INTRODUCTION TO SECTION 4

An analysis of student performance in A level physics modular examinations

Aims: 1) To determine whether there were any gender differences in the examination performance in the different modules.

2) To consider the reasons why all students consistently under-perform in the health physics module.

3) To see if a greater understanding of performance in A level physics modular examinations could improve teaching and learning strategies within the classroom.

Contents: Report

Evaluation from a Curriculum Leader (FEC)

Evaluation from the Head of Pre-19 Education (IOP)

Methodology: The research by McClune (2001) suggested that the modular structure of A levels was more favourable for boys than girls: 'There is some evidence to suggest that boys are more likely than girls to take advantage of some of the features of modular examinations' (McClune, 2001, p.79). I was particularly interested in this statement and wanted to determine the extent that this was true for our students at the FEC. I was also keen to determine whether any significant differences emerged between the performance of girls and boys in the different modular examinations, and whether this would reveal any differences between girls' and boys' conceptual understanding of the subject.

In order to extend McClune's study, I then analysed primary source data of the A level physics modular examinations. The first analysis (2008) showed particular under-achievement in the Health Physics module. Further investigation revealed that students were particularly weak at extended written communication and the ability to recall factual information. A content analysis was then conducted which showed that the health physics module had a greater proportion of prose style questions than other papers. The Examiner's

Report showed that the problems with written communication were not confined to students from our college, but a national problem.

During the year 08/09, I changed my teaching style to incorporate more activities that involved students expressing concepts in writing, then conducted a further analysis after the 2009 examination results were published. I conducted a third analysis after the 2010 results were published. Originally, the idea was to have three separate reports showing the improvement of the physics examination results each year, however, these have been combined into the one report which considers the progress made over the three year period.

Conclusions: There were no particular modules where the examination results revealed any differences in the performance between girls or boys. The main difference was that boys, on the whole, took greater advantage of the opportunity to re-sit examinations in order to improve their grades. Through this study, we were able to highlight the need to develop students' skills in written communication, but we also realised that students may have greater opportunity for success if teachers chose the optional module, selecting that which would lead to a higher grade in the examination rather than meet the needs of students' interests.

Dissemination of this study: After each stage of the research, my findings were shared with science teachers at the FEC, including other physics teachers. The report was sent to the Head of Academic Registry, who suggested an extension of this study could be to compare students final grade with initial target grade to produce a 'value-added' indicator. The report was shared with the Head of Learning and Standards, whose background was in Information Technology and showed great interest in how the analysis showed a need to guide students more carefully when selecting optional modules. The report was also sent to the Institute of Physics, although I received an email rather than an evaluation form.

AN ANALYSIS OF STUDENT PERFORMANCE IN A LEVEL PHYSICS MODULAR EXAMINATIONS (Based upon findings from a FE College)

INTRODUCTION

The main aim of this report is to determine how students perform in an A level physics (modular based) course of study, with the opportunity to re-sit particular modules on more than one occasion. The report is based upon empirical primary data from the examination results of students at a large college of Further Education, which for the purpose of this report shall be referred to as the FEC. Having produced the first report in 2008, the team identified that a greater emphasis must be placed upon developing students' written communication skills, as we believed that this was one particular aspect that could improve students' examination success. An evaluation was then conducted with the data from the 2009 examination results to determine if any improvements had been made. Further changes were implemented in the following year (2009/10), in order to drive examination success, with the results for 2010 evaluated at the end of the report.

Objectives

1) To determine whether any differences or trends emerge from the performance of girls and boys in the different modules.
2) To consider the reasons why all students consistently under-perform in the Health Physics module.
3) To see if a greater understanding of performance in the modular physics A level examinations can improve teaching and learning strategies within the classroom.

The report is divided into the following sections:

Part 1: This provides an outline of the OCR[1] modular A level Physics course structure, followed by an analysis of the examination results between the years 2004 to 2008 inclusive. The data shows that students consistently under-achieve in the second year modules, with the optional modules providing the students' weakest mark. By analysing the sample of 144 students between the years 2004 and 2008 inclusive, the performance of the female students was compared to that of the male students to see if any gender differences emerged.

Part 2: This section considers the style and structure of the Health Physics examination. It includes a content analysis of the examination questions (OCR, 2008) and considers the importance of good written communication skills for success in A level physics.

Part 3: This section is based upon a reflective analysis of the 2009 and 2010 Physics A level examination results in order to determine whether changes to teaching and learning within the classroom have had any effect upon the examination performance of our students. Did the changes made, as a direct consequence of what was found in parts one and two of the report, make any difference to the results?

Background to the study

McClune (2001) found that the modular structure of physics A level was more favourable for boys than girls: 'there is some evidence to suggest that boys are more likely than girls to take advantage of some of the features of modular examinations' (McClune, 2001, p.79). I was most interested in this statement and intent upon analysing data from the college to determine the extent that this was true for our students. I was also keen to determine whether any significant differences emerged between the performance of girls and boys in the different modular examinations, and whether this would reveal any differences between girls' and boys' understanding of the subject, for example, would there be any topics where the examination results of girls (as a group) showed a marked difference to that of the boys?

[1] OCR is the Oxford, Cambridge and RSA Examinations Board, with its head office in Cambridge.

Considerable research has been conducted into girls' interests in physics, however, this research was based upon surveys and questionnaires (for example, Stewart 1998). It is important to determine the extent that 'interests' correlate with 'ability', i.e. if girls' preferences relate directly or indirectly to conceptual differences, which may then lead to differences in performance in external examinations. This report provides a quantitative analysis based upon students' actual examination results in the various physics modules.

At the FEC, we have offered students a choice from the optional modules, based upon the assumption that students would perform better in a module that they had selected, rather than one that had been imposed upon them. Health Physics has, in general, been the module that is most popular with girls or those students who wish to develop careers in the medical profession.

In recent years, the Health Physics module has proved to be the least successful of all modules, for boys as well as girls, so I was perplexed by the puzzle of why a topic that was of particular interest, could lead to being the students' weakest modular result. Surely this module should produce better results if it reflected student interests?

Based upon the first evaluation of student performance in examinations (2008), I then identified some specific strategies which I believed would improve student performance. For example, developing students' written communication skills was a particular concern, so I subsequently developed more class and homework activities that involved students developing their discursive skills, both written and oral.

With the introduction of the new A level specifications in 2008, for first certification in 2010, we compared each of the examination boards and decided, as a department, to change from OCR to AQA. This was based partly on the fact that information from OCR, when conducting my research, had been neither helpful nor forthcoming.

Whilst this research is specifically based upon students at the FEC, it contributes towards, and extends, previous research that has been conducted into performance in modular examinations (McClune, 2001, Gipps and Murphy, 1994). Murphy and Whitelegg reported: 'There is little research evidence about the benefits of modular assessment in physics at key stage 5

and an absence of published research into modular assessment and its impact at key stage 4' (Murphy and Whitelegg, 2006).

PART 1: The OCR modular A level Physics course (2004 to 2008)

The pass rate for A level Physics has been 100% since 2005 yet it was found that students final grades were often from strong AS modular results combined with much weaker A2 marks.[2] Whilst this may be sufficient for students to access the university course of their choice, it does not necessarily mean that they have acquired the best foundation for higher education. The OCR Physics A level (7883) consisted of six modules, outlined in the table below:

TABLE 1: The OCR modules showing the marks allocated to each modular examination

MODULE	TITLE	MARKS
2821	Forces and Motion	60
2822	Electrons and Photons	60
2823	Wave Properties/ Coursework	45 for exam 45 for coursework
2824	Forces, Fields and Energy	90
2825	Optional Module 01 Cosmology 02 Health Physics 03 Materials 04 Nuclear and Particle Physics 05 Telecommunications	90
2826	Unifying Concepts in Physics/coursework	60 for exam 60 for coursework

The first year (AS) modules:

Forces and Motion (2821) included scalars and vectors, the equations of motion, density and pressure, as well as properties of materials. There is considerable overlap between the GCSE Physics course, with similar material but with a more rigorous mathematical approach.

[2] The first year of A level is referred to as the AS year, with the second year of A level referred to as the A2 year.

