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# Analysis of assessment strategies used in a Level 7, Year 1 engineering subject

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**Abstract**
This contribution critically analyses the assessment strategies used on the core Electrical Systems subject in the first year of a three-year, Level 7, degree programme in Electrical Engineering at Dublin Institute of Technology. An evidence-based approach is taken, by analysing the assessment data in detail.

## 1. Background

Since 2005, the author has had responsibility for development, instruction and assessment in the present version of the Electrical Systems subject in the first year of a three-year, Level 7, degree programme in Electrical Engineering at Dublin Institute of Technology. Level 7 programmes were previously referred to as technician programmes; candidates apply for such programmes (in common with all higher education programmes) through the Central Applications Office, in which points are given for examination results in six subjects taken in the Leaving Certificate, or equivalent. The maximum point score possible for a candidate is 600, with 55% of candidates scoring more than 300 points in 2007, for example (CAO, 2007a). Minimum points levels for programmes are set by student demand for the limited number of course places; in common with worldwide trends, student demand for technology courses is decreasing, leading to, for example, a minimum points level for the programme of 150 in 2007, with a median points level of 245 (CAO, 2007b). Though there is some debate as to whether the points scored by candidates in an examination process dominated by a terminal examination is the best predictor of subsequent success on an engineering programme, nevertheless it is clear that many, if not most, of the students entering the programme have lower academic ability when compared to their wider peer group.

In a typical year, between 25 and 35 learners commence the degree programme, the majority of whom come directly from second-level education; there are a small number of students who are mature learners (categorised as students over 23 years of age in Ireland) and a further small group of international students. In addition, since 2007, a part-time version of the programme has operated; part-time students and full-time students attend the same lectures and laboratories and sit the same assessments.

Finally, Level 7 programmes are distinguished from Level 8 programmes, which in Engineering are four years in duration, require a much higher minimum standard in Mathematics at the Leaving Certificate examination (or equivalent) and allow successful graduates to work directly for chartered membership of engineering professional bodies. Successful Level 7 graduates in engineering may directly achieve associate (or equivalent) membership of the professional bodies.

## 2. Description

Electrical Systems is a central technical subject in the programme, and learning in the subject is progressed further in the remaining two years of the programme. The subject is divided into two thirteen-week semesters; in each semester, students attend two hours of lectures and two hours of laboratories in the subject each week. Presently, the subject is assessed in the following manner:

- Terminal examination (50% of subject mark), held after the completion of the second semester. This examination has a compulsory question and five other questions, three of which are to be attempted. Two of these five questions are presently in multiple-choice format.
- Laboratory work (25% of the subject mark); this is assessed continuously over both semesters.
- Individual student project work (12.5% of the subject mark), assessed in the middle of the second semester.
- Module 1 assessment (12.5% of the subject mark); this is an exclusively multiple-choice examination, held after the completion of the first semester.

Thus, there is a mix of assessment strategies, with multiple-choice questions used to examine the fact-based material that forms an important part of the subject. The author's experience is that students tended to perform well in such questions, and that they ensured an understanding of a broad range of basic ideas, among other advantages. Further discussion and evaluation of the use of multiple-choice questions in an assessment strategy is available (O'Dwyer, 2007).

Table 1 shows some assessment data over four separate academic years for the Electrical Systems subject. The data is from the first sitting of all assessment components. The 009 course code refers to full-time students, with the 016 course code referring to part-time students.

