be observed that the performance of the students in different subject areas is more or less the same.

Industrial Engineering. The questions of GTE II for IE were grouped into three major subject areas. Table 3 shows the number of questions and the average percentage score in each area.

The students of IE showed a poor performance in Engng. Statistics and Operations Research. More emphasis should be given in these two areas. The courses in these areas are the major tools for the IEs.

Mechanical Engineering. The questions of GTE II for ME were grouped into three major subject areas. Table 4 shows the number of questions and the average percentage score in each area.

The performance of the ME students in Mechanical Design and Thermal Engineering was very poor.

Correlation between GTE II scores and GPA

Figure 3 shows the percentage test scores of the students in the departmental fundamentals (GTE II) against their GPA. The correlation coefficient for CE, IE and ME students are 0.56, 0.47 and 0.65 respectively. Such a low correlation coefficient indicates that the GPA of a student is not a real indicator for reflecting his understanding of departmental fundamentals.

Scores of major subject areas vs. GPA

Figures 4, 5 and 6 show the line diagram of the percentage test scores in major subject areas vs. the undergraduate GPA for CE, IE, and ME students respectively. The correlation coefficient between major subject areas and GPA for different departmental students are given in Table 5. The correlation between test scores and GPA of CE students seems to be poor for all major subjects. The correlations between test scores in different subject areas and GPA for IE students are also found to be poor. The correlation between Engng Mgmt—GPA and Engng Stat—GPA is very poor. Although the correlation between test scores and GPA for ME students in Production Engng and Thermal Engng is relatively higher, the correlation between Mechanical Design and GPA is extremely low.

Table 3. Number of questions and scores by subject area for IE

Subject Area	No. of Questions	Av. Percentage Score
Operations Research	27	48.02
Engng Statistics	22	44.55
Engng Management	29	52.30

Table 4. Number of questions and scores by subject area for ME

Subject Area	No. of Questions	Av. Percentage Score
Production Engng	30	55.29
Mechanical Design	27	36.53
Thermal Engng	15	38.16

Table 5. Correlation between major subject areas and GPA

Department		Subject Area		
Civil Engng.		Geotech.	Structure	Water Res.
	GPA	0.41	0.44	0.47
Indust. Engng.		Op. Res.	Engng Stat.	Engng Mgmt
	GPA	0.47	0.25	0.30
Mech. Engng		Prod. Engng	Mech. Design	Thermal Engng
	GPA	0.57	0.15	0.60