Electrons and Photons (2822) included basic circuit electricity, magnetism and an introduction to quantum physics (the photoelectric effect and wave particle duality).
Wave Properties (2822) studied the properties of waves: reflection, refraction, diffraction, polarisation, super-position and interference).

The second year (A2) modules:

Forces, Fields and Energy (2824) was the most complex module, comprising 12 sections that introduce new concepts at a more rigorous mathematical level. Topics include momentum, energy, circular motion, simple harmonic motion, gravitation, electric fields, magnetic fields, electromagnetic induction, heat, kinetic theory, radioactivity and nuclear physics. This is also the most mathematical of the modules, which includes two exponential relationships (radioactivity and capacitance). Students who do not study mathematics at A level require additional teaching, not only on logarithms but also on the use of calculators.

The Optional Modules (2825)
Within the physics team, we have always tried to offer students a choice, although health physics and cosmology are the most popular. All of the physics team are prepared to teach any of the modules that students prefer.

Unifying Concepts and coursework (2826)
This module synthesises students' knowledge and understanding from all aspects of the course and is coupled with the coursework component.

The following table (Table 2) shows that the marks allocated per paper are then converted into UMS marks (Uniform Mark Scale), which are standardised to ensure that the difficulty of the paper and the performance of the candidates are taken into account.

TABLE 2: The structure of the OCR examinations

Paper	Time allowed	Marks	UMS* Marks	Structure of exam
2821	1 hour	60	90	50 marks for structured questions 10 marks for extended answers
2822	1 hour	60	90	50 marks for structured questions 10 marks for extended answers
2823	45 minutes	45	60	Structured Questions, some of which may require extended writing.
2824	1 hour 30 minutes	90	90	75 marks for structured questions 15 marks for extended answers
2825 01 02	1 hour 30 minutes	90	90	75 marks for structured questions 15 marks for extended answers (approximately 30 marks allocated to analysis of data and/or comprehension.
2826	1 hour 15 minutes	60	60	The question paper contains questions which may require extended writing.

*UMS = uniform mark scale

One significant factor to consider during the analysis of results is the possibility of re-sitting modules. Students may re-sit examinations as many times as available and the best mark contributes towards the students' final grade. In this analysis of student performance, the students' best marks are used at all times. It was surprising to find that the students' best mark is not always their final mark for a particular examination, as some students fare less well in re-sit examinations than at first sitting. The number of opportunities for sitting a particular examination is shown in Table 3 below.

TABLE 3: The number of re-sit opportunities for each module

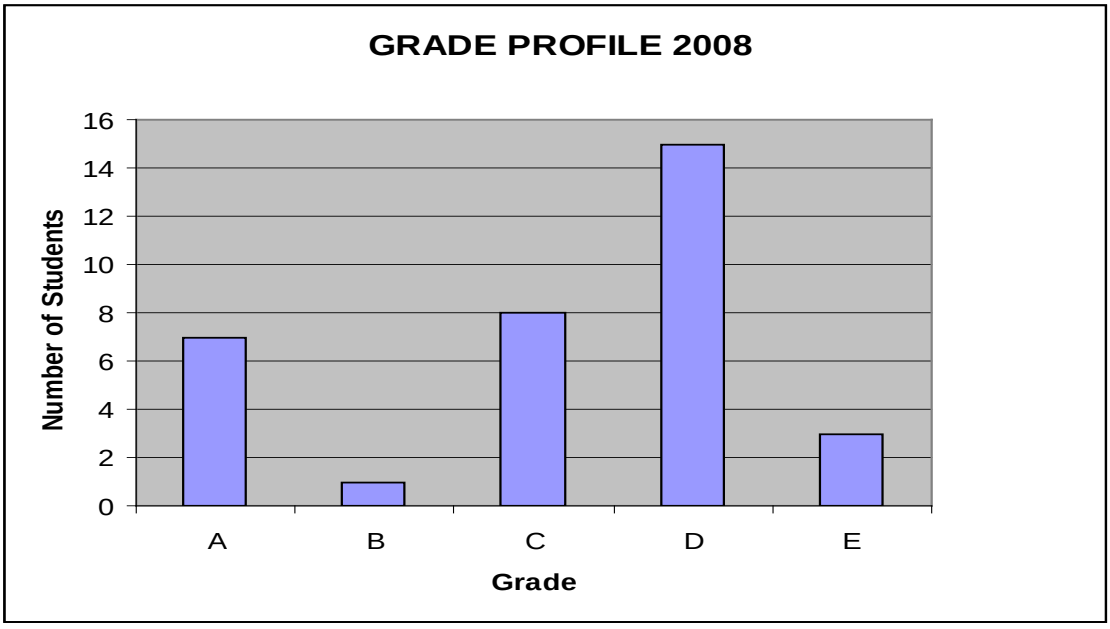
Module	Number of possible re-sits
2821	4
2822, 2923	3
2824	2
2825, 2826	1

One of the major reasons why students under-perform in the optional module could be that students only have the possibility of taking this examination once, whereas the perceived over-achievement in the first module is due to students having the opportunity to sit this examination up to four times. As the marks awarded for each exam varied, I converted the respective scores to percentages in order to make a direct comparison of student performance in the different modules.

The 2008 results

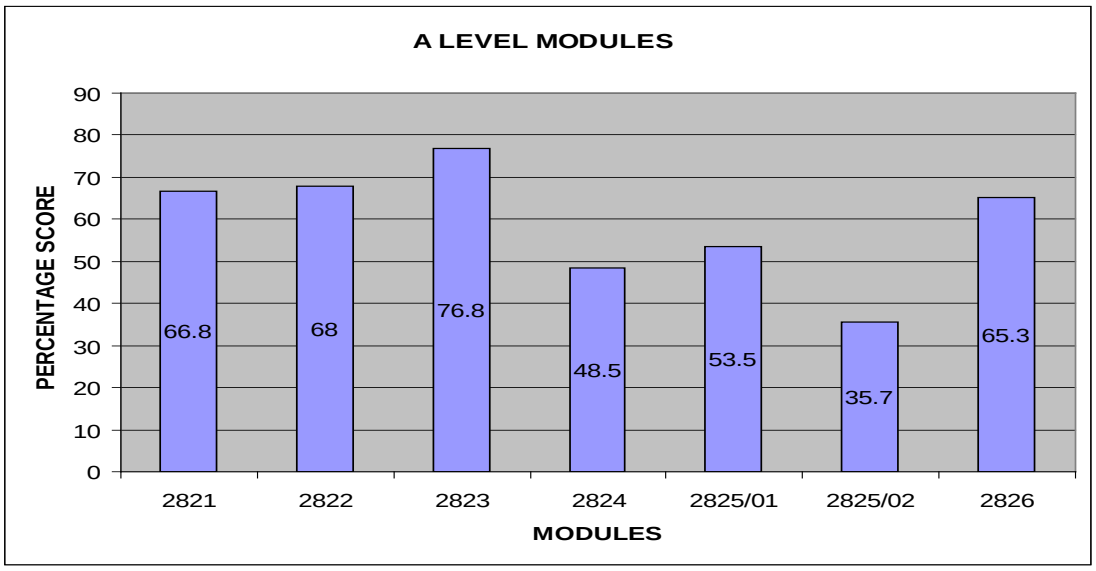
In June 2008, all 34 students who studied the course were successful in passing the A level physics course, contributing to a clear four year 100% pass rate. The grade profile, however, was a cause for concern as the distribution indicates that whilst we have a number of strong students, the modal grade was D.

CHART 1: The grade profile of the A level Physics results in 2008



Of the 34 students, 12 students studied Health Physics and 22 students opted for Cosmology. Of the 34 students in the cohort, there were 8 female students, dividing equally into 4 for Cosmology (2825/01) and 4 for Health Physics (2825/02). The chart below shows the average (mean) mark, expressed as a percentage, for the seven modules.

CHART 2: The average (mean) percentage mark obtained by students in the various modules (2008)



From the AS modules (2821, 2822 and 2823) it can be seem that students are most successful at the third module, however this mark is enhanced due to combining the examination mark from Wave Properties with the AS coursework marks. The last A2 module (2826) is the Synoptic Paper (Unifying Concepts) and this is combined with the A2 practical coursework to provide a stronger result than the other A2 modules.