| | 2005-6 | 2006-7 | 2007-8 | | | 2008-9 | | |
|---|---|---|---|---|---|---|---|---|
| Course code | | | 009 | 016 | Total | 009 | 016 | Total |
| Student number (sat exam) | 18 | 26 | 25 | 9 | 34 | 27 | 5 | 32 |
| Number who passed subject | 11 | 14 | 18 | 8 | 26 | 12 | 5 | 17 |
| % pass rate | 61 | 54 | 72 | 89 | 77 | 44 | 100 | 53 |
| Average examination mark | 42 | 41 | 39 | 61 | 45 | 40 | 59 | 43 |
| Average MCQ[1] test mark | 39 | 43 | 36 | 68 | 44 | 46 | 65 | 49 |
| Average project mark | 56 | 47 | 46 | 65 | 51 | 46 | 63 | 49 |
| Average laboratory mark | 53 | 54 | 61 | 79 | 65 | 44 | 69 | 49 |
| Average subject mark | 46 | 45 | 45 | 67 | 51 | 43 | 63 | 47 |
| Minimum (median) points | 175 (285) | 115 (275) | 150 (245) | - | - | 75 (290) | - | - |

Table 1: Summary of assessment data: four academic years

The results in the table show the average subject mark for the 2007-8 cohort is better than that scored in the previous two academic years (though it falls back a little in 2008-9). This improvement is almost wholly due to the good performance of part-time students on

[1] MCQ = multiple-choice question.

the DT016 programme. Of the full-time DT009 students, overall performance (as measured by average subject mark) is static from 2006-7 to 2007-8, though the pass rate for this cohort increases by 18 percentage points in this period. Examining the data in detail, it is revealed that average performance in the project and examination is very similar in 2006-7, 2007-8 and 2008-9 (for DT009 students), with a decline in performance in the MCQ test in 2007-8, followed by an increase in performance in the MCQ test in 2008-9. There is a significant decline in laboratory performance in 2008-9, following an increase in laboratory performance in 2007-8.

The puzzling increase in the pass rate for the students in 2007-8 is explained if, in more detailed work, the number of students who scored less than the examination mark threshold of 30% is counted; in 2006-7, 11 students were in this category (or 42%), whereas in 2007-8, 6 students were in this category (or 24%). This increased performance by (weaker) students in 2007-8 was due to more satisfactory answering of the 'conventional' questions on the examination paper, perhaps reflecting the change in teaching style employed from this academic year, with a greater emphasis placed on problem solving (though this did not carry over to the performance of the 2008-9 student cohort). Interestingly, a sharp decline in the performance in multiple-choice questions in the terminal examination was observed; the author suggests that this decline is due to a change in design in the multiple-choice questions in this and subsequent academic years to examine, more closely, depth as well as breadth of knowledge. This decline in performance in multiple-choice questions (by the DT009 cohort) is also seen in the MCQ test, as mentioned. The increase in percentage pass rate in 2007-8 is particularly remarkable against a background of a decline in median entry points in that year.

Overall, it is clear that significant numbers of students struggle to pass the subject on the first attempt, despite changes in teaching style and assessment strategies mentioned above and documented in detail elsewhere (O'Dwyer, 2008). To explore this further, the author takes an evidence-based approach to examining the assessment strategies, by analysing the assessment data in detail. The following issues are explored:

- The statistical relationship between the results obtained by students in the variety of assessment modes;
- The statistical relationship between examination results obtained and student lecture attendance;
- The statistical relationship between assessment results obtained and student learning styles, as determined using the index of learning styles questionnaire (Felder and Soloman, 1991);
- The statistical relationship between student terminal examination performance in this subject and cognate subjects, such as Mathematics.

## 3. Statistical relationship between the assessment results in different modes

Figure 1 shows that there is a highly statistically significant relationship between the terminal examination marks (May 2007, 2008 and 2009) and the Semester 1 MCQ test marks (January 2007, 2008 and 2009) for the DT009/DT016 cohort in all these years ($p < 0.0001$). A student who obtains 44% in the MCQ test can expect to get 40% in the final examination, on average.

Figure 2 shows that there is a highly statistically significant relationship between the examination marks and the continuous assessment marks for the DT009/DT016 cohort in the years outlined above ($p < 0.0001$). A student who obtains 46% in continuous assessment can expect to get 40% in the examination, on average.

Thus, students are not disadvantaged by any particular assessment mode used, considering the issue globally.