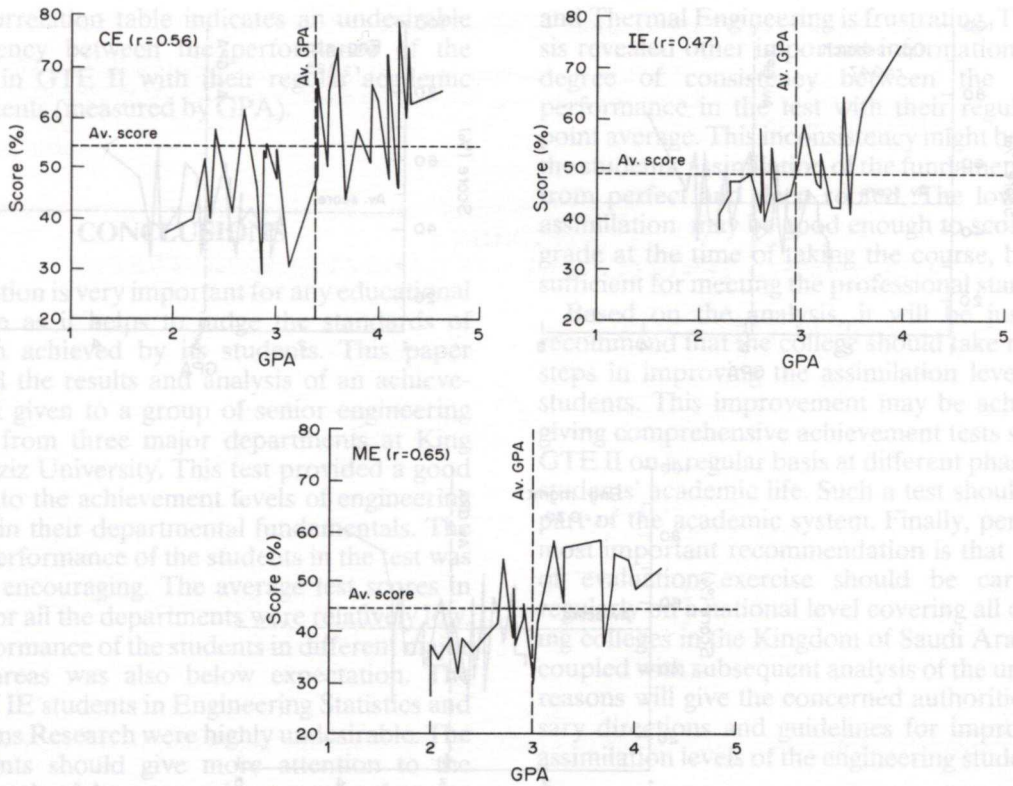

Fig. 3. Scores of GTE II vs. GPA for students of different departments.

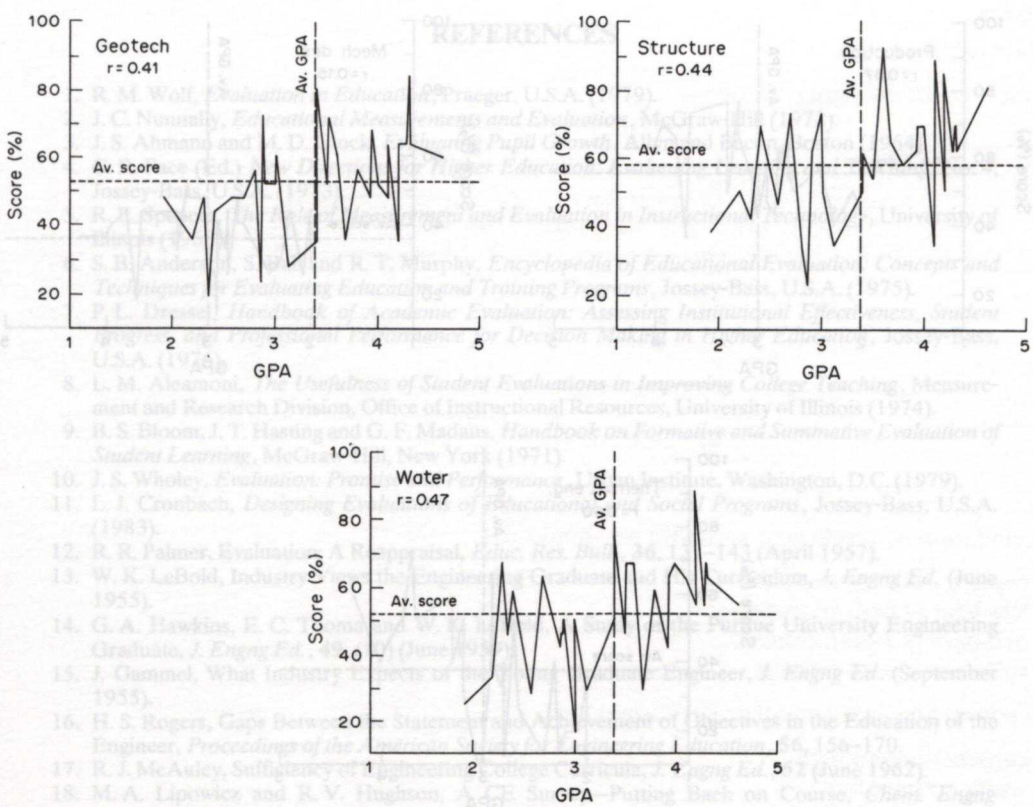

Fig. 4. Scores of major subject areas vs. GPA for students of civil engineering.