The fourth module (2824), as well as both of the optional modules (2825, 01 and 02) are those in which students appear to underachieve. Students have two opportunities of sitting module 4 (2824), so this perhaps indicates a very difficult modular examination. Both of the optional modules (2825/ 01 and 02) give cause for concern as this contradicts the belief that students should perform better in modules which they have chosen. The Health Physics module (2825/02) is the least successful module, with students achieving an overall average mark of 35.7% in 2008. Many of the students who had chosen this module, whether male or female, had selected this module as they wished to pursue a career in a medically-related field. The students were genuinely interested in the subject and believed they would achieve strong results from this module.

This initial analysis of the 2008 results led to greater investigation, through a recall of students' papers to investigate how students performed in a more detailed manner, as well as a more extended study using data from previous years of physics modular examination results.

Evaluation of the data 2004 to 2008 inclusive

After evaluating the results for 2008, I then obtained all of the available data from 2004 to 2008 inclusive to provide a sample of 144 students, of whom 22 were girls (15.3%). This provided a larger data group to analyse and the information extracted may consequently be more meaningful.

TABLE 4: The pass rate, the number of girls and boys who studied A level physics, along with optional modules chosen.

Year	Pass rate	Girls	Boys	Total number of Students
2004	20/21 95%	1 (1 Health)	20 (9 Health) (11 Cosmology)	21
2005	26/26 100%	4 (2 Health) (2 Cosmology)	22 (2 Health) (20 Cosmology)	26
2006	26/26 100%	3 (3 Cosmology) *Health Physics was not offered in 2006	23 (23 cosmology)	26
2007	37/37 100%	5 (4 Health) (1 Cosmology)	32 (11 Health) (21 Cosmology)	37
2008	34/34 100%	8 (4 Health) (4 Cosmology)	22 (8 Health) (18 cosmology)	34

I then conducted the calculations and produced graphs to show the average mark for each module, over the 2004 to 2008 period. Whilst the mean values are influenced by the size of the cohort and the standard deviation, the values give an overall approximation of the success of each module. These tables have been included in the Appendices at the end of the report.

If we consider how students have performed in the different modular examinations over this five year period, it is clear that a consistent pattern emerges. The optional modules are those in which students seriously under-perform compared to other modules.

It appears that students are considerably weaker in the understanding of the A2 modules and the final grade is bolstered, on average, by stronger AS modules. The data consistently shows that the Health Physics module has the lowest average score each year.

Following the study of each of the years as a separate cohort, I then conducted an integrated evaluation of the data from 2004 to 2008 inclusive to see if this revealed any interesting trends or patterns. For the first analysis, I compared the grade that all students achieved at the end of their AS course to the final grade achieved at the end of the A2 course. By conducting an analysis of all 144 A level Physics students' examination results from 2004 to 2008 inclusive, it was clear that the vast majority of students either achieved the same grade at A2 as they had at AS, or one grade lower.

TABLE 5: Comparison of A2 final result compared with AS result (2004 to 2008)

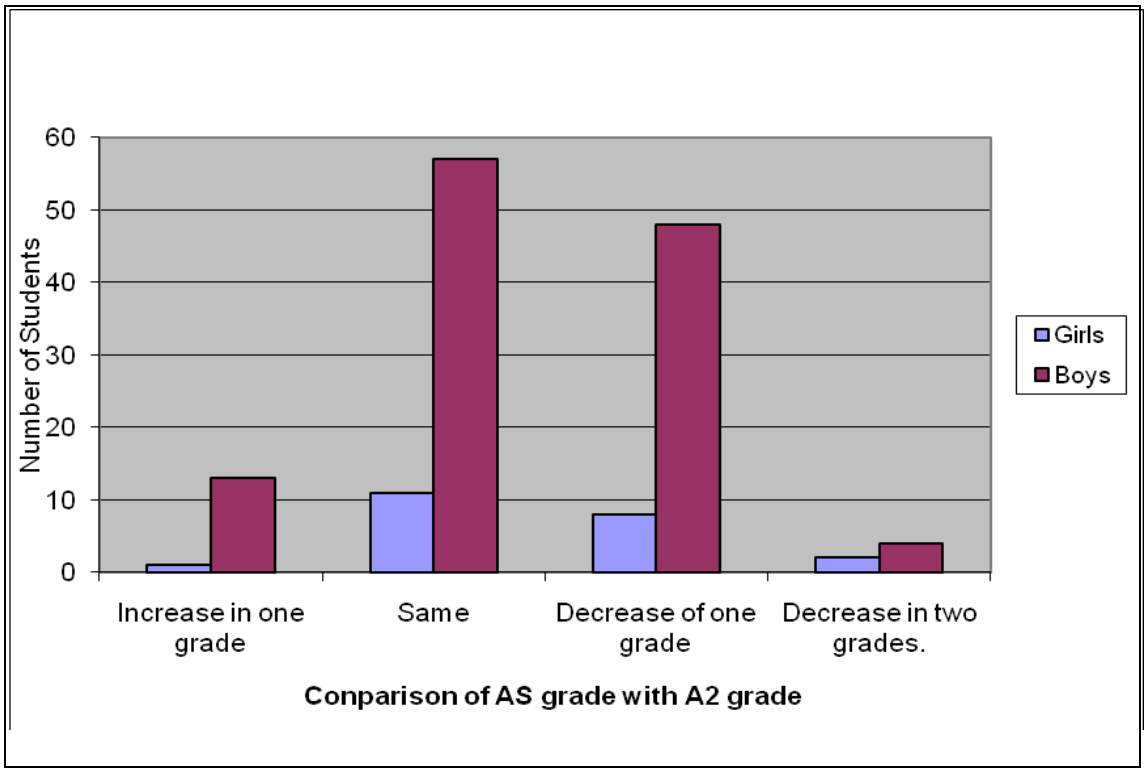
Difference in grade between AS and A2	2004	2005	2006	2007	2008	Totals
Increase in one grade	4	2	5	1	2	14 9.7%
Same	7	13	15	18	15	68 47.2%
Decrease of one grade	10	10	6	15	15	56 38.9%
Decrease in two grades.		1		3	2	6 4.2%
Total Number of students	21	26	26	37	34	144

It is interesting to see that despite the ability to re-sit modular examinations, there was not a single student who could achieve more than one grade higher in their A2 grade when compared to their AS grade. This perhaps shows the difficulty of the second year compared to the first, with those students who have improved their AS grade having taken re-sits of first year examinations in order to achieve the higher grade.

The next task was to see if there was any correlation between the number of re-sits taken and the final grade. I had anticipated that it could be shown that the more re-sits taken by a student, the higher their final grade would be, however there were no such simple correlations. For a student on a two year A level programme, the maximum number of re-sit examinations would be 8 (three for module 1, two for modules 2 and 3, then 1 for module 4). Therefore, it can be assumed that any student who took the opportunity to re-sit on more than 8 occasions had spread their studies over three years rather than two. One student (male) entered for 13 re-sit examinations, spread over three years and finally achieved an A grade. The second highest number of re-sits (10) was also spread over three years but resulted in a grade D.

Whilst evaluating the sample of 144 students, there was sufficient data to conduct an analysis of the performance of the female students in the cohort. Of the 22 girls in the sample, only one girl improved her grade between AS and A2, 11 (50%) kept the same grade, despite a range of 0 to 5 re-sits, 8 students dropped one grade between AS and A2, and 2 girls dropped 2 grades between AS and A2.

CHART 3: Comparison of how girls and boys used re-sits in order to improve their final A level physics grade (2004 to 2008)



The table below (Table 6) shows that girls are less likely to take multiple re-sit examinations than boys, with none of the girls attempting more than 6 re-sits. The modal number of re-sits for girls is 2, yet for boys, the modal number is 3 (the mean value for girls is 2.6, whereas the mean value for boys is 3.5).

