Report on Intel *Design and Discovery* Curriculum Project

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Terminology

For convenience, in much of this document, the *Design and Discovery* course title is abbreviated to D&D. The two major systems of public examinations for Irish school students are known as the *Junior Certificate* (taken at about age 16 years) and *Leaving Certificate* (taken at about age 18 years). These are usually abbreviated as JC and LC respectively. For example, the Junior Certificate Science course is written as JC Science.

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1. Introduction

This report was prepared in response to a request made to the author by Mr Frank Turpin (Education Manager, Intel Ireland Ltd.) in April 2004. The brief was to make a preliminary evaluation of the *Design & Discovery* course being piloted in two schools in the greater Dublin area: St. Wolstan's Community School, Cellbridge, and Lucan Community College. The nature of the evaluation was discussed in some detail with Mr Gerry Nolan (Education Specialist, Intel Ireland Ltd.) and I was made aware of the document *Formative Evaluation Proposal for Design & Discovery Pilot in Ireland*. Both schools were visited on several occasions to meet the teachers and students, and to see aspects of the course being implemented in the classroom. A questionnaire given to students by Intel at the start of the course was analysed, and followed-up by a second questionnaire. The latter was presented to Mr Nolan for comment/criticism (and through him to the D&D team in the USA). In late May, students from both schools were interviewed in small groups. On one occasion the author was present at a video conference held with the D&D team in the USA at which three of the D&D teachers were present, together with Mr Nolan. The teachers involved in the project were: Ms. Audrey Byrne and Mr Martin Gleeson of Lucan Community College; Ms. Louise Ward and Ms. Margaret Bonner of St. Wolstan's Community School.

2. Summary of major issues

2.1 Preamble

Schools are very busy places, and the lives of students and teachers within them are subject to many influences—not least from wider society, families, and interactions within classrooms. As a consequence, it is extremely difficult to make a robust and rigorous assessment/evaluation of any aspect of school life. This report cannot be regarded as 'objective' in all but a restricted sense in that I have faithfully reported the results obtained from the questionnaires, and tried to give a balanced commentary on those results. I have also formed a view of the strengths and weaknesses of the project as a result of my visits to the schools, conversations with the teachers involved and from the students' comments during the interviews. However, much of what follows is (inevitably) my personal view, and goes beyond the bare data collected. The specific points that follow are dealt with at more length in the body of this report.

2.2 Major points

1. The project has been successful in engaging the interest of the majority of the students. It has been equally successful in gaining the interest of girls and boys.
2. By taking part in the project, students have gained a deeper awareness of engineering, its processes and role in society. However, having completed the course, they are largely unaware of any *specific* learning outcomes.
3. In spite of the best efforts of the teachers, and Intel, a number of students remain unaware of the purpose(s) of the course, and fail to distinguish it from studying physics.

4. The project has not increased or influenced in any but a minor way the intentions of students to study further the physical sciences at Leaving Certificate, or look to make a career in some aspect of engineering. This is not so much a reflection on the nature of the D&D course, as a feature of students early decision-making and timing of choice of Leaving Certificate examination subjects. Such timing is a function of school policy; but has a marked influence on the potential for the D&D course to influence student behaviour.
5. Implementing, and maintaining the direction of, the course has been extremely demanding for the teachers.
6. Ambiguities exist in the choice of content of the D&D curriculum that need to be resolved. these ambiguities relate to the extent to which knowledge of more theoretical aspects of science are necessary (as opposed to desirable) to succeed in practical activities such as project work.
7. If D&D is to influence students' decisions to study LC Physics, it is vital that school administrative procedures allow students to make their subject choices late in the school year. Principals of school should be made aware of, and asked for their help in, this matter.
8. It is essential to modify/change aspects of the D&D course for successful implementation in Irish schools. Specifically, the choice of content and, in some respects, teaching approach should be modified to take account of:
   (i) prior study by students in JC Science and JC Technology courses;
   (ii) structure of lesson time available in schools during Transition Year;
   (iii) the great difficulty that schools have, or will have, in implementing a scheme of mentoring—indeed, it would be best to assume that mentors will not be available;
   (iv) the lack of integrated computing/internet access for students in normal D&D lesson time;
   (v) the desirability of including specifically Irish exemplars of engineering, e.g. reflecting experience of women in Irish industry, information about specific industrial concerns (Intel Ireland would be an ideal case), and engineering projects; e.g. the Dublin Port tunnel, Luas tramway.
9. The final stage in which students design and build their own devices in a project is very demanding on students and teachers. It would help if teachers were given suggestions/ exemplars of successful projects which they could use with students (if necessary).

3. Discussion[1]

3.1 General points

Much of what follows consists of suggestions of ways in which D&D might be changed to reflect the findings of the research. However, it should be realised that the course has been successful in retaining the interest of the majority of students. Transition year classes can be some of the most difficult to teach in school: the students are becoming more independent, and the flexible nature of the curriculum can give many the impression that the year is time for them to relax, free from the demands of examination work. It was a marked success that the majority of students remained very positive about the work they had done. Especially, the focus on short, practical tasks held their interest. I believe it to be essential to retain this aspect of the course.

1. The majority of the content of this section is also referred to elsewhere in the report.

3.2 D&D in Irish schools

The way the D&D curriculum has been designed to suit the needs of younger students in a more informal environment of a summer camp means that not all of it fits easily into teaching classes in Irish second level schools. In part this is because D&D was not intended to take into account students' prior experience of doing (especially) Junior Certificate examination course in Science and, for some, Technology. The basic work on design, with its emphasis on students looking more closely at objects (large and small) in their environment, and the design process itself will be new to many students (even if they have done JC Technology). However, work on electricity and on energy conversions are part of both those subjects, and D&D should change to reflect students' prior experience. Also, students around the age of 16 years have different impressions from younger students of the relevance of some topics.

This is not to say that students will have achieved a level of mastery of the concepts met at JC; but at present the D&D curriculum appears to assume that youngsters following the course will have no relevant prior knowledge at all. Examples outlining how the course could be changed are given in Table 1. One idea in making changes to the curriculum is to make the activities link more closely to modern life (which is dominated by digital electronics).

Table 1: Examples of curriculum changes

Electricity	*Activity*	*Comment*
Lesson 1. Revision of basic concepts of electricity: voltage is a measure of how much 'push' there is to make electricity flow; current is the movement of charge—electrons in metallic conductors.	Build series and parallel circuits using simple light bulbs (different intensifies of light); extend to include buzzers and motors (different sound levels and speeds of rotation).	Not with breadboards: they are unnecessary for this work and make it impossible to see the relevant connections.
Lessons 2, 3. Digital electronics. Emphasise that 'chips' are very sensitive to voltage because (mostly) they cannot pass large currents. Introduction to breadboards. Investigation of LEDs and CMOS logic gates.	Using breadboards to light a simple LED. Extension to using an AND gate to turn on a LED, or (better) a motor	Put in the context of a problem e.g. to turn on a machine if the power switch is 'on', and the safety switch is 'on'.
Energy conversions		
Lesson 1. Revision of relation between potential and kinetic energy; other energy conversions. Relevant demonstrations as in the present JC Science course.	Students do/watch suitable activities. Students build rotating toy as at present.	
Lessons 2, 3. Emphasis on conversions of electrical energy to other forms. Students make appropriate measurements and calculations. E.g. of speed of vehicle, energy needed to produce the motion.	Students build motorised vehicle using LEGO or other simple vehicle.	Kits are available from Irish laboratory suppliers that involve constructing vehicles from dowel, card etc.
Lesson 4. Students use logic gates to control motion of a vehicle in the context of a simple problem.	Students build circuits using AND, OR (etc.) gates to control the vehicles they have made earlier.	Leads into discussion of design problems for motorised toys; vehicles made from kits (not LEGO) tend not to run straight if not built accurately; matters of electrical safety etc.

3.3 Project work

In the interviews, a number of students indicated that there was a mismatch between the types of projects that they would have liked to build, and the level of knowledge that was needed to do so.It would be useful to put more of the work in lessons into contexts that require a problem solving approach to a task that had more of the flavour of a ‘mini project’, thus giving students a better guide to approaching their final project. Several examples could arise from the examples given in Table 1.

3.4 Links to LC Physics

It is evident that D&D contains little or no quantitative work. The problem here is that on the one hand D&D seeks to encourage more students to study physics and engineering; but on the other the course as it stands at the moment is very different from the current LC Physics programme. Thus, there is a danger that students might choose LC Physics based on what, to them, proves to be a false prospectus. If for no other reason, it would be wise to include some quantitative work in D&D. It is my view that, contrary to what many teachers might believe, much of the present LC Physics course could be taught if recast into more of a problem solving framework; but in reality this is not likely to happen in the near future.