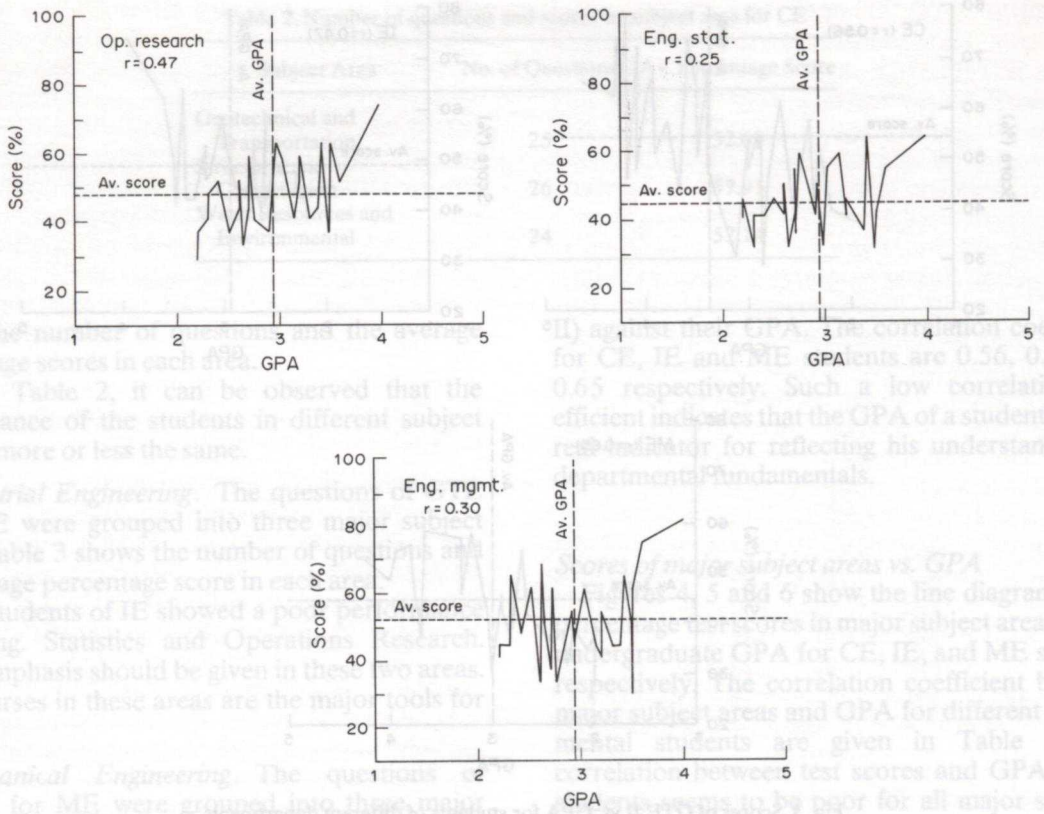

Fig. 5. Scores of major subject areas vs. GPA for students of industrial engineering.

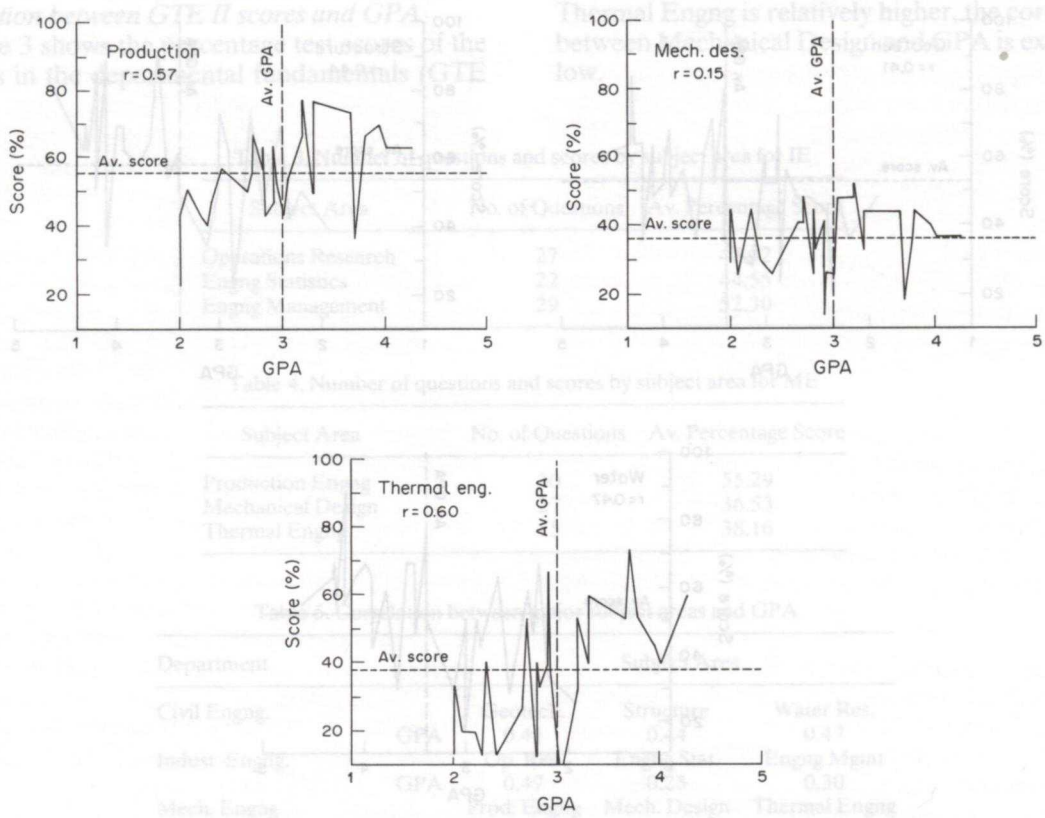

Fig. 6. Scores of major subject areas vs. GPA for students of mechanical engineering.