TABLE 6: The number of re-sit examinations taken by girls and boys

Number of re-sits taken by students	Girls	Boys
0	2	6
1	1	17
2	10	24
3	3	34
4	3	14
5	2	13
6	1	7
7		1
8		1
9		3
10		1
11		0
12		0
13		1

Many students believe that the easiest way to improve overall marks and ultimately their final grade, is to re-sit the AS modules. Two particular students who used this strategy to achieve the best grade possible were students K and J (both male students).

TABLE 7: The re-sit strategy of STUDENT K, who used strong AS results to counter weaker A2 understanding. Final Grade = C

Module	First mark	Final mark	Number of times that the examination was taken
2821	29/90	70/90	4
2822	36/90	54/90	2
2823	83/120	84/120	2
2824	44/90	44/90	2
2825	45/90		1
2826	73/120		1

TABLE 8: The re-sit strategy of STUDENT J, who used strong AS results to counter weaker A2 understanding. FINAL GRADE = B

Module	First mark	Final mark	Number of times that the examination was taken
2821	50/90	77/90	3
2822	58/90	65/90	3
2823	105/120		1
2824	51/90	53/90	2
2825	49/90		1
2826	85/120		1

If there was no opportunity to re-sit, student K would have achieved a final grade D, whereas by re-sitting first year modules, this improved to C, thus securing a place to study Biomedical Science at university. Similarly, student J would have achieved a grade C if the opportunity to re-sit first year modules was not possible. By taking re-sits, he raised his final grade to a B and went on to study Computing at university.

The two examples above illustrate students who have raised their final mark by using re-sits as a strategy for success. When conducting this evaluation, it was evident that boys seemed to take advantage of the modular system in order to improve their grades. It proved difficult to find examples of girls who had followed such a strategy. The girls did not choose to sit as many re-sits, nor did appear that they invest as much effort into the re-sits that they had chosen to take, as often the girls scored fewer marks in the re-sit examinations than their original mark. It would be an interesting extension to this study to explore the reasons why this is so, as girls and boys are encouraged to re-sit in order to achieve the best mark possible.

The final analysis (for this section of the report) explored how the girls performed in each module compared to the boys. This was based upon the sample of 144 students, with 22 girls and 122 boys. For each module, the results of the girls and boys were separated and then the mean score for each module was calculated.

CHART 4: Comparison of the performance of girls and boys in the different A level physics modules (2004 to 2008)

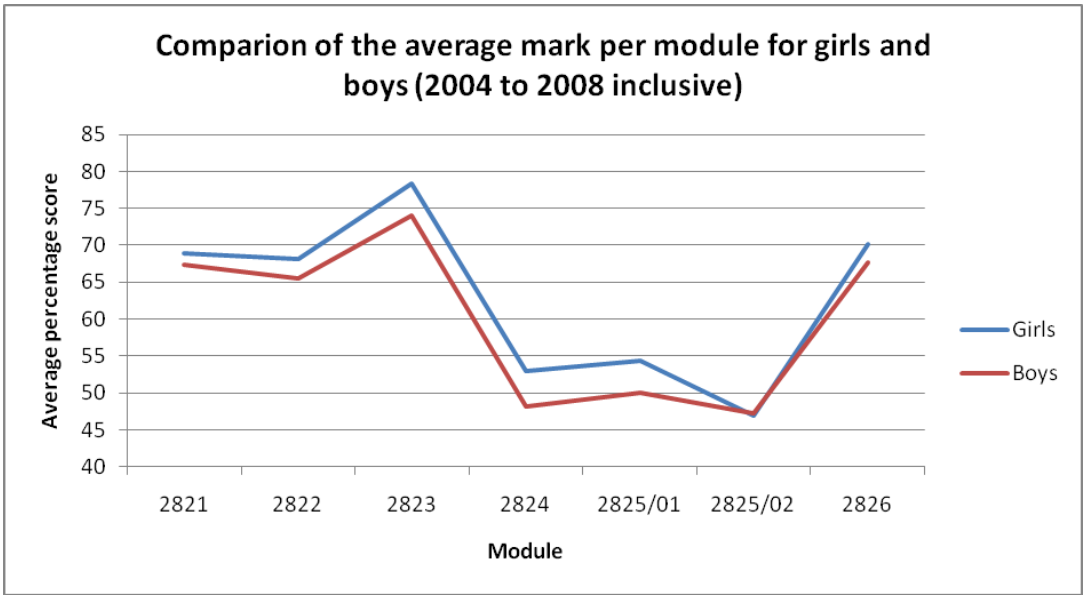


Chart 4 shows that the average (mean) percentage mark for girls and boys follow similar trends, however there is a slightly better result for the girls in the cosmology module and similar marks for the health physics module. There is no marked difference between the topics studied, rather that there are some topics (or examinations) that all students find more difficult than others.

One of the original objectives, when starting this analysis in 2008 was to see how students performed in the different modules, particularly to see if there were any differences between the performance of girls and boys in the different modules. It was of great concern to see that this analysis revealed that health physics was the least successful module for girls, despite the fact that this was an optional module that had been specifically selected by the students concerned. I was perplexed as to why a subject that the students found interesting could lead to poor performance in examinations and it was evident that there was a serious need to conduct a more rigorous study of the skills that were being tested in the optional modules, rather than simply considering subject content. It also leads to the dilemma of whether it is more important to teach a subject that is interesting and will engage the students, or whether potential examination success is a more important factor?

In order to pursue this investigation into performance in the Physics A level modular examinations, I contacted OCR to asked if further information was available. I was specifically interested in the number of candidates for each of the optional modules, as well as the number of females entered for each module. OCR provided the email address of the Chief Examiner for A level physics so that I could contact him directly.

After outlining the nature of my research, the Chief Examiner stated that he was prepared to release the number of students entered for each module but could not provide any information relating to the number of girls entered for each optional module. I had anticipated that there would be a greater ratio of girls taking the Health Physics module and that by choosing to study this module, may inadvertently decrease their chances of achieving a high grade. The Chief Examiner claimed (in a personal email communication) that he was not aware of any research that has been conducted into the choice of modules and advised that I contact the Institute of Physics should I wish to pursue this research further.

The information provided was limited to the number of candidates for the option modules in 2008 being 2460 for Cosmology, 1091 for Health Physics, 370 for Materials, 1734 for Nuclear Physics and 85 for Telecommunications.

PART 2: Analysis of the Health Physics Paper (June 2008)

Following the evaluation into how students performed in the different modules, I was concerned that, in general, students fared less well in the health physics examination than in the other optional module. I was particularly concerned as this module was generally favoured by girls. The average student score per module for 2008 was shown earlier in chart 2, where the average mark for the health physics module was particularly weak. In order to determine why the marks had been significantly lower than anticipated, we recalled four of the students' examination papers. The papers that we selected for recall were from students who were applying to study a health-related course at university and had specifically requested to study this module, hoping that this topic would help towards achieving a better final grade.

TABLE 9: Four students whose marks were 'pulled down' by studying the Health Physics module

Student	Health Physics Grade	Final A level Grade
Student A (Male)	D	B
Student B (Female)	E	C
Student C (Female)	E	D
Student D (Male)	U	D

For each of the candidates above, it can be seen that the health physics module was lower than their final grade and indicates that if these students had performed to a level consistent with their other modules, the overall grade may have been increased, rather than decreased. The candidates selected were conscientious students whose marks for the Health physics module did not reflect the amount of work that they had invested throughout the course.

Following a detailed analysis of the candidates' examination papers, it was clear that these students had lost a significant proportion of marks in the extended answer questions and other similar questions which relied upon the ability to express concepts in writing. One particular question asked candidates to discuss the process of Magnetic Resonance Imaging and two sides of A4 were expected for this response. The students could list factual

points but drawing them together to produce a coherent response proved too difficult. All papers showed a similar pattern in that the answers to the discursive questions were very weak in comparison to the numerical questions.

Content Analysis of the Six OCR Modules (2008)

Having established that the students under-achieved in the Health Physics module and realising that their ability to answer the discursive questions within the examination was weak, I decided to conduct a content analysis of the questions used in each of the modular examinations. The analysis was conducted on each of the six papers (June 2008) to explore the different types of questions used in each examination paper. The table below (Table 10) shows the number of times that particular words were used but does not reflect the allocation of marks to the questions.