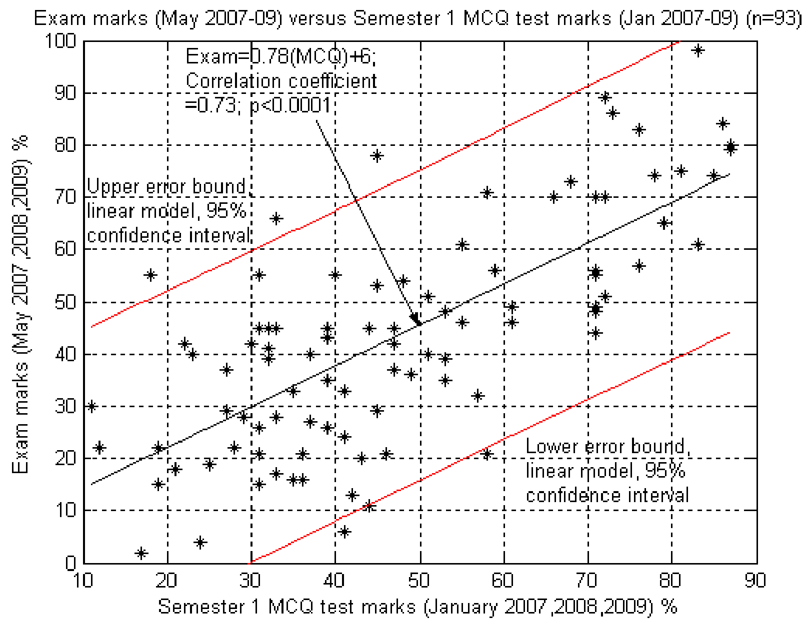


Figure 1: Relationship of terminal examination result to Semester 1 MCQ test result 2006-9

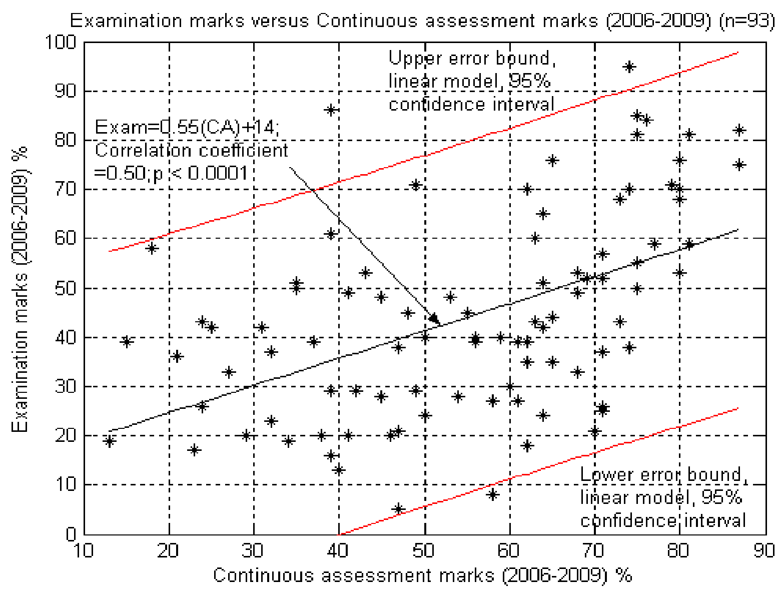


Figure 2: Relationship of marks achieved for examination work, compared to those achieved for laboratory and project work 2006-9

## 4. Statistical relationship between examination results obtained and student lecture attendance

There is a significant body of work that suggests that there is a statistically significant relationship between student lecture attendance and examination performance. Some suggest that the relationship is weak (e.g. Gatherer and Manning, 1998; Lockwood *et al*., 2006; Cleary-Holdforth, 2007), with others suggesting that it is strong (e.g. Cohn and Johnson, 2006; Newman-Ford *et al*., 2008). Good attendance is one marker of student engagement with a programme of study; in the first two academic years in which the author taught Electrical Systems (2005-6 and 2006-7), he observed that many students have poor lecture attendance in the subject, impairing their ability to take part in active learning of the material with their peers. To quantify lecture attendance in the subject, the author asked students to sign their names on an attendance sheet in each lecture, in the 2007-8 and 2008-9 academic years. The overall average attendance data is shown in Table 2.

