Teaching and assessment of students taking a first year, Level 7 subject: analysis and actions

Aidan O'Dwyer,
School of Electrical Engineering Systems,
DIT Kevin St., Dublin 8.
E-mail: aidan.odwyer@dit.ie

Abstract: This contribution critically analyses the teaching 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 author has the responsibility for development and instruction in the subject since 2004. In the 2004-5 and 2005-6 academic years, the didactic teaching approach and the assessment strategy ensured good educational outcomes. This was not the case in the 2006-7 academic year. The contribution will analyse the reasons for this, taking an evidence-based approach (i.e. analysing the assessment data in detail). Two conclusions that are drawn are that students have reasonable breadth of knowledge of the basic material, but knowledge depth is limited, and that students perform better in laboratories and project work than in examinations. Subsequently, the actions taken to improve student learning in the 2007-8 academic year will be detailed, and some preliminary analysis of the resulting assessment data will be provided.

1. Introduction

The author has had responsibility for module development and instruction since 2004 in 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 (the terminal examination at second level education), 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 the 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, 40 learners commence the degree programme, the majority of which 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, in 2007-8, a part-time version of the

programme was started; 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 modules; in each module, students attend two hours of lectures and two hours of laboratories in the subject each week. Over the 2004-7 academic years, the author taught the material by writing the lecture notes and problem solutions, in the lecture, on slides on an overhead projector; the students took notes of this material. Laboratories in the subject were similarly didactic, with students required to complete a different experiment each week from a laboratory manual. The subject was assessed in the following manner:

- Terminal examination (50% of subject mark), held after the completion of the second module. 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 first module.
- Module 1 assessment (12.5% of the subject mark); in 2006-7, this was an exclusively multiple-choice examination, held after the completion of the first module.

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 over the 2004-6 academic years was 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 such an assessment strategy are available [O'Dwyer, 2007].

In the 2004-5 and 2005-6 academic years, the didactic teaching approach and the assessment strategy ensured good educational outcomes. For example, of the 18 students who remained in the programme by the end of the 2005-6 academic year, 12 passed the subject at the summer examination and 3 more passed the subject by the autumn examination, a pass rate of 83%. The overall progression rate into Year 2 of the programme (over all modules) was 72% (or 13 out of 18 students).

The situation changed in the 2006-7 academic year. Of the 27 students who remained in the programme by the end of the academic year, 14 passed the subject at the summer examination and 3 more passed the subject by the autumn examination, a pass rate of 63%. The overall progression rate into Year 2 of the programme (over all modules) was

also 63%, indicating that the Electrical Systems subject (together with another subject, Electronic Systems) was responsible for the relatively poor progression rate.

Thus, it was decided to analyse fully the reasons for the relatively poor progression rate in the Electrical Systems subject in the 2006-7 academic year, given that progression had been satisfactory in the two previous academic years. Firstly, analysis of the assessment data was carried out. Numerical data was converted into graphical form to better capture data trends, while retaining individual student confidentiality. Subsequently, conclusions were drawn and actions taken to improve student learning in the 2007-8 academic year.

3. Analysis of the terminal examination data

As mentioned, the examination had a compulsory question and five other questions, three of which are to be attempted. Two of these five questions were in multiple-choice format. Figure 1 summarises the marks obtained from the student attempts at the two types of questions. Clearly, students scored better, on average, in the multiple-choice questions, a finding that was consistent with experiences in the previous academic years [O'Dwyer, 2007].