3.5 Ambiguities in the curriculum

Related to this last point is another aspect of D&D that should receive attention. It is exemplified in the *Facilitator Guide*, Session 4, Activity C, pp. 80–85 (but this is just one example to illustrate a more general point). Is the *main* purpose of the work that students learn how to *use* LEDs, or is it to learn *about* LEDs. If the former, it is not essential to know anything about the internal structure of LEDs; however, one does need to know what voltage will turn them on/off, their current requirements, and that they have two ‘legs’ that must be carefully distinguished in building a circuit. To know about the science ‘behind’ LEDs one does need to discuss the nature semiconductors, *p-n* junctions etc. It seems that it is the latter approach that is taken in many of the D&D lessons; but I think this stance should be reconsidered/re-evaluated. It is important to focus on the essential range of knowledge, understanding, skills etc. that one hope students will acquire. At present the course is giving mixed messages to both teachers and taught.

Where, for example, might students use a knowledge of semiconductors in building their final projects, or in becoming aware of the use of LEDs in household appliances? It should also be remembered that lesson time for D&D is very limited. Teachers found it impossible to cover the course as it exists at present. This may in part be due to the fact that the teachers were new to the course, and that it started relatively late in the school year. However, I suspect that if the full D&D curriculum and final project are given the time they need, there will always be too little time in Transition Year to cover all the material. Thus, some hard decisions about what, and what not, to include have to be made. The resolution of such matters also has implications for how teachers are inducted into D&D, as well as how it is taught, and experienced by students.

3.6 Mentors

The *Facilitator Guide* indicates (p. 5) that there should be two adults with the students at all times, with a typical group being 20 students. This requirement is not a necessary one for Irish schools (even if it is highly desirable). The Guide also says (p. 9) that ‘Mentors are a vital part of Design and Discovery. Mentors are partners in learning, who can inspire students and participate in Design and Discovery in many ways'. I think it highly unlikely that mentors will be available to help with D&D in the great majority of Transition Year classes. Of course, every effort should be made to recruit mentors, but even when they are available, it is possible that some schools/teachers may have reservations about working with them.[1] It may be best to assume that they will not be present, and to reconsider the nature of the D&D curriculum in this light. However, it should be emphasised that the teachers in the pilot project saw the course through to a successful conclusion even though they had no help from mentors.

A key point is that for single teacher to organise project work in a class of (about) 24 students is very, very demanding. Groups of students need ongoing help in the design and construction stages, and (in the nature of things) more than one group will be seeking help at any one time. It is a formidable task for the teacher to keep the class from fragmenting when many students believe that they are unable to proceed without the teacher's help.

There is a second matter here: students are highly reliant on their teacher to advise them on what they can choose as a project. Teachers feel responsible for setting their students onto a path that should meet with success (assuming the students are diligent). In a situation where teachers with no prior experience of project work, and possibly no prior knowledge of physics or craft/ technical subjects, are guiding students, the situation is likely to be very difficult for them. It is for this reason that I would strongly suggest that examples or suggestions for suitable project work are made available to teachers. This is not to say that they limit students' work to such activities; but that they have them to give to students who are unable to think of a project.

3.7 Increasing the uptake of physics and engineering

The evidence from the questionnaires and the interviews is that D&D, even though found to be highly enjoyable, had almost no influence on students' decisions to choose LC Physics, or to take up a career in a branch of engineering. Career plans/preferences appear to have been made long before Transition Year—D&D can do little about that. However, a number of students said that even if they had wanted to do LC Physics, it would have been difficult (if not impossible) because they had to make such choices well before the end of the D&D course.

Perhaps it should be said that one should look at D&D as part of the broadening of students' education, and not just in terms of its effect on choice of examination subjects or of career. The students who followed the D&D course benefited in many ways; not the least of which was a much more developed understanding of the role and importance of design and engineering in society—an outcome of the course that is of value in itself.

3.8 Additional resources

Few schools have direct internet access in their science laboratories, or in 'ordinary' classrooms. As a result, if students are to make use of the internet, it is often necessary for a teacher to book time in a 'computer room' where such access is available. This procedure can make life difficult. Not only does it require forward planning that does not easily fit into a curriculum such as D&D where it is hard to predict when students will complete their practical tasks. It also presupposes that the computer room will be free when D&D students need to use it. Here to is an issue that requires some thought, and guidance given to teachers about how they might best use computer-based resources with their classes.

1. Amongst other things the teacher unions may have a view on the use of mentors.

Later (page 26) the issue of the use of worksheets is discussed. Here, one might make the following points:

(i) The quality of the copying needs to be addressed.
Often the colour images in the *Facilitator Guide* do not copy well in black/grey and white.

(ii) The way the sheets that provide background information are used.
E.g. those that give information on lives/careers of practising engineers can appear very boring to students. Especially, they need to be localised to give them an Irish dimension, and guidance given to teachers on how best to use them. Especially, if students are to red them and extract meaning, some specific tasks need to be included that require the active involvement of the students.

(iii) Can the sheets be given to the students in the form of a course booklet, rather than being given out piecemeal?[1]

3.9 Support for teachers

It bears repeating that a course such as D&D, that requires a style of teaching that is different from that used in most school subjects, makes significant demands upon teachers—especially those that do not have a background in physics. In this respect, many teachers would benefit from an ongoing system of advice and guidance throughout the school year; i.e in addition to a short induction course. It would be worth considering if, and how, such a system could be implemented. Financial considerations alone would indicate that the use of a dedicated web site for Irish teachers would be worthwhile; especially if this were to include the facility for teachers to engage in dialogue with each other, and with others having an interest in the project.

4. Results of the initial questionnaire

4.1 General comments

A copy of the initial questionnaire is to be found in Appendix A (page 32). At the outset it should be understood that one has to be careful in making inferences from the results of the questionnaire—especially in respect of extrapolating trends in the data to predicting results in the wider population of Irish schools and students. The two schools taking part are very different from each other in many ways. Perhaps the most obvious difference is that St Wolstan's Community School is a girls' school and Lucan Community College is mixed. However, St. Wolstan's is a younger school than Lucan and the working environment is different (e.g. layout of laboratories, range of equipment available). It is my impression that the socio-economic background of students in the two schools is markedly different. (This impression was reinforced by responses to the questions asking the students about their career aspirations). In addition, some of the teachers had degrees in physics, and others did not.

4.2 Analysis of Questions 1 to 20

Results for both schools combined are presented in Table 2, and for the schools separately in Table 3. The responses were scored as 1, 2, 3 or 4, with 1 corresponding to 'disagree' and 4 to 'agree'. With uniform spread of choices, the expected mean would be 2.5. Higher scores represent a tendency to agree rather than disagree with the statement.

1. In conversation with Mr Nolan, it seems that this is to be done.

Although there are differences in the means for most questions, the two schools share a very similar pattern. Only the results for question 2 (‘I am interested in my maths class’) show a significant difference at the 5% level (p=0.013).[1]

Overall the majority of students tend to ‘agree’ or ‘agree a little’ with all but five of the statements (those with average scores less than 2.5). Only question 20 produced a score that was heavily weighted to the ‘disagree’ (52.6% of responses) and ‘disagree a little’ (21.1% of responses). This result shows a distinct bias of the students to discount engineering as a career. Of the four other questions with ‘negative’ responses, it is worrying that they all refer to science and/or mathematics. This pattern fits with other surveys (in Ireland and many other countries) that show a tendency of second level students to dislike the science and mathematics they study at school.

Responses to some questions appear contradictory. For example students tend to agree with both questions 15 and 16 although the former is about a preference for working on one’s own, and the latter about working in groups. The pattern of response is slightly negatively correlated (ρ = 0.2) but the result is not significant at 5% level (p = 0.14).

It is useful to analyse the correlations between responses to the questions in a little more depth. The data was subjected to a cluster analysis, which yielded the results shown in Figure 1, and summarised in Table 4. It can be seen that the students’ responses to some questions follow a pattern; e.g. students that considered themselves good at designing things also had thought of a career that made use of design skills (questions 3 and 11). That, in itself is not surprising; but the cluster diagram shows that those two responses are not very closely linked to questions that probe about engineering as a profession (questions 17, 19, 20). This suggests that design and engineering are not very closely linked in the students’ minds. (However, there is *some* connection between the two groups of responses.)

Likewise, questions that focus on science and mathematics (2, 5, 9, and to a lesser extent 12) are closely linked to themselves, but not closely linked to anything else. Thus science and maths also appear to be separated by the students from matters related to engineering. Responses to questions 6, 14 and 16 bear little consistent relation to any other questions.

1. In passing, it should be noted that with a fairly small number of students, the differences in means have to be relatively large before they become significant at the 5% level.