TABLE 10: The number of times that particular questions were asked in the different modular examinations (2008)

JUNE 2008 EXAMINATIONS	**Force and Motion**	**Electrons and Photons**	**Wave Properties**	**Forces Fields and Energy**	**Health**	**Unifying Concepts**
	2821	**2822**	**2823**	**2824**	**2825**	**2826**
State	5	5	6	2	1	5
Define	1	2	1	1		
Describe	3	1	2	2	1	
Explain	3	4	3	**13**	**10**	**3**
Sketch/draw/ label/underline	3	6	5	3	2	7
Suggest			2		2	
Complete the sentence			1			
Write down				5		
Calculate/ show that	11	9	6	16	9	4
Determine	1	1			1	
Complete the table		1			1	
Find					1	1

There is a marked increase in the number of 'explanations' required for papers 2824 and 2825, however this analysis did not reflect the number of marks allocated to the questions. A second analysis (Tables 11 and 12) compared the number of marks for each question in the different modules:

TABLE 11: The number of marks allocated towards different questions in the Force and Motion module (2008)

TYPE OF QUESTION 2821 (Force and Motion) June 2008	**Marks Allocated**
State	1, 2
Sketch graph	3, 3
Underline	1
Show that	1, 3, 1
Calculate	2, 3, 2, 3, 2, 2, 3, 4, 2,
Describe	5, 1, 7
Define	1
State and explain	2, 2, 1
Determine	3
Total marks for the paper = 60	Calculations = 31/60 = 51.6%

TABLE 12: The number of marks allocated towards different questions in the Health Physics module (2008)

TYPE OF QUESTION 2825/ 02 (Health Physics) June 2008	**Marks Allocated**
State	2
Sketch	4, 3
Calculate	4, 3, 3, 2, 4, 2, 1
Explain	2, 2, 3, 7, 1, 3, 2, 3
Suggest	1
Describe	10
Complete table	1
Determine	2
Find	2
Complete table	3
Total marks for Health Physics = 70	Calculations = 22/ 70 marks (31.4%)

This comparison shows that the first examination consists mainly of short questions, with only three questions greater than 3 marks (one calculation worth 4 marks and two descriptions, of 5 and 7 marks each). The Health Physics questions include two 4 mark calculations and two 'extended writing' questions of 7 and 10 marks respectively. Therefore one of the reasons why students at the FEC fare better in the earlier examinations is not necessarily an issue of subject content, nor the fact that there are opportunities to re-sit, but the difference may lie in the style of assessment. The second year examinations require stronger abilities with written communication, as well as more complex thinking skills such as synthesis of information.

I was interested to determine if this was a problem within the college, however, in the Examiner's report for the June 2008 OCR Physics Examinations, there were several comments that indicated a national problem with students' ability to articulate their responses to the extended questions:

> 'Candidates are still reluctant to use words rather than symbols and many still do not do enough practice during their course. A significant number of candidates treat physics questions as finding a formula and putting in some numbers.'
>
> 'It was noticeable that a number of good candidates are still failing to achieve in the extended answer questions. It was common to find vague answers and with the MRI question, it was clear that many candidates did not understand the principles and wrote confused statements.'
>
> 'There were still many responses which were ambiguous….'
>
> 'Most candidates had a go but failed to give reasons that backed up their point of view…..'
>
> (Examiner's Report, OCR, 2008)

Throughout the Health Physics module, both male and female students (at the FEC) expressed concern that whilst they enjoyed learning about the practical applications of physics towards real life (and human) problems, the main feature that they disliked about this particular module was the number of descriptive or explanatory answers required in the examination questions.

This presents a dilemma for physics teachers as we are encouraged, as good practitioners, to make lessons enjoyable. Unfortunately, to ensure good examination results, there was a strong need to work harder at developing students' written communication skills and develop more fluent writing styles. Many of the students openly expressed a dislike of writing and asked for 'the sort of questions that we did at GCSE'.

Research conducted with primary school children by Mercer (2003) suggested that children learn science through a discursive process. He suggested that language should be used to 'enable students to become fluent speakers of science' (Mercer, 2003, p.359). Mercer found that discussion between students developed a greater conceptual understanding of the topics, helping them to make meaning out of some of the more abstract topics.

Whilst this research was conducted within a primary school, it appears that during secondary education, language is not as significant in the learning of scientific concepts. The current physics GCSE examination papers have a large proportion of multiple choice questions with rather minimal opportunities for extended writing. As schools are under pressure to achieve targets, teachers are more likely to teach the skills necessary for the qualification, rather than those which are for their wider education.

This research can be extrapolated to A level students, however, where there is clearly a need to develop students' ability to think, evaluate and explain their ideas in a coherent and fluent manner. According to Bernstein (1971), children from working class backgrounds have communication skills which are limited to a 'restricted code', whereas middle class children have powers of expression which follow a more 'elaborate code'. He claimed that 'we can expect a major problem of educability whose source lies not so much with the genetic code but in the culturally determined communication code' (Bernstein, 1971 p.151).

Good classroom teachers know that simply teaching content is not sufficient, for we must develop higher order thinking skills and encourage young people to think for themselves. It became increasingly apparent, however, that one of the most important skills that would help students at the college, who are predominantly working class, would be the development of improved written communication skills. I had always believed that physics was an academic discipline in which students could succeed, irrespective of social

class. Having conducted this evaluation, however, it is clear that improving written communication skills could lead to improvement in the students' performance in the second year examinations.

During the academic year 2008/9, the A level physics students showed interest in the study of the Health Physics module, so again a choice was offered of the study of this module or cosmology. Throughout the year, we emphasised the need to develop strong written communication skills, and many classroom activities and extension tasks were designed to develop these skills. It became clear that students could not differentiate between 'needs' and 'wants'. At the college, there is a great emphasis upon students enjoying their learning experience and they are encouraged through a range of opportunities to express their views, for example, the student council, course committee meetings and student course evaluations. I agree that student feedback is extremely important but students often use these surveys as a means of complaining about teachers who challenge them to work outside of their 'comfort zone' in order to develop the very skills in which they may be weak and need strengthening. According to Brookfield:

> 'The trouble with the 'meeting needs' rationale is not just that it sets up an unattainable standard, but that students sometimes take a dangerously narrow view of their needs. Students who define their needs as never straying beyond comfortable ways of thinking, acting and learning are not always in the best position to judge what is in their own interests.'
>
> (Brookfield 1995, p.20)

The year presented a challenge of gently encouraging students to work in a different way. The students appreciated my efforts, and respected my aspirations of raising their examination results, although they were reluctant to embrace any new styles of learning that did not concur with their experiences at secondary school. The students worked with me to develop these skills but it would be fair to say that they did these tasks out of courtesy, without any whole-hearted desire to improve their education in a wider sense.

Conclusions for the 2008 report

The aim of the report was to use empirical data from the FEC in order to study student performance within the modular examination structure. Previous research into this subject is limited and by using several years of data, a larger sample enables a more meaningful result. It must be stressed that when evaluating differences between girls and boys performances in examinations, girls are a small subset of the group and arguably not representative of all girls at that age.

Whilst evaluating this data, it emerged that there were no significant differences between girls and boys performance within particular modules, however the module which has traditionally been more favoured by girls (Health Physics) does not actually favour the girls in return. Within physics, we believe that offering some degree of choice maintains the interest of the students and allows them to develop particular interests in the subject. It had been expected that physics students would perform better in an option that they had selected, and the student survey indicates that the students enjoyed studying the topic of Health Physics. The students particularly enjoyed visiting the hospital and seeing some practical applications of the subjects and how it could save lives. On the other hand, the students did not like the amount of descriptive or explanation questions that were in the examination.

Whilst students may not particularly like having to develop their ability to communicate clearly and effectively, this is the skill that is most necessary to improve the grades for the Health Physics module. There is also a strong necessity to learn and recall factual information, which some science students seem unable to appreciate. This leads to the question of whether it is always in the students' interest to study a topic which they may enjoy but may not lead to good examination results?