| | DT009 | DT016 | Overall |
|---|---|---|---|
| 2007-8 | 39% | 74% | 49% |
| 2008-9 | 46% | 62% | 49% |

Table 2: Average attendance data: 2007-8 and 2008-9 academic years

Thus, on average, approximately half the students attended the lectures, with full-time students having a lower attendance record. This is comparable with data published by Kolari *et al*. (2008), which reference studies at a Finnish university suggesting that engineering students are absent from 61% of their lectures and 59% of their laboratory exercises.

Figure 3 shows that there is a highly statistically significant relationship between the Semester 1 MCQ test results and lecture attendance for the DT009/DT016 cohort ($p < 0.005$). Examination of this figure shows that the pass mark of 40% may be obtained with a lecture attendance level of 30%, on average.

Figure 4 shows that there is a highly statistically significant relationship between the exam results and lecture attendance for the DT009/DT016 cohort ($p < 0.005$). Examination of the figure shows that the pass mark of 40% may be obtained with lecture attendance level of 38%, on average.

There are, of course, other ways to view this data. One simple view, as suggested by Lockwood *et al*. (2006), is to determine the variation in final mark (on average) calculated for no lecture attendance compared to compulsory lecture attendance. Data is summarised in Table 3.

| | Average mark (assuming no attendance) | Average mark (assuming compulsory attendance) | Value added by attending lectures (%) |
|---|---|---|---|
| 2007-9, terminal exam | 26 | 63 | 37 |
| 2007-9, MCQ test | 31 | 61 | 30 |

Table 3: Effect of compulsory lecture attendance on student scores (on average)

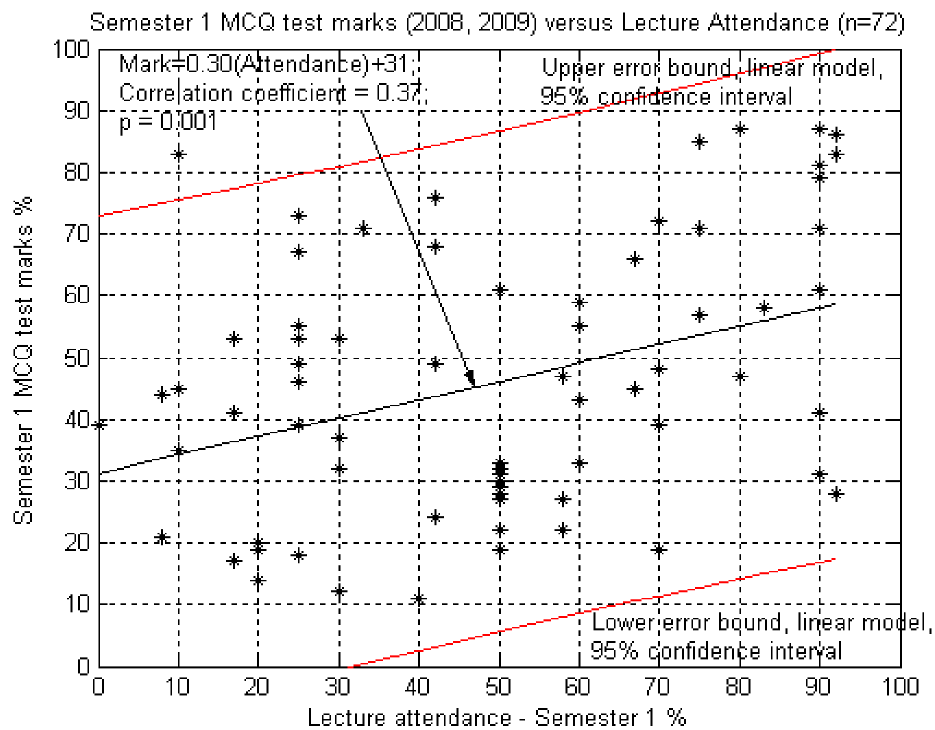


Figure 3: Relationship between MCQ test marks and lecture attendance 2007-9 (n=72)