Table 2: Initial questionnaire: Means of responses to questions 1 to 20, both schools[a]

Question	*Mean*
1. I like taking things apart and putting them back together again.	2.96
2. I am interested in my maths class.	2.39
3. I am good at designing things.	2.67
4. I like to know how things work.	3.38
5. I enjoy doing projects in school that involve maths and science.	2.32
6. I often think about what I want to do after I graduate from school.	3.61
7. I know what an engineer does.	2.82
8. I am good at solving problems.	3.00
9. I would like a career that requires a maths or science background.	2.19
10. I can explain my ideas to someone else so they can understand them.	3.12
11. I would like a career that involves designing things.	2.60
12. It is important for me to be good at science.	2.77
13. Creative thinking is one of my strengths.	2.95
14. I try to think of different ways to solve a problem before deciding on a solution.	2.86
15. I like to find out things on my own.	3.11
16. I like working with a team to create things or solve problems.	3.18
17. I could be a successful engineer.	2.11
18. I try to solve problems first before asking for help.	3.33
19. I consider myself mechanically inclined.	2.21
20. I am interested in pursuing a career in engineering.	1.84

a. Total number of students = 57

Table 3: Initial questionnaire: Means of responses to questions 1 to 20 by school[a]

Question	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Positive or negative response[b]*	*Question*	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Positive or negative response*
1	1	3.21	+	11	1	2.33	—
	2	2.79	+		2	2.79	+
2	1	2.79	+	12	1	3.00	+
	2	2.09	—		2	2.61	+
3	1	2.67	+	13	1	2.96	+
	2	2.67	+		2	2.94	+
4	1	3.38	+	14	1	3.08	+
	2	3.38	+		2	2.70	+
5	1	2.58	+	15	1	3.21	+
	2	2.12	—		2	3.03	+
6	1	3.75	+	16	1	2.96	+
	2	3.52	+		2	3.33	+

Table 3: Initial questionnaire: Means of responses to questions 1 to 20 by school[a]

Question	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Positive or negative response[b]*	*Question*	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Positive or negative response*
7	1	2.83	+	17	1	2.04	—
	2	2.82	+		2	2.15	—
8	1	3.13	+	18	1	3.46	+
	2	2.91	+		2	3.24	+
9	1	2.46	—	19	1	2.00	—
	2	2.00	—		2	2.36	—
10	1	3.29	+	20	1	1.58	—
	2	3.00	+		2	2.03	—

a. St Wolstan's C. S., 24 students; Lucan C. C., 33 students.
b. Compared to mean of 2.5. "+" means students tended to agree rather than disagree with the statement (and vice versa for "—").

Table 4: Initial questionnaire: Clusters for responses to questions 1 to 20

Question in which responses tend to cluster together	*Nature of cluster*
17. I could be a successful engineer. 19. I consider myself mechanically inclined. 20. I am interested in pursuing a career in engineering.	Very clear
3. I am good at designing things. 11. I would like a career that involves designing things.	Very clear
2. I am interested in my maths class. 5. I enjoy doing projects in school that involve maths and science. 9. I would like a career that requires a maths or science background. 12. It is important for me to be good at science.	Very clear
4. I like to know how things work. 18. I try to solve problems first before asking for help.	Very clear
8. I am good at solving problems. 10. I can explain my ideas to someone else so they can understand them. 15. I like to find out things on my own.	Clear
1. I like taking things apart and putting them back together again. 7. I know what an engineer does. 13. Creative thinking is one of my strengths.	Less clear
6. I often think about what I want to do after I graduate from school. 14. I try to think of different ways to solve a problem before deciding on a solution. 16. I like working with a team to create things or solve problems.	Less clear

4.3 Analysis of Questions 21 to 26

Question 21 asked: 'Describe what you think an engineer does at work. What kinds of skills are needed to become an engineer?'. There was a large number of different answers to both parts of this question—see Table 5 on page 11. There are aspects of these answers that deserve further attention.

First, It is evident that even at the start of the course, between 25% and 30% of students had at least some awareness of what engineers do. However, this may have been a result of the introductions to the course given by the teachers in its first few days. (The questionnaire was completed after the D&D course had started.)

Secondly, almost 25% of the students identified engineering with being good at maths; but the response to question 9 ('I would like a career that requires a maths or science background') was, on average, answered with 'dislike' or 'dislike a little'. The students in Lucan were more negatively oriented than those in St Wolstan's. (See the entries in Table 2 and Table 3.) Thus there is a significant problem: for many students, a positive experience of the D&D course itself may not be sufficient to overcome an initial bias against maths. Perhaps the course should have at least some *simple* mathematics included in it that would give students a positive experience of using maths in an engineering context. In practice, many courses in engineering at third level do make significant demands upon the mathematical ability of students. Thus, owing to the possibly misleading impression it might give to students, one might question if it is wise to avoid the use of maths in the D&D course.

Table 5: Initial questionnaire: Question 21 combined responses from both schools

Category	*Number of responses*	*Percentage of all responses*
What an engineer does at work		
builds/makes/creates things	19	24.7
designs machines/things	15	19.5
solve problems	15	19.5
depends on type of engineer	11	14.3
fixes/works with machines/things	10	13.0
makes life easier/useful objects	2	2.6
takes things apart/finds out how they work	2	2.6
does technical/mechanical work	1	1.3
puts things back together	1	1.3
satisfies needs	1	1.3
Kinds of skills needed		
be good at maths	14	17.7
be creative	10	12.7
be good at physics	8	10.1
be good at practical work/with hands/manual work	6	7.6
be good at technology/mechanically minded	6	7.6
be good at/use science	6	7.6
use imagination	5	6.3
be good at problem solving	3	3.8
have patience	3	3.8
be able to measure	2	2.5
be logical	2	2.5
be broad-minded	1	1.3
be dedicated	1	1.3
be good at design	1	1.3
be good at improving things	1	1.3
be good at technical drawing	1	1.3
be intelligent	1	1.3
be open-minded	1	1.3
be strong	1	1.3
good at metalwork	1	1.3
help society	1	1.3
know about computers/electronics	1	1.3
know about machinery	1	1.3
know about tools	1	1.3
knowledge (unspecified)	1	1.3

Question 22 asked the students to 'name some things that have been created by an engineer'. As with question 21, there was a wide-range of answers to this question—see Table 6. there is little to comment upon here, except perhaps to say that some of the examples were (again) likely to have occurred as a result of initial teaching; e.g. the entry for 'paper clips'.

Table 6: Initial questionnaire: Question 22 combined responses from both schools

Category	*Number of responses*	*Percentage of all responses*
cars/bikes/buses/trains/boats etc.	25	17.0
buildings/bridges etc.	18	12.2
machinery/engines	17	11.6
aeroplanes	13	8.8
computers/chips	13	8.8
central heating systems	10	6.8
paper clips	6	4.1
boats	4	2.7
carton lids	3	2.0
chemicals	3	2.0
roads	3	2.0
telephones	3	2.0
computer software	2	1.4
cooking/kitchen equipment	2	1.4
electrical equipment	2	1.4
lighting	2	1.4
sound/music equipment	2	1.4
underground pipes	2	1.4
almost everything	1	0.7
antibiotics	1	0.7
cigarette box	1	0.7
fridge	1	0.7
lifts/escalators	1	0.7
pens	1	0.7
railway lines	1	0.7
taps	1	0.7
tractors	1	0.7
weapons	1	0.7

Question 23 asked the students to name the ‘type of career they were interested in’. There is a wide range of careers mentioned. The popularity of teaching as a career is noticeable, and largely reflected the choice of students in St. Wolstan’s school. Only five answers specifically mentioned engineering (of some type)—see Table 7.

It is relevant to point out that one of the key results coming from the second questionnaire, and my interviews with the students, was that choices of career were made long before the start of the D&D course. Also, in the majority of cases, students had made decisions about their choices of Leaving Certificate subjects based on their proposed careers before the D&D course began.

Table 7: Initial questionnaire: Question 23 combined results from both schools

Career	*Number of responses*	*Percentage of all responses*	*Career*	*Number of responses*	*Percentage of all responses*
teacher	12	17.1	acting	1	1.4
hair/beauty	4	5.7	banker	1	1.4
psychiatry/psychology	4	5.7	carpenter	1	1.4
audio/visual	3	4.3	cars	1	1.4
journalist	3	4.3	engineer	1	1.4
lawyer	3	4.3	fashion	1	1.4
accountant	2	2.9	forensic science	1	1.4
architect	2	2.9	Gardai	1	1.4
business/sales	2	2.9	information technology	1	1.4
child care	2	2.9	nursing	1	1.4
doctor	2	2.9	photographer	1	1.4
electrical engineer	2	2.9	pilot	1	1.4
interior design	2	2.9	to do with science	1	1.4
lab technician	2	2.9	train driver	1	1.4
mechanical engineer	2	2.9	travel agent	1	1.4
medicine	2	2.9	unsure	1	1.4
musician	2	2.9	zoo keeper	1	1.4
social worker	2	2.9			

Question 24 asked students to indicate the ‘course/skills that you most need for your career choice’. The responses are shown in Table 8. It appears that they used it as a request to state the Leaving Certificate examination courses, or passes therein, that they would need for their chosen career. That this is so is suggested by the fact that in the majority of cases the answers appeared to be the names of examination subjects rather than skills. there is little of note in the pattern of responses.