The fourth physics module is disproportionately more difficult than the other modules, with a greater volume of topics that also require more advanced mathematical ability. Students recognise this module to be extremely difficult so concentrate upon achieving high grades in the AS modules by multiple re-sits in order to achieve the best grade possible. It was found that boys are far more likely to take advantage of the opportunity to re-

sit examinations than the girls, who were much more cautious about re-sitting examinations.

My research showed that there were several reasons why students at the college fare better in the first year modular examinations than the second:

1) The first year modules could be taken again (re-sits) to achieve a higher grade, whilst the second year modules can not.

2) The first year modular examinations were based on recall of simple factual information with some simple calculations, whereas the second year modules required students understanding, and memorising for the examinations, more detailed and complex information.

3) The second year modules contained questions which required extended writing responses, where students at this college were particularly weak.

The issue of social class and communication skills was discussed by Bernstein and is, perhaps, outside the confines of this report. It is important that as teachers, we are aware that whilst students may understand what we are saying, and understand the text books, if the vocabulary and terminology are not in words they use themselves, they may be unable to articulate responses in the examination room. Therefore developing students' vocabulary and powers of expression are crucial.

With the introduction of the new specifications in 2008, we decided to change examination boards from OCR to AQA as they appear to provide greater feedback and support for centres. Having attended presentations by AQA, OCR and Edexel, a general consensus was reached with all three sciences opting for AQA.

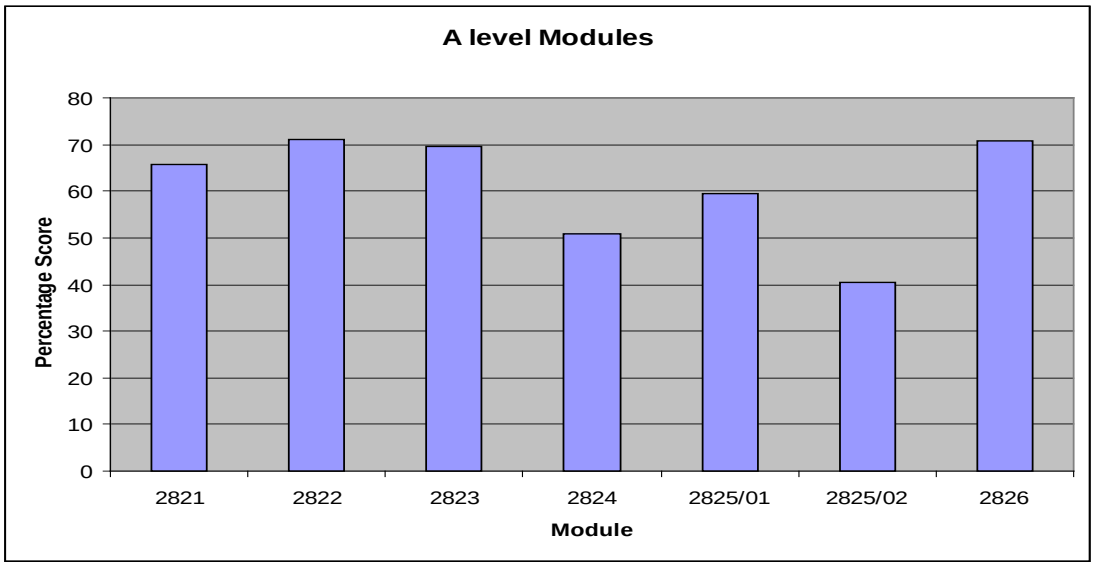
Over the forthcoming year, we made a conscious effort to adapt our teaching and learning methods in order to develop students' written communication skills. We continued to allow students a choice for the optional modules, but fully informed students of the difference in the examination style and the requirement for a more rigorous recall of extended factual information. We could then evaluate whether students can be trained to perform well in the examinations and assess any improvements with the 2009 A level results.

PART 3: Evaluation of the 2009 and 2010 results

Reflections upon 2009 results

The results for 2009 produced another 100% pass rate, which has now been held for 5 years. There were only 15 students, of which 3 were girls. 2 of these girls chose to study Health Physics, whilst the other girl chose to study Cosmology.

CHART 5: Average (mean) marks obtained in the different physics A level modules (2009)



The least successful module was, again, Health Physics (2825/02). The average (mean) mark for the Health Physics examination had improved from 35.7% to 40.5 %, which was not as much of an improvement as we had hoped for. This was particularly disappointing as the students who studied this module were fully informed of the research that was being conducted into the modules and the problems that this particular module presented. Both class work and homework had a greater emphasis upon the ability to articulate and express concepts, as this had emerged as one of the reasons that students underachieved in this module.

When we compare the students' AS grades to their final grades, the data is more pleasing and reveals that students were making greater progress in the second year of their course compared to previous cohorts of students.

One student improved his AS qualification by two grades, which had not been achieved at all during the years 2004 to 2008.

TABLE 13: Comparison of AS performance against final A2 grade (2009)

	Percentage of students in 2009	**Percentage of students between 2004 and 2008**
Improved by two grades	6.7	0
Improved by one grade	20.0	9.7
Same grade at AS and A2	53.3	47.2
Decrease of one grade	20.0	38.9
Decrease of two grades	0	4.2

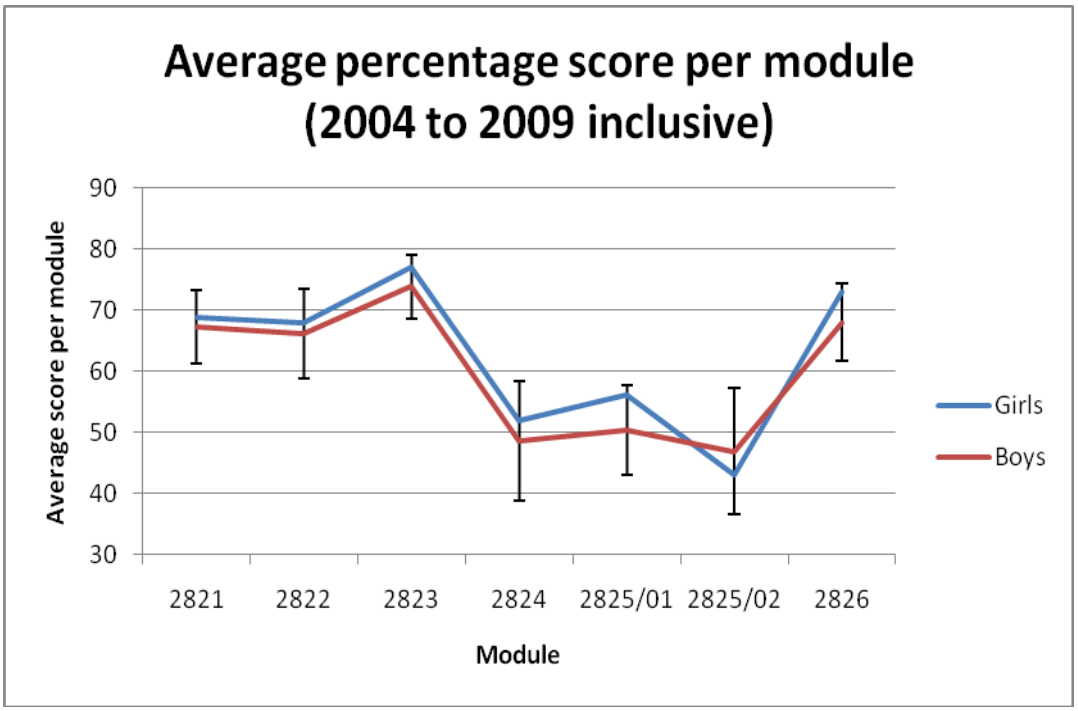
Overall, 26.7% of the students improved upon their AS result (2009) compared with 9.7% in the 2004 to 2008 study. Similarly, there were only 20% of the students who decreased their grade between AS and A2, compared to 43.1% in the 2004-2008 survey. The average marks for the second year modules were much higher in 2009 than 2008, showing that with a particular emphasis upon developing students' written and verbal communication skills, we were able to 'lift' the students towards greater success with their problematic A2 modules.