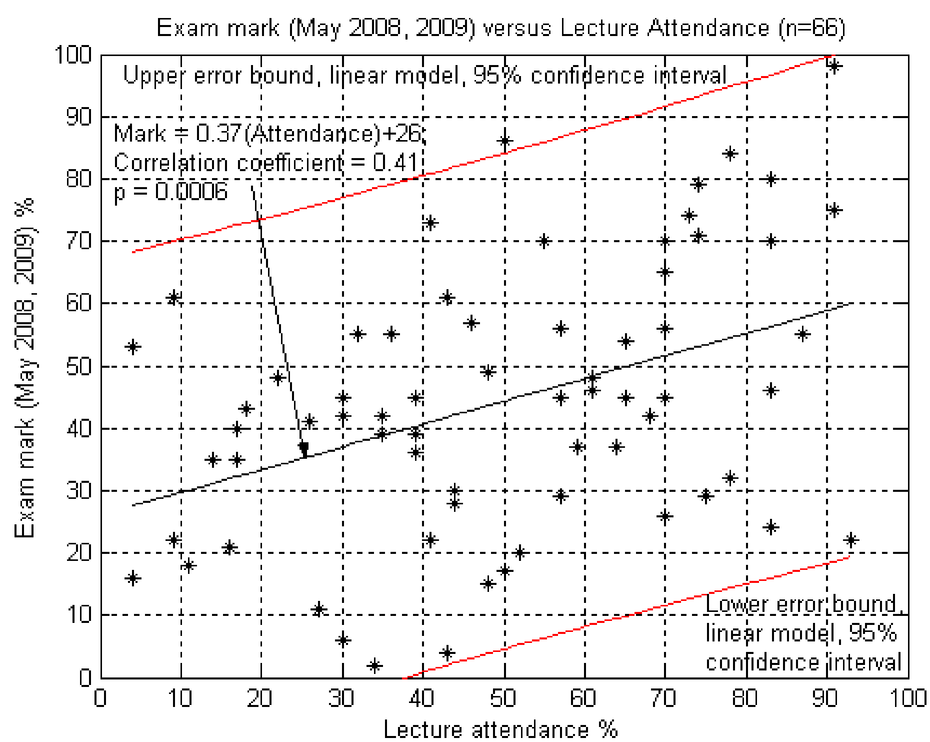


Figure 4: Relationship between terminal examination marks and lecture attendance 2007-9 (n=66)

However, as Lockwood *et al*. (2006) suggest, it may be erroneous to suggest that compulsory lecture attendance would improve examination outcomes, as the relationship could also be the result of other factors such as student motivation, interest and aptitude.

As an alternative, the % improvement in examination performance (on average) for each lecture session attended is given in Table 4.

| | % improvement |
|---|---|
| 2007-9, terminal exam: each hour lecture attended | 0.8 |
| 2007-9, MCQ test: each hour lecture attended | 1.2 |

Table 4: % improvement in examination performance (on average) for each lecture session attended

Overall, it is clear that DT009/DT016 students who have chosen to attend lectures more regularly perform better in their examinations than students that have chosen to attend lectures less regularly. The % improvement figures are broadly compatible with those quoted by Purcell (2007) for Irish engineering students in Years 2 and 3 of a Level 8 programme.