Table 8: Initial questionnaire: Question 24 combined results for both schools

Category	*Number of responses*	*Percentage of all responses*
Maths	33	18.3
English	29	16.1
Science	29	16.1
Computers	19	10.6
Writing	16	8.9
Art	10	5.6
Irish	7	3.9
Biology	3	1.7
Engineering	3	1.7
Business Studies/accounting	2	1.1
French	2	1.1
Geography	2	1.1
History	2	1.1
Music	2	1.1
Childcare	1	0.6
Construction Studies	1	0.6
Home Economics	1	0.6
Social & Scientific	1	0.6
Technical Graphics	1	0.6
Theatre Skills	1	0.6

Question 25 asked 'what types of things do you think you will learn while participating in this project?' The responses are shown in Table 9. Again, the entries have been influenced by the way the course was introduced to the students. That is, teachers had already done a good job in 'selling' the course to their students, who were fairly clear about what they expected from taking part in the project.

Table 9: Initial questionnaire: Question 25 results for both schools

Category	*Number of responses*	*Percentage of all responses*
how to design things	21	20.0
how to make things	11	10.5
become more creative/imaginative	9	8.6
don't know/blank	9	8.6
how things work	8	7.6
how to solve problems	6	5.7
about electronics	5	4.8
how to invent things	4	3.8
how things are invented	2	1.9
how things could be changed for the better	2	1.9
how to think more creatively	2	1.9
learn more about engineering	2	1.9
what engineers do	2	1.9
about design & technology	1	1.0
discover things	1	1.0
how to discuss design	1	1.0
how/why things are made	1	1.0
more about technological approach to science	1	1.0
work in groups	1	1.0

5. Results of final questionnaire

5.1 General comments

The means of the responses from both schools to question 1 to 22 are collected in Table 10. It should be noted that a score of 1 corresponds to 'strongly agree' and a score of 5 to 'strongly disagree'. Thus, scores lower than 3 represent 'positive' responses, and scores less than 3 are 'negative' responses. As with the results from the first questionnaire, correlations between the answers were determined and a cluster diagram obtained (seeFigure 2 on page 47). However, in this case the diagram provides little information of any use.

The first eight questions focused on students' opinions related to Junior Certificate Science. The second set, questions 9 to 16 concern students' experience of JC Technology. Many of these are linked to questions 17 to 26 that focus on D&D. The questions concerning JC Technology were included because in a number of aspects of that course are similar to those in D&D—especially the emphasis on practical activity and project work. Thus it seemed worthwhile to discover if students that had taken the technology course would have different perceptions of D&D from those students that had not experienced JC Technology.

Table 10: Final questionnaire: Means of responses to questions 1 to 26 for both schools[a]

Questions	*Mean*
Section A	
1. I think JC Science was a difficult subject	3.32
2. I think JC Science was more difficult than most other subjects	3.37
3. I think JC Science was an interesting subject	2.00
4. JC Science opened my eyes to the types of jobs and careers available in industry	3.00
5. The things I learnt in JC Science are helpful in my everyday life	2.72
6. The things I learnt in JC Science would be helpful in a career in engineering	2.59
7. JC Science made me want to study a science subject at Leaving Certificate	2.46
8. I think that studying JC Science has helped me in doing the D & D course	2.71
Section B	
9. I think JC Technology was a difficult subject	3.13
10. I think JC Technology was more difficult than most other subjects	3.25
11. I think JC Technology was an interesting subject	2.44
12. JC Technology opened my eyes to the types of jobs and careers available in industry	2.31
13. The things I learnt in JC Technology are helpful in my everyday life	2.56
14. The things I learnt in JC Technology would be helpful in a career in engineering	1.87
15. JC Technology made me want to study a science subject at Leaving Certificate	3.06
16. I think that studying JC Technology has helped me in doing the D & D course	2.06
Section C	
17. I find the D & D course interesting	2.24
18. I think the D & D course is more difficult than most other subjects in Transition Year	3.24
19. The D & D course has opened my eyes to the types of jobs and careers available in industry	2.65
20. The things I am learning about in the D & D course are helpful in my everyday life	2.61
21. The things I am learning about in the D & D course would be helpful in a career in engineering	2.12
22. The D & D course makes me want to study a science subject at Leaving Certificate	3.02
Questions 23 to 26	
23. How does your interest in the D & D course compare with your interest in JC Science?	2.79
24. How does your interest in the D & D course compare with your interest in JC Technology?	2.94
25. How difficult do you find the D & D course compared to JC Science?	3.07
26. How difficult do you find the D & D course compared to JC Technology?	3.44

a. In questions 1 to 22, means of less than 3 indicate that the students were agreeing with the statement; means of more than 3 show that they disagree with the statement.
In questions 23 and 24, scores of less than 3 mean the students found D&D more interesting than JC Science and JC Technology respectively.
In questions 25 and 26 scores of less than 3 show that the students found D&D more difficult than JC Science and JC Technology respectively.

5.2 Questions 1, 2, 3, 8, 17, 18, 23, and 25

The result for questions 1 and 2 show that on the whole students did not find JC Science to be a difficult subject; neither did they think it was more difficult than other JC subjects. In both cases, the means are close to the mid point, indicating that the preference was not very marked. They were more positive in saying that they found JC Science to be an interesting subject (question 3) and they thought that studying JC Science had helped them in their D&D work. The mean of 2.79 in response to question 23 indicates that the students found D&D to be more interesting than JC Science—an encouraging result. This is especially so because the difference is significant even at the 1% level ($p = 0.002$).

The result for question 17 is particularly encouraging, the vast majority found D&D to be interesting (only five students chose to 'disagree' or 'strongly disagree' with the statement). The result fits with the very positive responses given in the interviews (see "Interviews with students" on page 22). Likewise, the result for question 18 shows that the students felt that D&D was not more difficult than their other Transition Year courses.

The result for question 25 shows that they found D&D to be of approximately the same difficulty as JC Science. In fact there is no difference at the 5% level ($p = 0.269$). Whether one finds this result good, bad, or of no consequence will depend on one's expectations; but I think that, on the whole, it is a positive outcome. If D&D were considered to be much more difficult or much easier then it might lead to students becoming demotivated. However, it is noticeable that D&D makes no mathematical demands of the students; also, it does not require students to demonstrate a high level of understanding of the work they do—or, rather, it does not build in a formal test of such understanding in the way commonly used in JC Science. This, together with the emphasis on practical work would lead one to think that students might find D&D easier than JC Science. However, the practical aspects of D&D are almost entirely dealing with applications in the realm of the physical sciences, and it is well known that both boys and girls prefer the biological over the physical sciences. Also, one must take into account that the types of activity that the students were asked to do were usually different from anything they might have met in JC Science; this would tend to enhance the perceived level of difficulty.

5.3 Questions 4 to 8, and 19 to 23

Questions 4 and 19 asked about the link between JC Science or D&D and knowledge of careers in industry. Students agreed (slightly) that D&D had 'opened their eyes to the types of jobs and careers available in industry', and were neutral in respect of JC Science. Given the emphasis placed in parts of D&D on the roles of engineers in industry and wider society, it would appear that this aspect of D&D has only been partially successful. The difference between the means is not significant at the 5% level ($p = 0.051$)

Questions 5 and 20 concerned the link students perceived between JC Science, D&D and everyday life. In both cases, student did perceive such links to exist, with D&D being rather more positive. However, the difference between the means fails to be significant at the 5% level ($p = 0.767$) so one should not claim that D&D is in fact more influential than JC Science.

Responses to questions 6 and 21 show that students thought that both JC Science and D&D would be helpful in a career in engineering. The mean for D&D indicates that students thought that D&D is more helpful in this respect, and the result is significant at the 1% level ($p = 0.003$). This is a positive outcome.

However the mean for question 22 show that D&D had little or no influence on encouraging students to take a science subject at Leaving Certificate. JC Science had more influence in this context (see question 7). The difference between the means is significant at the 5% level ($p = 0.021$). This result is, perhaps, to be expected because the majority of students had in fact made their choice of Leaving Certificate courses before they started D&D. However, perhaps the D&D curriculum should specifically address this issue; i.e. make it clearer to students how choice of Leaving Certificate subjects (especially physics and maths) are linked to future career choices in engineering.

5.4 Questions 9 to 16, 24 and 26

It should be noted that the results that follow apply only to the 16 students that studied JC Technology. (These students also studied JC Science.) See Table 11.

Table 11: Final questionnaire: Number of students that studied JC Science and/or Technology

	St. Wolstan's C. S.		*Lucan C. C.*	
Studied JC Science	20	(100%)	21	(95%)
Did not study JC Science	0	(0%)	1	(5%)
Studied JC Technology	7	(35%)	9	(41%)
Did not study JC Technology	13	(65%)	13	(59%)

The means of questions 9, 10, 11 are very similar to those of the corresponding question about JC Science: students found Technology not to be a difficult subject, not more difficult than other JC subjects and an interesting subject to study. These results confirm the impression that I gained during the interviews: students did not perceive any significant overlap between the two courses, and did not feel that D&D was duplicating previous work. However, there were some comments that were an exception to this general rule.