Figure 1: % marks obtained – multiple-choice versus conventional questions
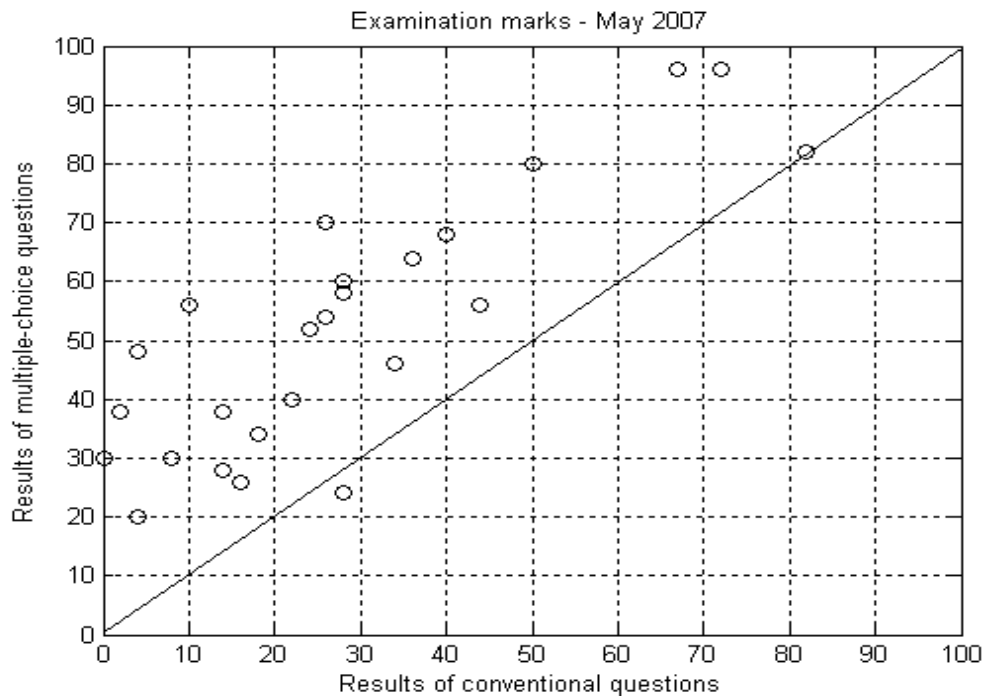
Of the two multiple-choice questions, greater student success in answering Q2 compared to Q4 was shown (see Figure 2). Q2 deals with DC material, covered in Semester 1; Q4 deals with AC material, covered in Semester 2. Clearly, students are more knowledgeable about DC material. The author suggests that the transition to third level study, recognised to be a challenging one for many students, means that little time can be devoted by students to detailed work in the subject; however, the fundamentals of DC electrical systems are easier to pick up in laboratories and lectures. In addition, the

Junior Certificate syllabus in Science treats electricity and magnetism [NCCA, 2003], so even students who have not taken Physics at Leaving Certificate level have previously covered the fundamentals of the DC material.

Figure 2: % marks obtained – Q2 versus Q4
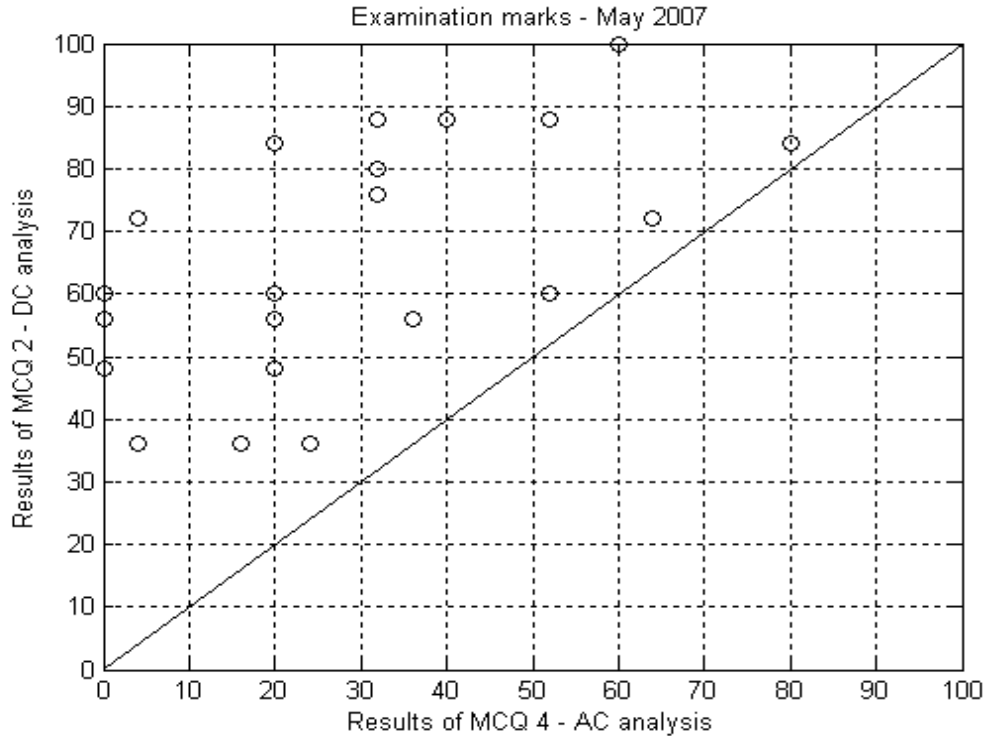
There is also evidence of poor examination technique by students when answering multiple-choice Q4, in particular. It is recognised that raw scores from multiple-choice questions should not be used directly. The reason is that, for example, in a test with four choice-questions, a student may know the answers for 20% of the questions and guess the answers correctly for one quarter of the rest of the questions, passing the examination. Scaling may be done using a simple approach (which employs negative marking), which is the method used by the author. Analysis shows that many weaker students answered more than half of the 25 parts of question 4 incorrectly, despite being advised to only answer the question parts if they were confident of the answers.