## 5. The statistical relationship between assessment results obtained and student learning styles, as determined using the index of learning styles questionnaire

In a seminal paper, Felder (1988) suggested that engineering students (in particular) have four dimensions to their learning styles. Each of the dimensions is described in opposite terms (active versus reflective, sensing versus intuitive, visual versus verbal and sequential versus global). In summary, active learners learn by trying things out or working with others, while reflective learners learn by thinking things through or working alone; sensing learners are oriented towards facts and procedures, while intuitive learners are oriented towards theories; visual learners prefer visual representation of presented material, while verbal learners prefer written or spoken explanations; sequential learners learn in incremental steps, while global learners are systems thinkers who learn in large leaps. Felder measures student learning styles by means of an Index of Learning Styles (ILS) on-line survey (Felder and Soloman, 1991), composed of 44 multiple-choice questions, with two possible answers for each question. In a series of papers, Felder and co-workers (e.g. Felder *et al*., 1998; Felder and Spurlin, 2005) suggested that most engineering students are active, sensing, visual and sequential learners.

The ILS survey was carried out in the 2007-8 and 2008-9 academic years. In both years, the on-line survey form was printed out, distributed to the students for completion in week 1 of the author's subject and the survey results were collated. A summary of the results, with explanations, and how the average results would inform the author's subject teaching in the semester was provided to the students in week 2 of the subject; in addition, each student received their own individual survey result. Of the 86 members of the DT009/DT016 class group (over two years), 67 completed the survey form, giving an overall response rate of 78%. It should be mentioned that student participation was voluntary, with no student exposure to any risks or reprisals for refusing to participate (as in the study performed by Zywno, 2002).

Detailed analysis of the data is shown in Figures 5 to 8, in which strengths of the reported preferences are indicated. Having completed the survey, each learner is assigned a point on the scale from –11 to +11 for a given dimension. For example, in the active-reflective dimension, a learner scoring –11 is a strongly active learner, with a learner scoring –1 being a marginally active learner. Clearly, a large percentage of students have no significant preferences, except for the Visual-Verbal category, for which a large majority of students have a moderate or strong preference for visual learning. Particularly interestingly, the majority of students show no strong preference for active learning; traditionally, Level 7 programmes place particular stress on active learning in laboratories and workshops.