TABLE 14: Comparison of 2008 and 2009 average (mean) modular marks

YEAR	**Module 4**	**Module 5/01 Cosmology**	**Module 5/02 Health**	**Module 6 Synoptic**
2009	50.8	59.6	40.5	70.9
2008	48.5	53.5	35.7	65.3

The overall achievement (final grades) of the students, based upon their AS qualification also had improved considerably. Having a further year's data, we could extend the extended study of 2004 to 2008 to now incorporate 2009. If we compare the performance of the girls and boys in different modules over this extended period, we now have a larger data set of 159 students, of which 25 were girls.

CHART 6: Comparison of girls and boys performance in the different A level physics modules (2004 to 2009 inclusive)



The graph above is a visual display of the differences in performance between the girls and the boys in the different modular examinations, with data from 2004 to 2009 inclusive. The graph shows that for the compulsory modules, there is very little difference between the average (mean) score for the girls or the boys, with the girls scoring slightly better in each of the five compulsory modules. The standard deviation is shown for the boys' average marks per module. The data shows that the girls fare less well with the Health Physics module than with the Cosmology.

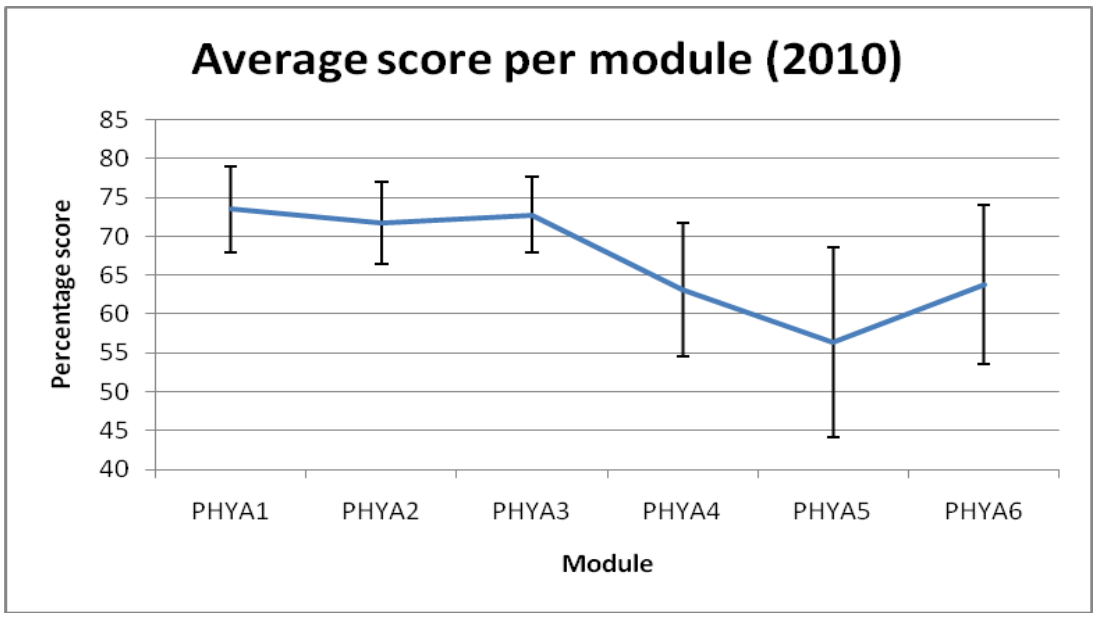
It must be stressed, however, that the 159 students in this cohort are students who have chosen to study A level Physics, and therefore can not be compared to younger pupils for whom the study of science is compulsory in state schools. If a similar analysis was applied to questions in the GCSE examinations, it may reveal more significant discrepancies in the understanding of different concepts and could possibly provide a valuable insight into the barriers that prevent girls from studying physics at A level.

Reflections upon 2010 results

After the original analysis was conducted in 2008, we decided to change examination boards from OCR to AQA, as we believed that this board may be better suited for our candidates. This decision was made after attending the various presentations that were organised in 2008 for the new specifications that all boards would have to follow. The first cohort to study AQA Physics A level achieved their final results in the summer of 2010. A comparison between the results is not feasible due to the different content and structure of the modular units.

In order to implement a further change, we decided that we would not offer our students a choice of optional module but teach the astrophysics module to the whole cohort.[3] When I explained my reasoning to my A level physics class, with the charts showing the average (mean) mark for each of the modules, all of the students were in full accord. Whilst both of the girls in my class would have preferred to study medical physics, they appreciated that the decision was in their best interests, as they both needed to achieve high grades in order to secure their university places. The 2010 A level examination results again showed 100% pass rate, which has now been sustained for six continuous years.

CHART 7: The average (mean) modular mark for the different AQA Physics modules (2010):



[3] OCR offered Health Physics and Cosmology, AQA offered Medical Physics and Astrophysics

TABLE 15: Comparison of the average (mean) percentage mark in the different modules (2008 to 2010)

YEAR	MODULE 1 AS	MODULE 2 AS	MODULE 3 AS	MODULE 4 A2	MODULE 5 A2	MODULE 6 A2
2010 (AQA)	75.5	72.8	72.9	63.2	56.4	63.8
2009 (OCR)	65.6	71.1	69.5	50.8	COSMOL 59.6 HEALTH 40.5	70.9
2008 (OCR)	66.8	68.0	76.8	48.5	COSMOL 53.5 HEALTH 35.7	65.3

The AQA modular examinations were similar in structure to the previous OCR modules, with three taken in the AS year and the next three taken in the A2 year. Whilst comparisons between boards are not fair due to the differences in content and structure, the above table compares the average mark per module for the 2010 cohort of students with previous years' students. It must be stressed at this point that differences could be due to continuously improving the teaching and learning strategies within the classroom and the very nature of the students themselves, as each yearly cohort is different in character.

The average mark for the AQA astrophysics module (Unit 5) was less than that of the Cosmology in the previous year, but when compared to the marks achieved for the Health Physics module, showed and increase of the mean mark, which perhaps justifies our decision to abandon student choice.

If we consider the 5 girls as a separate group, the mean marks were above the boys in all modules:

TABLE 16: Comparison of the average (mean) mark of the girls and boys in the different modules (2010)

	MODULE 1	MODULE 2	MODULE 3	MODLUE 4	MODULE 5	MODULE 6
GIRLS	77.8	78.7	75.3	64.3	58.5	68.7
BOYS	72.7	70.3	72.2	63.0	56.0	62.8

It is important to stress that this can not be shown to indicate that girls outperform the boys in general, merely that there were some strong girls in this particular cohort.

Conclusion to the study

One of the main conclusions that I have drawn from this extended study into the performance of students in A level modular physics examinations is that it has made me increasingly aware of my own classroom practice and how everything that I do within the classroom has a direct bearing upon student performance.

Conducting this research has raised my awareness of the external factors that have an effect upon student performance, such as the choice of examination board and choice of optional modules. By making simple decisions on behalf of the students, we have maintained our 100% success rate and improved the percentage of high grades achieved by our A level physics students.

One of the original objectives was to determine whether there were any differences in examination performance between girls and boys that would reveal differences in the understanding of physics. No significant differences emerged, however one of the main limitations of this study is that the girls in the A level classes have already studied GCSE and been successful at that level, so perhaps not representative of all girls in society.

The cumulative data shows that boys, in general, take more re-sits than girls. This supports the work conducted by McClune (2001), which showed that boys were more likely to take advantage of the modular system of examinations. There has been considerable research that suggests girls prefer those topics of physics that relate to the more human aspect of the subject (Stewart 1998), with health physics being particularly popular with girls.

Unfortunately, we have found that due to the style and format of this particular examination, our students did not fare well in health physics. This leads to the dilemma of whether it is more important to teach topics that students find interesting or those which lead to examination success.

The second objective of this investigation was to explore the reasons why students under-performed in the Health Physics modular examination. It was found that this examination required a greater amount of written communication than other modular examinations. The problems with this paper are not confined to the college, as it was noted in the Examiner's Report (2008) that 'A number of good candidates are still failing to achieve in the extended answer questions'. Despite devising a range of resources to develop extended writing skills, many students expressed a clear dislike of this type of learning, preferring the numerical aspects of physics. There are possible social class issues underlying this dilemma, as working class students may have restricted powers of expression compared to middle class students (Bernstein, 1971).