4. Analysis of other assessment modes

As mentioned, the following assessment modes are also used:
- 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 first module.
- Module 1 assessment (12.5% of the subject mark); in 2006-7, this was an exclusively multiple-choice examination, held after the completion of the first module.

Detailed analysis shows that there is a reasonable correlation between:

- the terminal examination mark and the module 1 assessment mark (Figure 3)
- the laboratory assessment mark and the project assessment mark (Figure 4),

with weaker correlations between the marks obtained from the other assessment strategies.

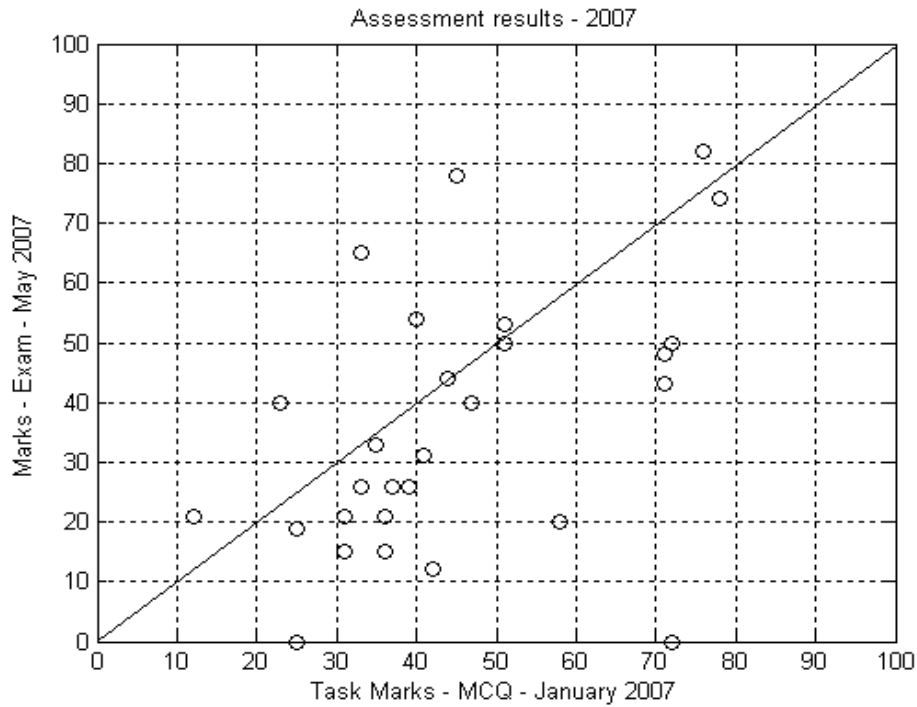Figure 3: Examination vs. Module 1 assessment