The result for question 12 (mean 2.31) shows that students did feel that JC Technology had increased their awareness of jobs and careers in industry. The mean for only these students' answers to question 19 was 2.75 (as opposed to 2.65 for all students). This appears to suggest that they thought the D&D course was less effective in this respect. However, the difference is not significant at the 5% level ($p = 0.168$) so one should not claim that the difference exists in reality.

Responses to question 13 indicate that students felt that JC Technology was helpful in everyday life— a result similar to that for JC Science. On comparing the means for questions 13 and 20 for these students alone, no difference was found ($p = 0.633$), thus showing that hey thought Technology and D&D were equally effective in this respect.

The Technology students felt that the course was very helpful for a career in engineering (question 14, mean 1.87). The equivalent question (21) had a mean of 2.31 for these students, with the difference just failing to be significant at the 5% level ($p = 0.069$). However, it would be interesting, and possibly important, to investigate this result further should the occasion arise: does JC Technology really give students a greater impression than does D&D that what they studied would be helpful in a career in engineering? Or is that D&D does not provide these students with any 'added value' in this area?

Students did feel that the Technology course was a help in studying D&D (question 16); they were more positive about this than students were about the usefulness of JC Science.

The means of questions 24 and 26 show that students found the D&D course of (almost) the same interest as, and somewhat easier than JC Technology.

In summary, studying JC Technology has little influence on students' opinions about D&D, with the possible exception of their views on how it relates to careers in engineering.

5.5 Questions 27 and 28

Table 12 summarises the numbers of choices of physics, chemistry and biology made by the students. There were very few students who made changes to their subject choices. However, this patter may partly be a reflection of school administrative procedures: a number of students said that it was too late to change their choices (even if they had wished to make changes). With relatively few students involved it would be unwise to make broad generalisations; but taken with the evidence of the interviews (see later) D&D it is clear that D&D had little influence on the majority of students' choices of LC subjects.

Table 12: Final questionnaire: Totals of responses for questions 27 and 28[a]

Subject	*Before Transition Year*	*Present choice*	
Physics	13	11	4 students opted out, 2 students opted in
Chemistry	14	16	2 students opted out, 4 students opted in
Biology	26	20	6 opted out
None	2	6	

a. There were no choices made for Physics & Chemistry (combined) or Agricultural Science.

5.6 Question 31

This question was also used in the first questionnaire. It was included in order to discover if there would be any difference in the types of responses now that the students had experienced much of the D&D curriculum. The data is summarised in Table 13. Comparison should be made with the entries in Table 5 on page 10. The overall pattern of entries is similar, with the main difference being a greater variety of entries under the 'skills needed' section in the first questionnaire. It seems that experience of D&D has not markedly changed the students' views. However, it should be said that the range, and general accuracy, of the original set of opinions was already impressive.

Table 13: Final questionnaire: Question 31 combined responses from both schools

Category	*Number of responses*	*Percentage of all responses*
What an engineer does at work		
designs machines/things	23	36.5
builds/makes/creates things	13	20.6
fixes/works with machines/things	7	11.1
makes life easier/useful objects	6	9.5
depends on type of engineer	3	4.8
invents things	2	3.2
makes things better/safer	2	3.2
plans things	2	3.2
solves problems	2	3.2
puts things back together	1	1.6
takes things apart/finds out how they work	1	1.6
use maths to solve problems	1	1.6
Kinds of skills needed		
be good at maths	15	18.5
be good at practical work/with hands/manual work	11	13.6
be creative	9	11.1
be good at physics	9	11.1
be logical	7	8.6
use imagination	6	7.4
have patience	5	6.2
be good at design	4	4.9
be good at technical drawing	4	4.9
know about machinery	3	3.7
be good at problem solving	2	2.5
be good at/use science	2	2.5
knowledge (unspecified)	2	2.5
be open-minded	1	1.2
know about computers/electronics	1	1.2

5.7 Question 32

This too was asked in the first questionnaire. The results are presented in Table 14, and should be compared with Table 7 on page 13. As with the previous question, the patterns of entries are very similar. Apart from the decline in number of students choosing teaching as a career, there is little change. Especially, the number of students choosing engineering (in any of its guises) has not increased.

Table 14: Final questionnaire: Question 32 results from both schools

Career	*Number of responses*	*Percentage of all responses*	*Career*	*Number of responses*	*Percentage of all responses*
teacher	5	9.8	engineer	1	2.0
law	4	7.8	fashion	1	2.0
medicine	4	7.8	hair/beauty	1	2.0
nursing	4	7.8	journalism	1	2.0
psychology/psychiatry	4	7.8	lab tech	1	2.0
accountancy	2	3.9	physiotherapy	1	2.0
audio/visual/media/music	2	3.9	science	1	2.0
Gardai	2	3.9	social worker	1	2.0
mechanical engineer	2	3.9	soldier	1	2.0
acting	1	2.0	something practical	1	2.0
architect	1	2.0	using physics/maths	1	2.0
carpenter	1	2.0	speech & language	1	2.0
cars	1	2.0	sport	1	2.0
child care	1	2.0	train driver	1	2.0
civil engineer	1	2.0	veterinary	1	2.0
design (unspecified)	1	2.0			

5.8 Question 33

This question asked for the students' ideas about the subjects that they thought they would need, also appeared in the first questionnaire. It is unclear why there were so few entries made in addition to the choices shown by ticking the boxes. The percentages of English, maths and science have increased slightly over those in the original questionnaire (see Table 8 on page 14); but there is little one can deduce from the results of this question.

Table 15: Final questionnaire: Question 33 results from both schools

Subject	*Number*	*Percentage of all responses*	*Subject*	*Number*	*Percentage*
Science	23	24.7	Accounting	2	2.2
Maths	21	22.6	Engineering	2	2.2
English	19	20.4	Biology	1	1.1
Computers	9	9.7	Irish	1	1.1
Writing	9	9.7	Social Science	1	1.1
Art	4	4.3	Technical Drawing	1	1.1

5.9 Question 34

The results for this question are shown in Table 16 and should be compared with those in Table 9 on page 15. Just as in the previous question, the number of entries was smaller than in the first questionnaire. The only marked change in the nature of the results is the appearance of 'circuits', but as shown in the table, this mainly occurs because of the choices made by the students in St. Wolstan's. This matter is discussed on page 26.

Table 16: Final questionnaire: Question 34 results

	Number of responses: St. Wolstan's	*Number of responses: Lucan C. C.*	*Total*	*Percentage of all responses*
designing things	13	8	21	32.8
about circuits	12	2	14	21.2
make things	3	6	9	14.1
about materials	3	2	5	7.8
how things work	3	1	4	6.3
about designing career	0	2	2	3.1
about engineering	2	0	2	3.1
developing products	0	2	2	3.1
about science	0	1	1	1.6
inventing things	0	1	1	1.6
problem solving	1	0	1	1.6
ways to improve things	0	1	1	1.6
work in a team	1	0	1	1.6

6. Interviews with students

6.1 General comments

Thirty eight students from both schools were interviewed in small groups, of size ranging from two to four students. Interviews lasted between 10 and 20 minutes. On meeting each group the students were told that participation was entirely voluntary, and that there responses would be kept confidential and that none of their comments would be used in a way that could identify the individuals concerned. I also emphasised that I had no immediate interest in the D&D course, that I would like to hear their true opinions and not what they thought I might want to hear. The questions they would be asked were shown to them (see Table 17), and then they were asked if they would agree to the interview being recorded on tape.

In practice, follow-up questions were used to probe further many of the students' responses. Owing to the way that the conversation ebbed and flowed, the order of the question shown in the table was not always followed; but the themes of all of them were covered in all interviews—in short, the interviews were semi-structured in nature. For example, in response to the second question it was often the case that students began to say what they liked about the course; i.e. began answering question 5 unprompted by me.

It was clear that there were differences in the responses between students from the two schools, and in the case of Lucan between the two groups within the same school. Where these differences are relevant they are indicated below. However, it is important to realise that the very fact that such differences arise in this small pilot-project makes it unwise to generalise from individual students' responses without good cause. In effect we are examining their views as the result of an interaction between the students, their teachers and teaching styles, the course content, as well as school administrative structures. It is not sensible to take the students comments as being about the D&D course in isolation or, for example, as it appears in the course

Table 17: Main questions used in the interviews

1. How did you come to take part in the D&D project?
2. What were you told about the course at the start?
3. Has the course you have done turned out like that?
4. Have you enjoyed the course?
5. Which parts did you like?
6. Which parts did you not like?
7. How do you think the course could be improved?
8. Do you think it is equally suited to boys and girls?
9. Has the course influenced your decisions/opinions about choosing engineering or science as a career or future course of study?
10. Have you anything else you would like to say about the course?

handbook. Especially, the students' views show very clearly how vital it is to consider the effectiveness of the course design and materials in the context of Irish schools. However, it will be seen that many students had highly relevant insights that should not be disregarded.