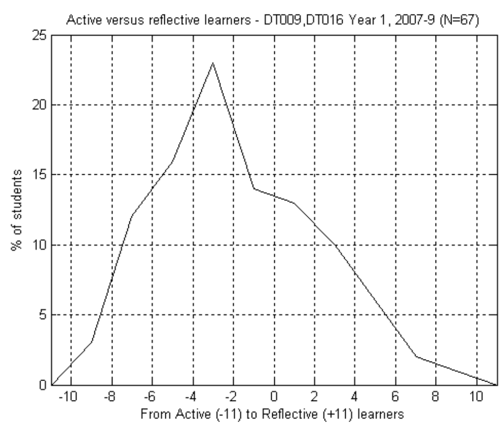


Figure 5: Active versus reflective learners

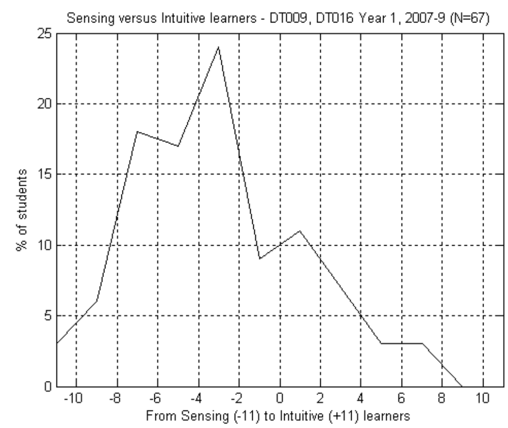


Figure 6: Sensing versus intuitive learners

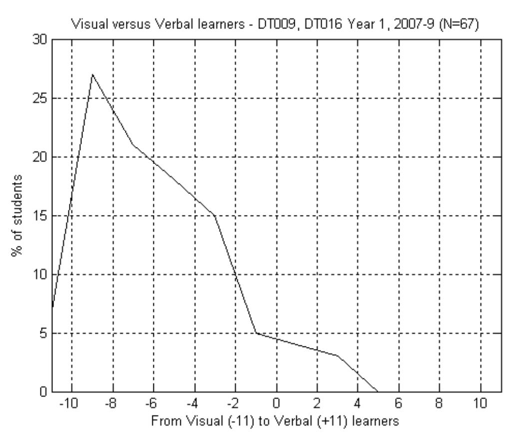


Figure 7: Visual versus verbal learners

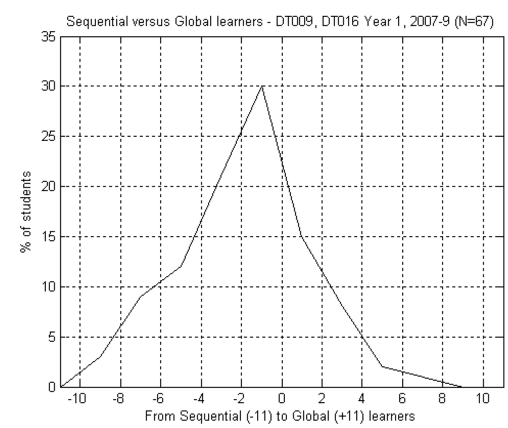


Figure 8: Sequential versus global learners

The results of the ILS survey informed instruction in the subject in the 2007-9 academic years. Lecturing was done using PowerPoint, with extensive visual material employed. Lectures were also made available on the WebCourses online environment. This is partly because attendance at lectures was unsatisfactory; in addition, the subject was followed by a significant number of part-time students. Active learning in the lecture environment was prioritised, with approximately 35% of the lecture time devoted to student problem solving exercises, with the aim of increasing the depth of knowledge of the material. In addition, the MCQ test and the terminal examination were changed to incorporate more visual components in the questions.

In a further analysis of the data, it is revealed that learning styles and performance at assessments are not correlated in a statistically significant way. For example, the p value for the relationship between the terminal examination mark and the sequential/global scale is 0.43 (n=55). Interestingly, there is a borderline statistically significant relationship between laboratory assessment marks and reflective learners in the first semester of the 2008-9 academic year (p=0.058, n=26), suggesting that the laboratory work is not engaging active learners in this semester.

## 6. Statistical relationship between student terminal examination performance in this subject and cognate subjects

Figure 9 shows that there is a highly statistically significant relationship between the terminal examination marks in Engineering Science (Physics) and Electrical Systems for the DT009/DT016 cohort ($p < 0.0001$). A student who obtains 47% in the Engineering Science terminal examination can expect to get 40% in the Electrical Systems terminal examination, on average.

Figure 10 shows that there is a highly statistically significant relationship between the terminal examination marks in Mathematics and Electrical Systems for the DT009/DT016 cohort ($p < 0.0001$). A student who obtains 51% in the Mathematics terminal examination can expect to get 40% in the Electrical Systems terminal examination, on average.

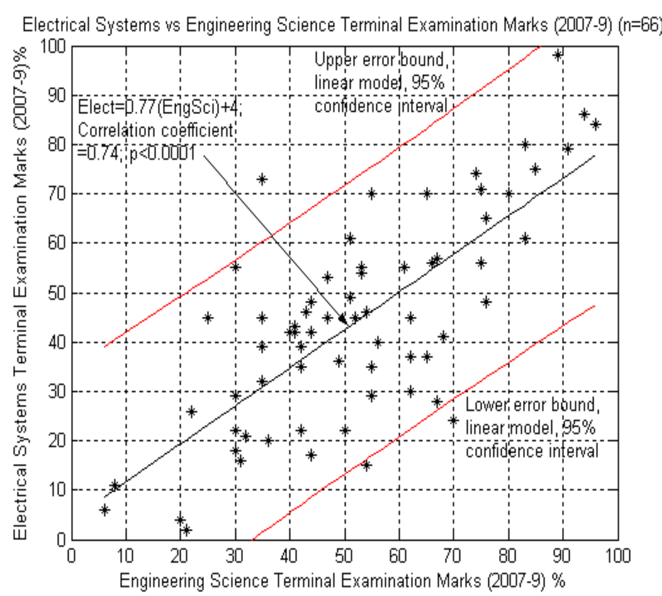


Figure 9: Relationship between the terminal examination marks for Electrical Systems and terminal examination marks for Engineering Science (Physics) 2007-9