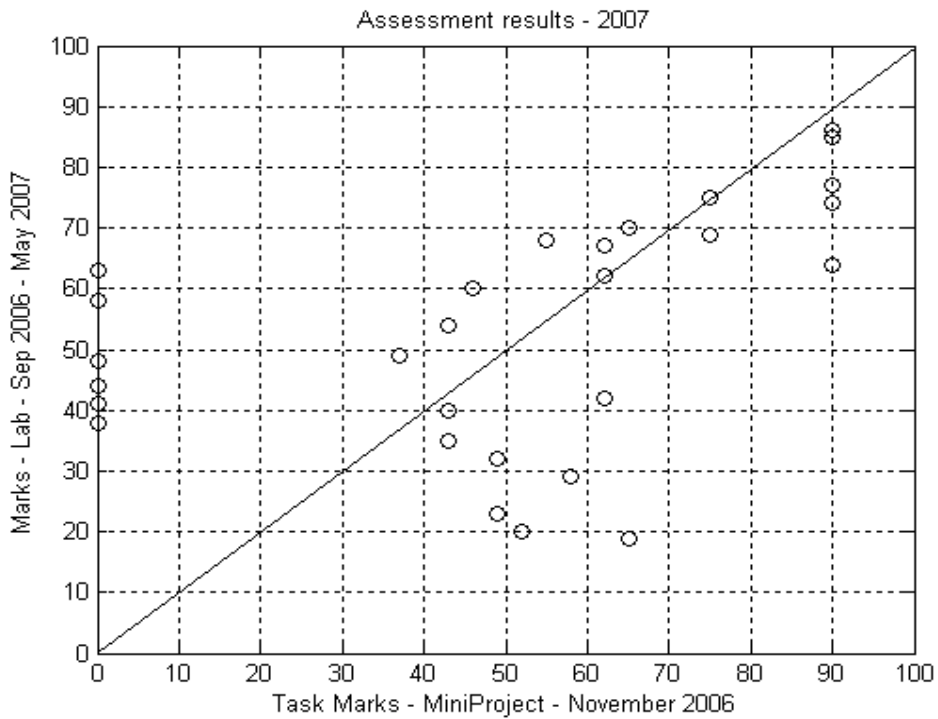Figure 4: Laboratory assessment vs. Project assessment

Figure 5 shows the correlation between marks obtained by students in a more active learning mode i.e. through laboratory and project work (assessed by continuous assessment) and marks obtained by students by examination. Clearly, students score better in an active learning environment.

Figure 5: Examination assessment versus continuous assessment
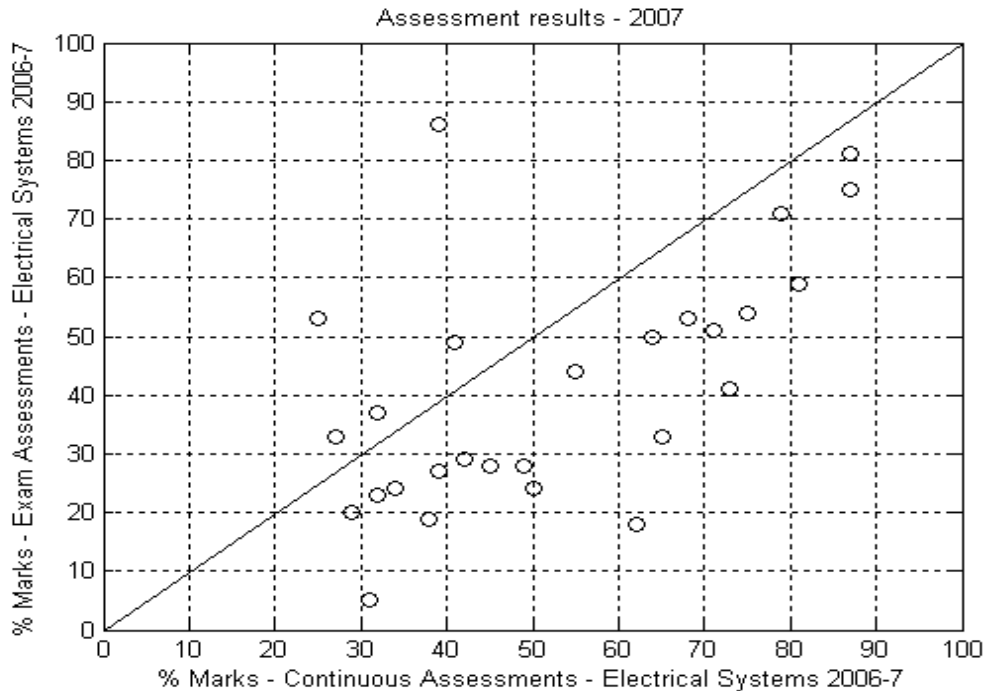
5. Conclusions from the analysis

The following conclusions can be drawn from this analysis:
- As revealed by the terminal and Module 1 examinations, students have reasonable breadth of knowledge of the DC material, but knowledge depth is limited. In particular, student ability to describe phenomena and solve problems, which have been assessed using the conventional questions, is underdeveloped (except for the small minority of gifted students). Students, on average, have poor breadth and depth of knowledge of the AC material.
- On average, students perform better in laboratories and project work than in examinations. Though some of the difference may be due to the assessment methodologies employed, it is recognised that many engineering students favour an active and visual learning style [Felder and Spurlin, 2005].