The correlation table indicates an undesirable inconsistency between the performance of the students in GTE II with their regular academic achievements (measured by GPA).

CONCLUSIONS

Evaluation is very important for any educational institution as it helps to judge the standards of education achieved by its students. This paper presented the results and analysis of an achievement test given to a group of senior engineering students from three major departments at King Abdul Aziz University. This test provided a good insight into the achievement levels of engineering students in their departmental fundamentals. The overall performance of the students in the test was not very encouraging. The average test scores in GTE II for all the departments were relatively low. The performance of the students in different major subject areas was also below expectation. The results of IE students in Engineering Statistics and Operations Research were highly undesirable. The IE students should give more attention to the fundamentals of these two subject areas, otherwise they will not be in a position to solve engineering management problems with utmost confidence in their professional life. Similarly, the performance of ME students in the areas of Mechanical Design and Thermal Engineering is frustrating. The analysis revealed other important information, the low degree of consistency between the students' performance in the test with their regular grade point average. This inconsistency might be because the students' assimilation of the fundamentals is far from perfect and deep rooted. The low level of assimilation may be good enough to score a good grade at the time of taking the course, but is not sufficient for meeting the professional standards.

Based on the analysis, it will be justified to recommend that the college should take necessary steps in improving the assimilation levels of the students. This improvement may be achieved by giving comprehensive achievement tests similar to GTE II on a regular basis at different phases of the students' academic life. Such a test should form a part of the academic system. Finally, perhaps the most important recommendation is that this kind of evaluation exercise should be carried out regularly on a national level covering all engineering colleges in the Kingdom of Saudi Arabia. This coupled with subsequent analysis of the underlying reasons will give the concerned authorities necessary directions and guidelines for improving the assimilation levels of the engineering students.

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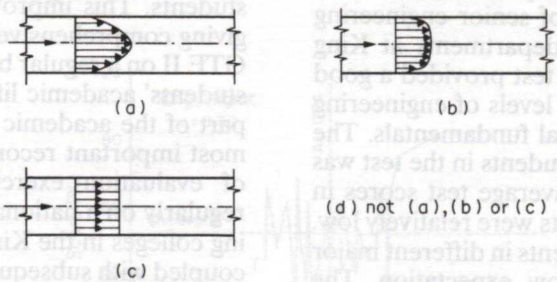
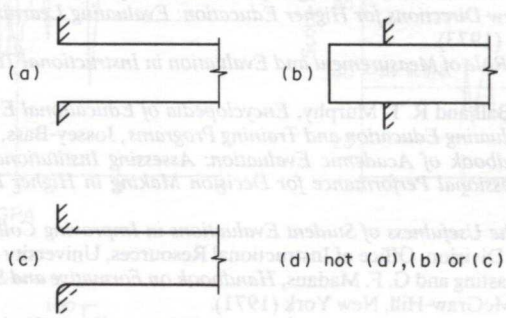
APPENDIX A
SOME SAMPLE TEST ITEMS OF GTE II FOR CIVIL ENGINEERING

1. Velocity profile in turbulent pipe flow looks like



2. In a rectangular channel the mean velocity at a section is 5 m/s and the depth of flow is 1 m. The flow is
   (a) critical
   (b) subcritical
   (c) supercritical
   (d) not (a), (b) or (c).
3. Mean velocity at a vertical section in an open channel occurs below the surface at
   (a) 0.5 d
   (b) 0.6 d
   (c) 0.8 d
   (d) Not (a), (b) or (c).
4. The best form of the pipe entrance is



5. For foundation concrete near seashore we should use
   (a) rapid hardening cement
   (b) low heat of hydration cement
   (c) ordinary portland cement
   (d) sulfate-resistant cement.
6. When concreting in hot weather, we should keep
   (a) cement content high
   (b) water content low
   (c) water content high
   (d) aggregate content high.

7. Segregation in concrete is caused by
   (a) high water/cement ratio
   (b) poor compaction
   (c) low aggregate/cement ratio
   (d) bleeding.

8. The structure which is both stable and determinate is shown in