6.2 Questions 1, 2 and 3

Owing to the ways that schools organise their Transition Year programmes, and the fact that the schools were invited to take part in the project after the year had begun, students could not freely opt for the D&D course when they were choosing their options for Transition Year work; rather, they had selected a programme that 'changed its spots'.[1] Their teachers attempted to persuade them (in the main successfully so) that the course would be both interesting and rewarding for them to do. The students' comments showed that nearly all were happy to take part, believing that the course would be very practical and involve a lot of designing and making things—especially they looked forward to building the main project towards the end of the course. The idea that they would not be following a 'normal' school course was also very appealing. However, not everyone was aware of the primary focus of the course:

'I thought it would be about maths and that…'
'I hadn't a clue it was about engineering…'

A number of the Lucan students regarded the D&D as physics because it was timetabled with that title. It was noticeable that these students continually referred to liking (or not) 'the physics' and did not mention any aspect of engineering or the content of the D&D curriculum unless prompted to do so. Typical comments from these students were

'I wouldn't take physics…don't find it interesting really…(this course) hasn't changed my mind';
'I know what physics is about now';
'know more about physics …so it's good';
'well, like, everyone said physics was so hard but it wasn't what I expected…its not easy, but not so hard…'
'definitely doing physics for Leaving Cert.… made me even more keen to do physics…'. (However, this student had 'decided on physics last year' i.e. prior to starting Transition Year and the D&D programme.)

1. One student said 'Intel had chosen us'.

The implication is that the D&D course was viewed as primarily being about physics alone. It is likely that this perspective was influenced by the fact that one of the Lucan classes was taught the D&D course for two-thirds of the weekly timetable allocation to the original Transition Year Physics programme, and one third remained allocated to that curriculum. Very few students from the other class in Lucan, or the class in St. Wolstan's (in both of which all three periods each week were given to D&D), showed this bias.

In mentioning that they started the D&D course after Christmas, there were several students who said that it was a shame that this left them so little time to complete the course—especially the final project:

'problem was (we) didn't have enough time'
'should have started to make our project much earlier'.

The majority of students said that the course was like the descriptions they had been given by their teachers; however, a minority had reservations:

'told we were going to design things but not about all the sheets';
'at the start we were told we could make anything we wanted but now we are told we can't do this or that'

The issue of 'the sheets', i.e. photocopied extracts from the *Facilitator Guide*, was mainly, but not entirely, confined to St. Wolstan's. We shall return to this point, and to others already mentioned, in the sections that follow.

6.3 Questions 4, 5, 6 and 7

The overwhelming number of comments were highly favourable: the great majority of students had enjoyed the course. This was true of students from all three classes. A selection of the positive responses are given below, roughly grouped according to the context in which the comments were given.[1] Even one girl who hadn't enjoyed the course, said she would recommend the course to other students. It is inevitable that some students would not like the course, but they were in a clear minority. See Table 18.

1. In the quotations, an ellipsis (…) is used to represent parts of students' phrases that were irrelevant to the point in hand, or to represent pauses, or where interjections were made other than by the person being quoted.

Table 18: Examples of positive comments made in response to questions 4 and 5

Positive comments relating to practical aspects of D&D
'its a great class…I like the fact that it's a very practical class…it's great to get stuck in and do something for yourself'
'invention aspect—that's good…exploring ideas like he asked us to design structures'
'broken up into teams to get circuits to work…great to get it working…'
'its not like taught to you…you have to think for yourself…'
'it's not just taught off the blackboard or book…easier to learn…using your hands'
'better it was practical… using your hands…able to help one another'
'making the things that work…better than JC Science'
'I knew I wanted to do engineering…(but) this year definitely altered my perception (of engineering)…good practical work, building stuff'
'really interesting to do the practical work, imaginative'
'I found like the wiring part of it very interesting'
'electronics and (the) like was good, flashing light and that'
'really interesting…got to make something…design paper clips'
'invented different types of paper clips…crank shafts…that was good'
'I like the whole engineering aspect of it…making things'
'this has been really interesting…making toys and such'
'(it) was ok—making things'
Other positive comments
'it's helped me to think for myself'
'main things we learnt were constructing things and team work'
'the project got you thinking in new ways'
'much more interesting than I thought it would be…finding out how things work…'
'good to do something new'
'its interesting…deals with a lot of different aspects'
'got to work in groups…with friends'
'how to think for yourself…how things work'
'didn't find anything boring about it'
'makes you think more, do better at this, ways of making it better'
'really opens up your mind…makes you think a lot more…challenging'
Other comments of interest
'you don't find out how hard design is until you try it'
'inventing stuff isn't easy'
'makes you think this is what it is, this is what it could be' ('it' being an unidentified device)
'friends in fifth year doing physics (are) kicking themselves that they didn't get to do this course…'
'definitely a help for doing physics in the Leaving Cert.' (about the electricity/electronics)
Girl who had done Technology at JC: had she learnt more this year? 'yeah a bit…stuff about circuits I only figured out this year'

The critical comments made in response to questions 6 and 7 are given in Table 19. It is evident that the overwhelming majority focused on three or four issues: Also, there were a number of other comments that arose in response to question 10, and grouped in Table 22 on page 31 that are of relevance here.

(i) Work on electric circuits. Students from both schools said they found this confusing at times, and that they found it hard to get the circuits to work on the breadboards. Indeed, breadboards are confusing when one meets them at first, and it is debateable whether they are of any use when working with simple components such as light bulbs. For example, one problem is that connections are hidden from view. Students often have no idea of what path the current is taking. Neither group (to my knowledge) used the boards for prototyping circuits with seven segment display LEDs etc. for which breadboards are essential. However, having said this, it is the case that the students in St. Wolstan's found the electricity section more of a problem than students in Lucan. In part this may reflect the different approaches, and familiarity of the teachers with work in electricity.[1] It may also indicate students' preference to spend a short time only on any one topic—and short in their time scale means one week, or set of three lessons. Some of the comments in the table show that for them, three weeks on one topic can be a very long time!

(ii) Worksheets/handouts. Again, students in St. Wolstan's were more vocal in stating negative opinions about the number and quality of the photocopied pages which they were given. However, students from Lucan also had firm opinions about them. First, there were just too many. My feeling about this reflects comments of some of the students: if all the sheets are really essential, it would be best to have them available in a course booklet that students receive at the start of the course. secondly, the appearance of the sheets does matter, and a number of them that I saw did not photocopy well. What was clear (or relatively so) in the *Facilitator Guide* did not transfer well to black and white. Also, students are now so used to seeing colour in books etc. that the fact that of there being no colour at all is definitely off-putting.

I would agree with the students that the instructions were sometimes unclear if they had to serve as the only resource for them to use. I believe that in the USA project, videos and internet resources were widely available for use during teaching; but this is not the case (and will not be for the foreseeable future) in the great majority of Irish schools. Allowance should be made for this; changes to the sheets may be necessary.

However, I suspect that the way some of the sheets were used (or not used) may have added to the negative perceptions of the students. They could see the clear need for information about specific tasks, building devices etc.; but it is my feeling that they were not convinced of the necessity of being provided with information relating to other matters, such as the careers of individual engineers. However important it might be thought to give students background information, teachers need more guidance on ways to integrate it with the practical part of the course. For the students, it is the practical that draws, and holds, their attention; and because there is so much of it, almost anything else can appear boring by comparison. Also, the context of that information needs to be 'localised' to Ireland; for example, by including exemplars of Irish engineering projects and 'life stories' of Irish women and men in engineering. Several students said, it was a pity that, with Intel so close to them, they did not visit the company as part of the course. Indeed, it would be beneficial if industrial visits were made an integral part

1. Both teachers in Lucan had considerable experience in teaching physics, whereas in St. Wolstan's this was not the case.

of the course. However, owing to the financial repercussions of teachers being away from school, this may prove difficult to implement.

(iii) Timing. It is in the nature of pilot projects to be imperfect, and a number of the problems that the students identified arose because D&D began (relatively) late in the school year. However, of crucial importance is the fact that there was definitely not enough time available to implement the course as it was designed. Teachers had to make decisions about what they could, or could not leave out, and it was inevitable that many important parts had either to be rushed, or omitted entirely.

However, the knock-on effects were considerable. For example, by limiting the electricity work, students did not get experience of using components that they had not already met in JC Science, and they were severely limited in applying such knowledge that they did have to designing their final projects. A number of them indicated that their imaginations went far beyond their capabilities in this respect.

Of course, it would be so much better if they could use motors, LEDs, and buzzers (as indicated in the manual), or even digital components (such as logic gates). However, to do this effectively requires more time than is allowed for in the D&D curriculum. It certainly needs a re-evaluation of the demands made upon teachers (especially non-physicists) and teaching methods when, in a school context, a teacher is faced with a class of (say) 24 students and no additional help (e.g.mentors).