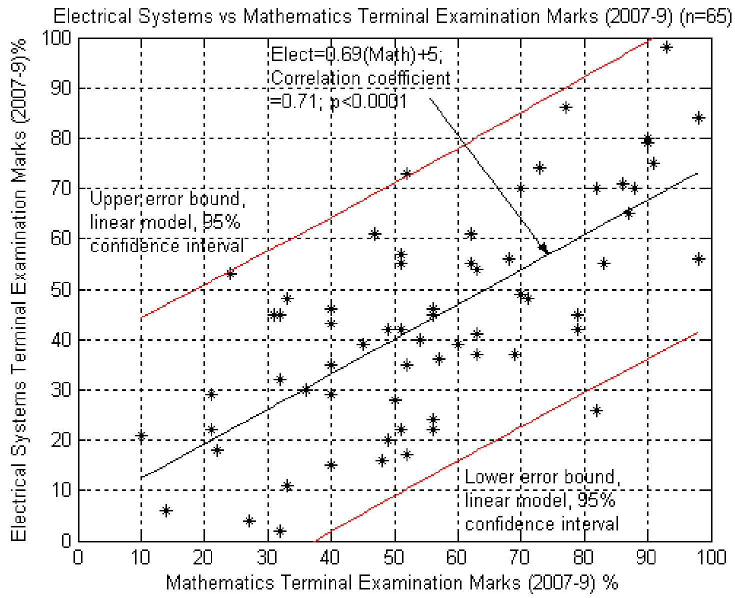


Figure 10: Relationship between the terminal examination marks for Electrical Systems and terminal examination marks for Mathematics 2007-9

## 7. Conclusions

The author has taken an evidence-based approach to examining learning and assessment strategies used on the core Electrical Systems subject in the first year of a three-year, Level 7, degree programme in Electrical Engineering at Dublin Institute of Technology. The conclusions of this work are as follows:

- there is a highly statistically significant relationship between (a) student terminal examination performance and Semester 1 test performance and (b) student examination performance and continuous assessment performance, over the 2006-9 period;
- there is a highly statistically significant relationship between (a) student Semester 1 test performance and lecture attendance and (b) student terminal examination performance and lecture attendance, over the 2007-9 period;
- there is no statistically significant relationship between assessment results obtained and student learning styles, as determined using the index of learning styles questionnaire (Felder and Soloman, 1991), over the 2007-9 period;
- there is a highly statistically significant relationship between student terminal examination performance in Electrical Systems and the cognate subjects of Engineering Science and (separately) Mathematics, over the 2007-9 period.

Assessment performance, particularly for the full-time DT009 student cohort, remains disappointing. In the 2009-10 academic year, the author will take the following actions with the aim of engaging students more deeply in the subject:

(1) In Lecture 1, the subject learning outcomes will be explained, and a diagnostic test will be taken by the students to assess misconceptions as a result of prior learning in the subject (Engelhardt and Beichner, 2004), with the aim of correcting such misconceptions during the learning period. In addition, the author will communicate

to students the statistically significant relationships between assessment performance and lecture attendance.

(2) Throughout the lecture programme, regular formative assessments using multiple-choice questions, perhaps with the aid of clickers, will be introduced; a pilot scheme has revealed that such formative assessments have improved student performance in achieving some learning outcomes in the subject in the 2008-9 academic year.

(3) Further active learning techniques, including a more structured mini-project and pedagogical techniques such as personification in circuit analysis (Jenkins, 2008), will be introduced.

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