The following actions were taken in the 2007-8 academic year to address the difficulties:
- At the start of the module, the students were requested to complete the index of learning styles questionnaire [Felder and Soloman, 1991]; 35 replies were received (there were 41 registered students on the programme at that stage). Analysis revealed that students, on average, were strongly visual learners, with a less strong preference for active learning (Figures 6 and 7).
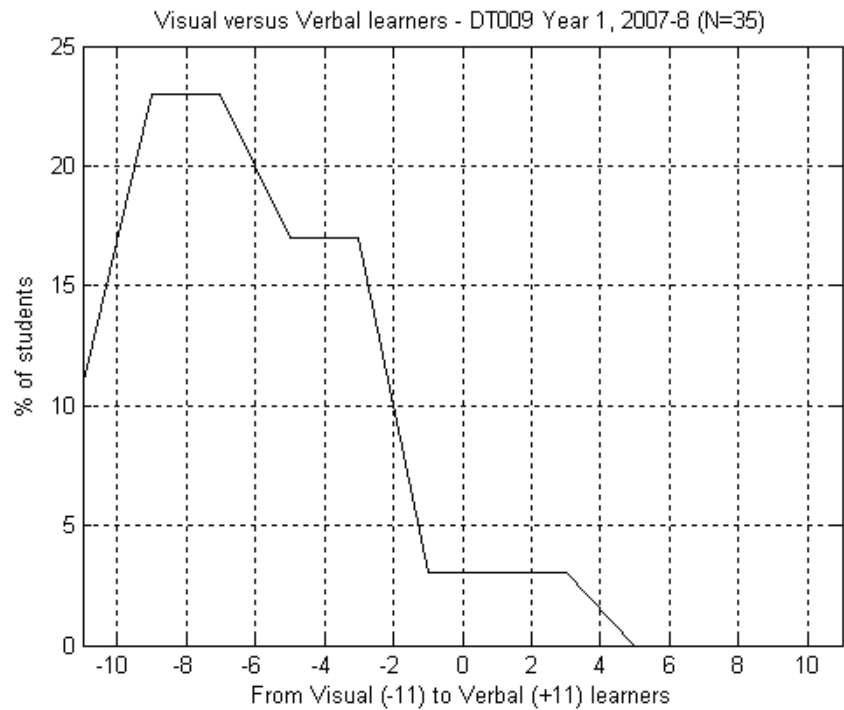
Figure 6: Visual vs. Verbal learners

Visual versus Verbal learners - DT009 Year 1, 2007-8 (N=35)

Figure 7: Active vs. Reflective learners

Active versus reflective learners - DT009 Year 1, 2007-8 (N=35)
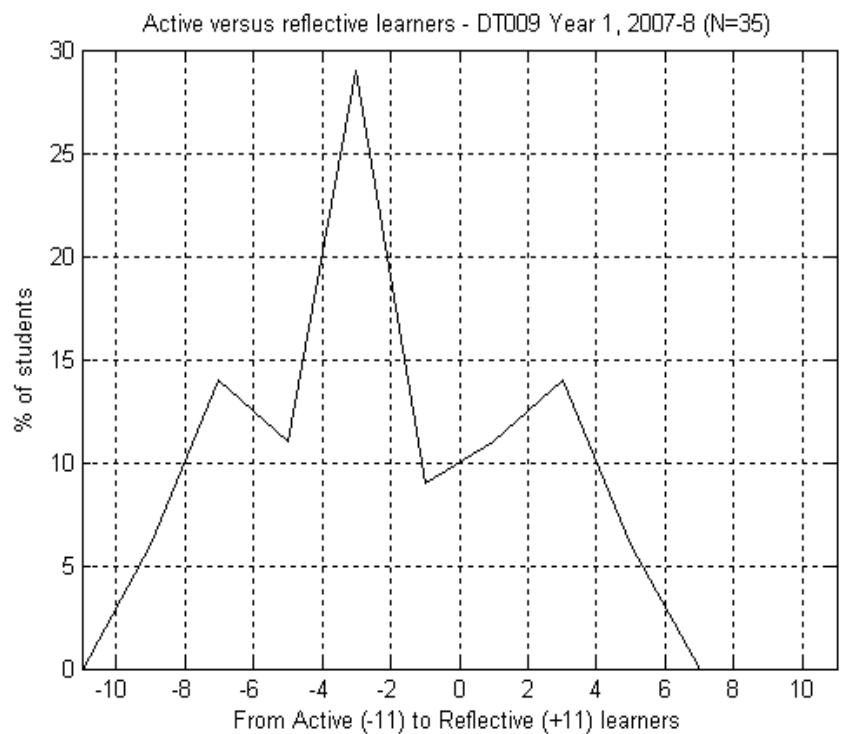
An analysis of the results for each individual, and the average results, was discussed with the students in Week 2 of the module. Advice was given on how to optimise each individuals learning.