The absence of additional help in the classroom is a huge issue in relation to students designing a final project. Anyone who has experience of guiding youngsters in project work[1] knows that it is one of the most demanding roles that a teacher can take on. It is difficult to guide/assist students to choose a project that they would like to do, *and* one that is likely to be realised successfully. It puts a great responsibility on the teacher, and often one may be working beyond the limits of her/his degree specialism. Further, once projects are underway, the teacher is ‘on call’ to trouble-shoot problems for many students at onc. This is especially so given that when a group’s progress is halted it is the teacher who is called upon to sort the problem out—and one can only work with one group at a time. Such activity puts huge demands upon a teacher’s ability to manage her/his classroom effectively—students easily lose motivation if their difficulties remain unattended for very long.

In short, the issue of whether mentors will be available to help in class is one of the most important to resolve before the scheme widens to include many more schools. So to is the extent, and type, of support that is made available to teachers on an on-going basis.

(iv) Cognitive demands made by D&D. Concern about this issue was expressed by very few students; but it is one that is shared by myself and by some of the teachers. The students in the target age range are approximately 16 years of age, and in nearly all cases they will have completed the JC Science and Maths courses; a number will also have completed the JC Technology course. In all of these respects the target population is significantly different from that in the USA. In my view, D&D does not always sufficiently build upon, and extend the capabilities of the Irish students to understand what they are doing. It also does not take into sufficient account the possible difficulties for both teachers (if not physicists) and taught in explaining their observations, or outcomes of their practical activities, or applying them to new

1. I taught a course called ‘Project Technology’ in school for a number of years that had at its heart students designing, building and testing individual projects.

situations. This is not the place to go into great detail about such matters; but two examples may suffice to illustrate the general points.

First, the introductory work on electric circuits. It appears to be taken for granted that students will know that (in metals) electric current is the ‘flow of electrons’ and what voltage ‘is’. In my experience both notions are a significant source of problems for students, who will (for example) persist in talking of voltage ‘going through’ things. The very idea of a ‘voltage source’ tends to reinforce such a notion. the use of a seven segment LED display is fine, but what are students to make of the table of pin designations that include such terms as ‘Common Cathode’, ‘Anode RHDP’ etc.? What is a teacher expected to say if asked to explain how the seven segment display works? Incidentally, physicists might well quibble at the use of terms such as ‘negative power track’ (What one wonders is ‘negative power’?)

Secondly, the design and build activity for the rolling toy. This is a fun activity, and the manual does link the action of the toy to ideas about potential and kinetic energy. However, the students that I spoke to about this task were far from impressed: they could not see how they could make use of the toy, or apply its principles to another device. In any event, they thought that the toy was not very ‘cool’ for people of their advanced years! I suspect that it might need a person with an engineering background to make the most effective pedagogical use of this activity.

Table 19: Critical comments made in response to questions 6 and 7

Critical comments
(i) about the electricity/electronics module
‘electronics went on too long’
‘we learnt that in third year’
‘series and parallel circuit instructions were confusing’
‘it was kinda hard to understand …you had to put them in different ways…’
‘some things were boring…circuit boards…got very confused…’
‘we found it (electronics) hard to start with…’
‘electronics (was) too long and too simple…circuits often didn’t work’
‘circuit boards were annoying…interesting to find out how they work…but they wouldn’t work properly’
‘just as interesting to make them (the circuits) without the boards’
‘electronics took for ever…three weeks’
‘making circuits …we did that for ages… a good few weeks’
‘circuits dragged on for so many classes’
‘basic electronics…(was) pretty elementary and (we) spent absolutely ages on it…the wind-up toy was fun to make but not very practical’
(ii) about the worksheets
‘(I didn’t like) the sheets and stuff you had to read about’
‘pictures (were) hard to understand’
‘some sheets were useful …(those) with activities on them’
‘sheets were a nightmare…got so many…had to keep them…we read them, if there was a question we had to answer them’
‘the sheets just go on and on’
‘I didn’t like filling in the sheets everyday…’
‘other sheets sometimes interesting, but too many of them…writing is so boring…black and white prints…didn’t want to read it…’
‘(we) need a booklet with all the sheets in’
‘(it would be better) if the language used were structured better…(sometimes the sheet) gives three instructions in one’
‘(the practical sheets were) interesting’, but the ‘crank shaft sheet (was) hard to understand’
‘(they were) kind of repetitive…who use it, how they use it…just takes a lot of time’
‘only one crank shaft worked…(we) couldn’t understand the diagrams’
‘directions for the wind-up toy were kinda hard to understand’
‘some of the instructions were really really hard…no one could figure it out’

6.4 Question 8

This asked about the suitability of D&D for girls and/or boys. Very few of the students could see any gender bias in the course, and the great majority thought it equally suitable for girls and boys. see Table 20.

Table 20: Comments in the context of question 8

About gender issues
'(D&D) appeals to both boys and girls' (this, or similar, was the response from all but a few students)
'some of the designs the girls have come up with are really clever' (said by a boy)
'most of the girls didn't get what it was about…the electrics…(the girls) hadn't got a clue' (comment by a girl)
'(girls in our class) weren't really interested in it' (comment by boy in same class as the girl quoted above)

6.5 Question 9

This question asked students if D&D had influenced their choices of Leaving Certificate subjects or careers. See Table 21. The short answer was, for all but one or two people, 'no'. It has been pointed out earlier that this may partly reflect the fact that students had to make their choices long before D&D was complete. It is also the case that students seem to decide on their future career paths in second or third year; i.e. one or two years before transition year begins. Both these points need to be considered when examining the rationale for running D&D in schools.

Independently of the main focus of this question, some students volunteered answers that raise the issue of where lie the root causes of the low uptake of physics—see the later entries in the table.

Table 21: Comments in relation to question 9

About influencing choice of Leaving Certificate subjects or careers
'I wouldn't mind taking physics, but I've already made my choices'. (This, or very similar said by several students.)
'probably would have thought about (physics) more, considered it…'(if he had done D&D earlier)
'physics is not a subject you would be looking to get points off' (said by a boy explaining why he would not choose physics at LC)
should change the LC course to make it more interactive not just learn out of books
'don't think it has influenced me' (this or very similar comments were made by many students)
I asked a boy who had already chosen engineering as a career: 'when did you decide you wanted to do engineering? Reply: 'in third year'.
'it's so different from any other classes we've had…if I was doing this in second or third year I would definitely have put it on my list (of subjects to do)…the normal course (JC Science) put me off (physics)'
'hasn't put me off physics and engineering, just hasn't made me more enthusiastic'
On why several girls were not going to do LC Physics: 'physics at JC was hardest of the three…(it) put you off'
'I was already interested in physics' (meaning D&D hasn't influenced me in choosing physics)

6.6 Question 10

This was 'catch all' question, and the responses are gathered in Table 22. Nearly all the entries have been discussed earlier, and will not be referred to again.

Table 22: Other comments made in the context of question 10

Critical comments about other issues
'problem was (we) didn't have enough time' (this was a common comment)
'didn't really enjoy it, very simple, not very demanding'
'(I found the course) hard to follow'
'the course was set up for 9 or 12 year olds in America…not suitable for 16 year olds…not challenging enough…more advanced (work) would be better'
'if it were made more challenging it would be better'
'I didn't enjoy it…have absolutely no interest in design or engineering' (said by girl who did JC Technology)
'(they) should give you an idea or area for a project to focus on'
'kind of hard to make something new…think up things'
'(the course) could have been more interesting, could have made our designs a lot earlier'
'I thought it was the most boring thing ever' but the same girl also said 'I'd advise a third year to give it a go'
'change it to (suit) people our age…make it more challenging'
'(it would be) good if Intel would bring us up …show us around'
'very hard to come up with something new, or improve on it'
'we had loads of really good ideas; but we not allowed do them (because we are told) they are too high-tech'
'when we realised we had to make it and sort out the technology it restricted us a lot…we don't have anything high-tech (in our project)'
'not one (project) in our class is electronic…there is no real invention'
'most of the stuff we had already done at JC'
'better if we started earlier even in second year'

7. Appendix A: Details of the results from the initial questionnaire

7.1 Questions 1 to 20

Table A1: Initial Questionnaire: Results for Questions 1 to 20 (combined schools)