The third objective was to see if teaching and learning strategies within the classroom can improve as a consequence of this research. This is clearly demonstrated by the need to develop greater use of language and written communication activities. Rather than focus upon syllabus content, it is important for students to develop their abilities to recall, explain and verbalise physical phenomena. The use of language is important in the learning process.

By studying examination performance, and sharing appropriate findings with my students, has encouraged them to adopt statistical strategies when considering re-sits. Rather than entering for as many as possible, encourage students to reflect upon which modules will produce the greatest increase in overall results. The study showed that girls take fewer re-sits, in general, than boys, so as a result of this investigation I now spend more time counselling, or encouraging girls to take advantage of re-sit opportunities.

Overall, the study has been worthwhile as it has enabled statistical data to drive improvements, not only in the achievement of our students, but in the quality of teaching and learning in the classroom.

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Appendix

Chart A1: Average mark per module for the 2007 A level Physics modules

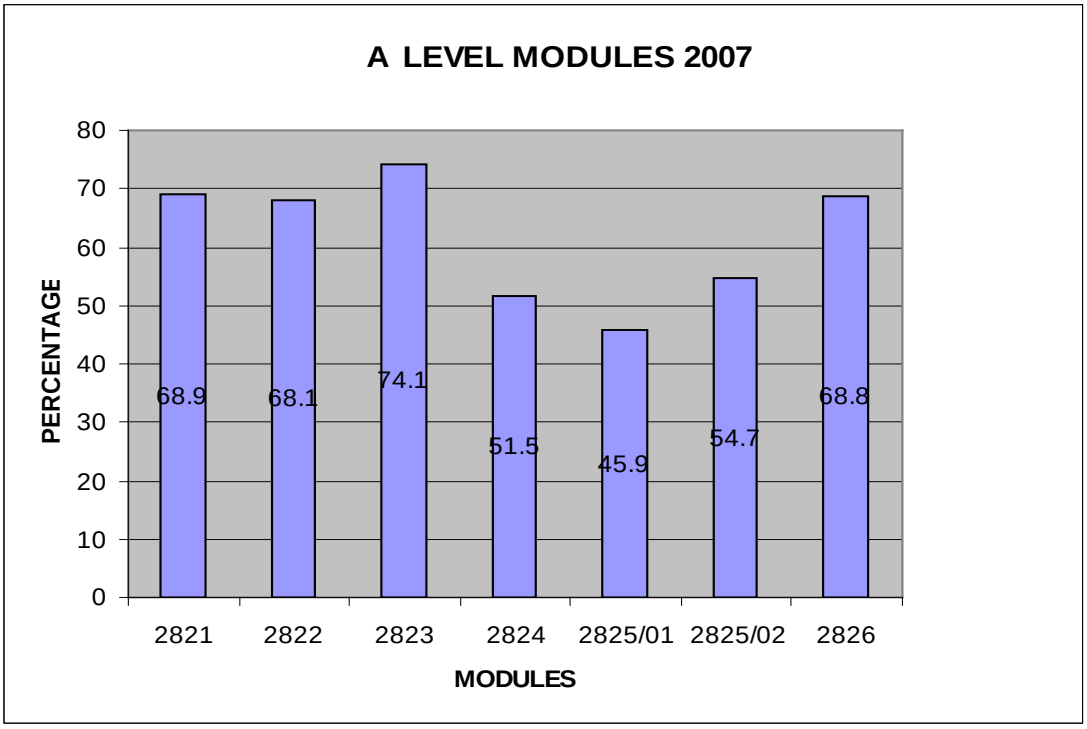
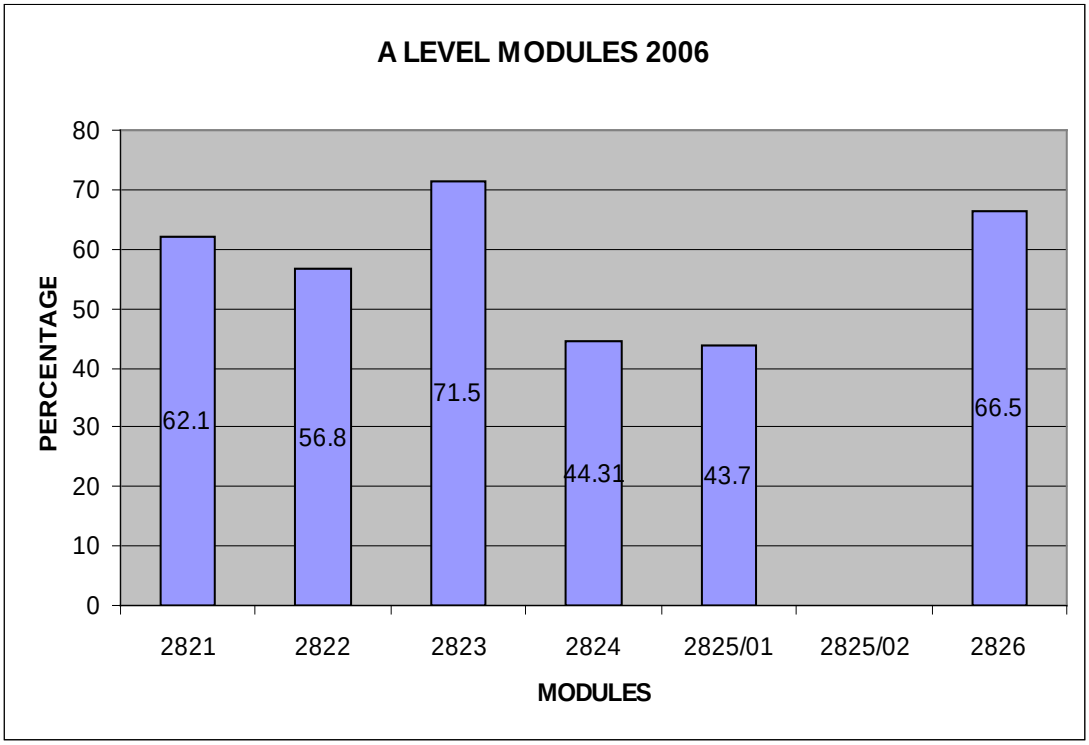


CHART A2: Average mark per module for the 2006 A level Physics modules



Report Evaluation Form

REPORT:

AN ANALYSIS OF STUDENT PERFORMANCE IN A LEVEL PHYSICS MODULAR EXAMINATIONS

REVIEWER

Curriculum Leader for Science and Mathematics
Sixth Form B, FEC

Comments on the report:

The report provided a useful analysis of student performance in the A level physics modules. At the college, we have offered students a choice of optional module, however it is clear that student choice is based upon interest rather than which option will lead to best examination result.

Since Marianne produced the first evaluation, we have implemented a number of changes within the physics department, as we can appreciate that students need to make informed choices about which re-sits and modules to study.

Are there things that could be added or removed to improve it?

It would be an interesting extension for further study to investigate whether student performance in A level modular examinations followed a similar pattern in chemistry and biology.

In what way could the contents of this report influence the wider profession?

The work that Marianne has conducted has been of value to the cross college science and maths team. It could be of value to other schools and colleges who offer students a choice of modules at A level.

It is important that teachers realise when offering a choice of modules that student interest is only one of the factors that need to be considered. Clearly, the style of the examination and the skills required favours some students more than others.

Signature:

Supplied

Sent: Wed 19/01/2011 15:13
To: marianne hill
Subject: RE: Research into examination performance

Dear Marianne,

Many thanks for this. It's interesting - and a little worrying from the exams point of view. Have you let the Awarding Organisation know?

I wonder if it is something to do with more people being entered for the health module; though I can't really think why that would distort the results. Anyway, it might be worth challenging them with it.

The shame is that it is another case of having to teach something in order to help exam performance rather than enthuse the students. But such is the way with the pressures now.

I did see an e-mail that XXXX sent about take-up in your college. And we are having a think about that as well.

Best wishes,

(name supplied)

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