- Based on the results, the lecturer completely changed the teaching approach in 2007-8. Teaching was done using PowerPoint, with extensive visual material employed. Lectures are also made available on WebCT. This is partly because attendance at lectures for the full time students in 2006-7 was unsatisfactory (though no statistics are available); in addition, the module in 2007-8 was followed by a significant number of part-time students. Active learning in the lecture environment has been 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. It was hoped that these strategies would assist students in their understanding of the AC material in Semester 2, in particular.
- The module assessment strategy was changed, as follows:
  - The Module 1 assessment was still in multiple-choice form, but included questions that assess depth as well as breadth of knowledge. Many of the multiple-choice questions had a visual component, because of the emphasis places on more visual learning techniques;
  - The student project was preformed and assessed in the middle of the second semester, with the aim of increasing participation rate to 100%;
  - The terminal examination was changed to incorporate more visual components in the questions.
  Otherwise, the considered opinion was that the nature of the assessments is appropriate.
- The lecturer scheduled a tutorial on good examination techniques.

6. Student performance in the 2007-8 academic year – preliminary analysis and discussion

Table 1 summarises assessment results over three academic years. DT009 refers to the full time student cohort, with DT016 referring to the part-time student cohort.

Table 1: Assessment results over three academic years

	2005-6	2006-7	2007-8		
	DT009	DT009	DT009	DT016	Total
Student number	18	27	29	9	38
Number who passed module	12	14	18	8	26
% pass rate	67	52	62	89	68
Average examination mark	43	38	39	60	44
Average Module 1 test mark	-	43	36	68	44
Average project mark	62	64	53	65	56
Average laboratory mark	53	51	60	79	65
Average module mark	48	45	46	66	51
Minimum (median) points	175(285)	115(275)	150(245)	-	-

The results in the table show the average module mark for the 2007-8 cohort has improved, though this improvement is almost wholly due to the good performance of mature students on the DT016 programme. Of the DT009 students, overall performance

(as measured in average module mark) is slightly improved, though the pass rate for this cohort increases by 10 percentage points. This appears to be due to the better average performance of weaker students in the 2007-8 academic year, allowing more of this cohort to pass the module. This increase in percentage pass rate is against a background of declining median entry points, and may be due to the new teaching style adopted.

However, examination and Module 1 test performance of the DT009 students, in particular, is still disappointing. The author is presently conducting further analysis on student performance in the 2007-8 academic year, in particular analysing the relationship between student learning style and student performance, with the objective of further optimising instruction in the subject.

References

CAO (2006a). Central Applications Office Leaving Certificate Results Nominal Points Score 2006. Available at http://www2.cao.ie/app_scoring/points_stats/LC06PTS.pdf (accessed 17 June 2008).

CAO (2006b). Central Applications Office Points required for entry to 2006 courses. Available at http://websr2.cao.ie/points/lvl76_06.pdf (accessed 17 June 2008).

O'Dwyer, A. (2007). Experiences of assessment using multiple-choice questions on a first year module in electrical engineering, *International Symposium in Engineering Education*.

NCCA (2003). Notes on the revised syllabus: Junior Certificate Science, available at http://juniorscience.ie/jsss/Files/jc_science_sy_rev_notes.pdf (accessed 17 October 2007).

Felder, R.M. and Spurlin, J. (2005). Applications, reliability and validity of the index of learning styles, *International Journal of Engineering Education*, 21, 1, 103-112.

Felder, R.M. and Soloman, B.A. (1991). Index of learning styles questionnaire, http://www.engr.ncsu.edu/learningstyles/ilsweb.html