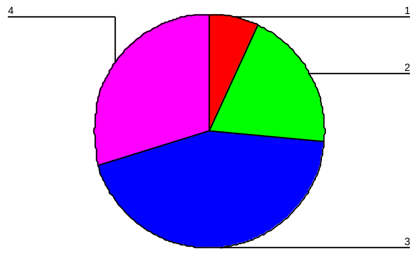
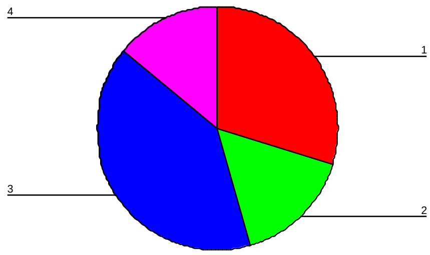
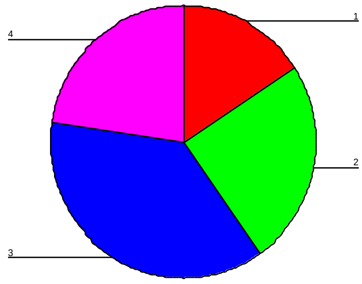
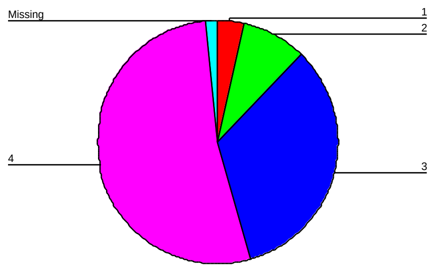
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	
1	4 7.0%	11 19.3%	25 43.9%	17 29.8%	
2	17 29.8%	9 15.8%	23 40.4%	8 14.0%	
3	9 15.8%	14 24.6%	21 36.8%	13 22.8%	
4	2 3.6%	5 8.9%	19 33.9%	30 53.6%	

Table A1: Initial Questionnaire: Results for Questions 1 to 20 (combined schools)

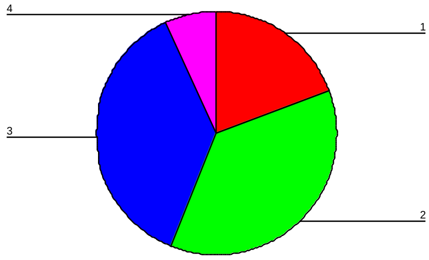
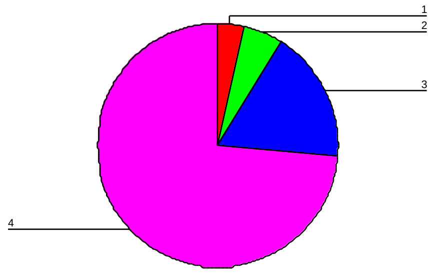
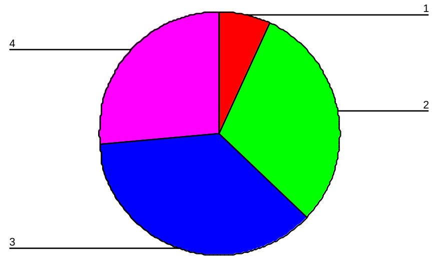
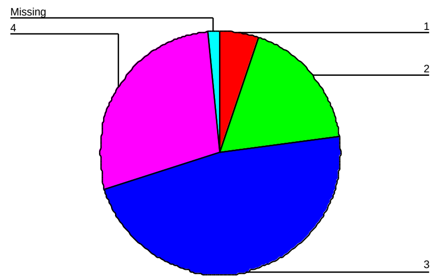
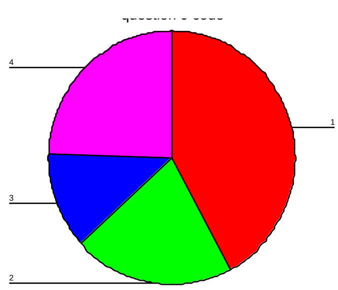
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	
5	11 19.3%	21 36.8%	21 36.8%	4 7.0%	
6	2 3.5%	3 5.3%	10 17.5%	42 73.7%	
7	4 7.0%	17 29.8%	21 36.8%	15 26.3%	
8	3 5.4%	10 17.9%	27 48.2%	16 28.6%	
9	24 42.1%	12 21.1%	7 12.3%	14 24.6%	

Table A1: Initial Questionnaire: Results for Questions 1 to 20 (combined schools)

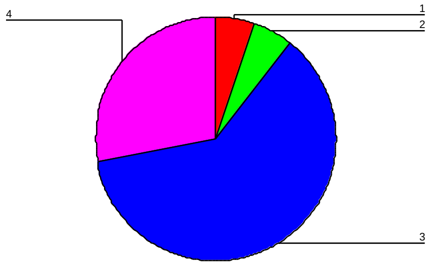
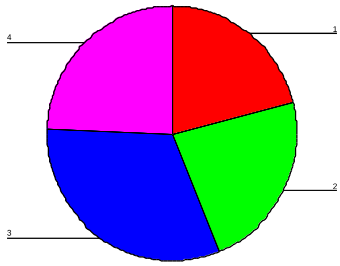
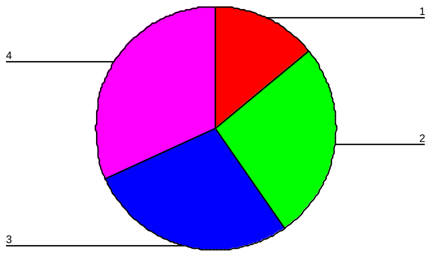
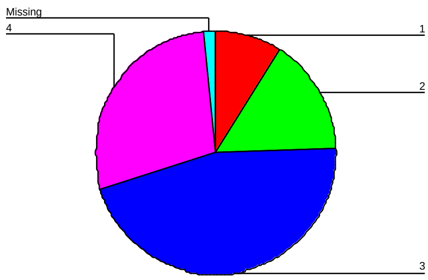
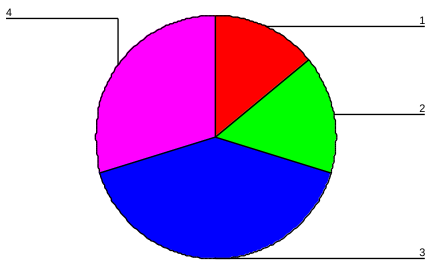
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	
10	3 5.3%	3 5.3%	35 61.4%	16 28.1%	
11	12 21.1%	13 22.8%	18 31.6%	14 24.6%	
12	8 14.0%	15 26.3%	16 28.1%	18 31.6%	
13	5 8.9%	9 16.1%	26 46.4%	16 28.6%	
14	8 14.0%	9 15.8%	23 40.4%	17 29.8%	

Table A1: Initial Questionnaire: Results for Questions 1 to 20 (combined schools)

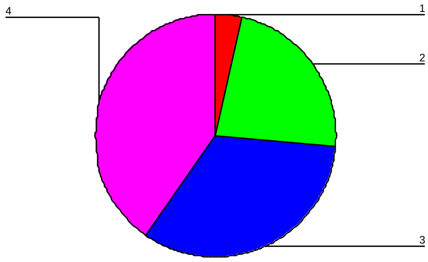
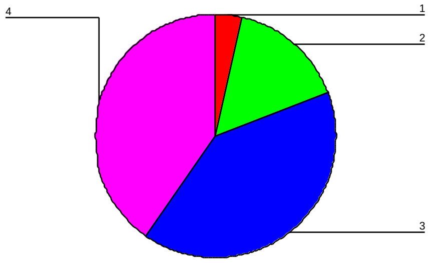
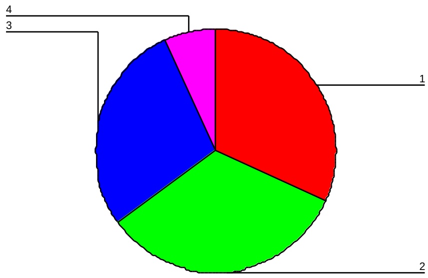
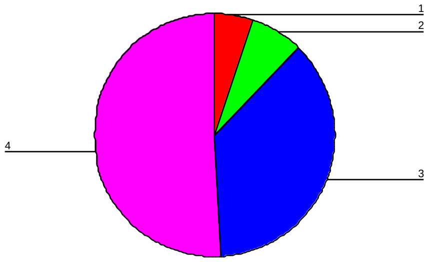
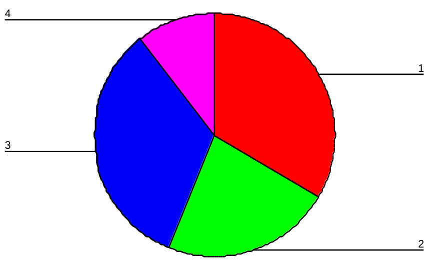
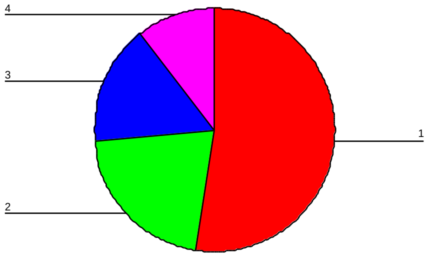
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	
15	2 3.5%	13 22.8%	19 33.3%	23 40.4%	
16	2 3.5%	9 15.8%	23 40.4%	23 40.4%	
17	18 31.6%	19 33.3%	16 28.1%	4 7.0%	
18	3 5.3%	4 7.0%	21 36.8%	29 50.9%	
19	19 33.3%	13 22.8%	19 33.3%	6 10.5%	

Table A1: Initial Questionnaire: Results for Questions 1 to 20 (combined schools)

Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	
20	30 52.6%	12 21.1%	9 15.8%	6 10.5%	

7.2 Cluster diagram for responses to first questionnaire

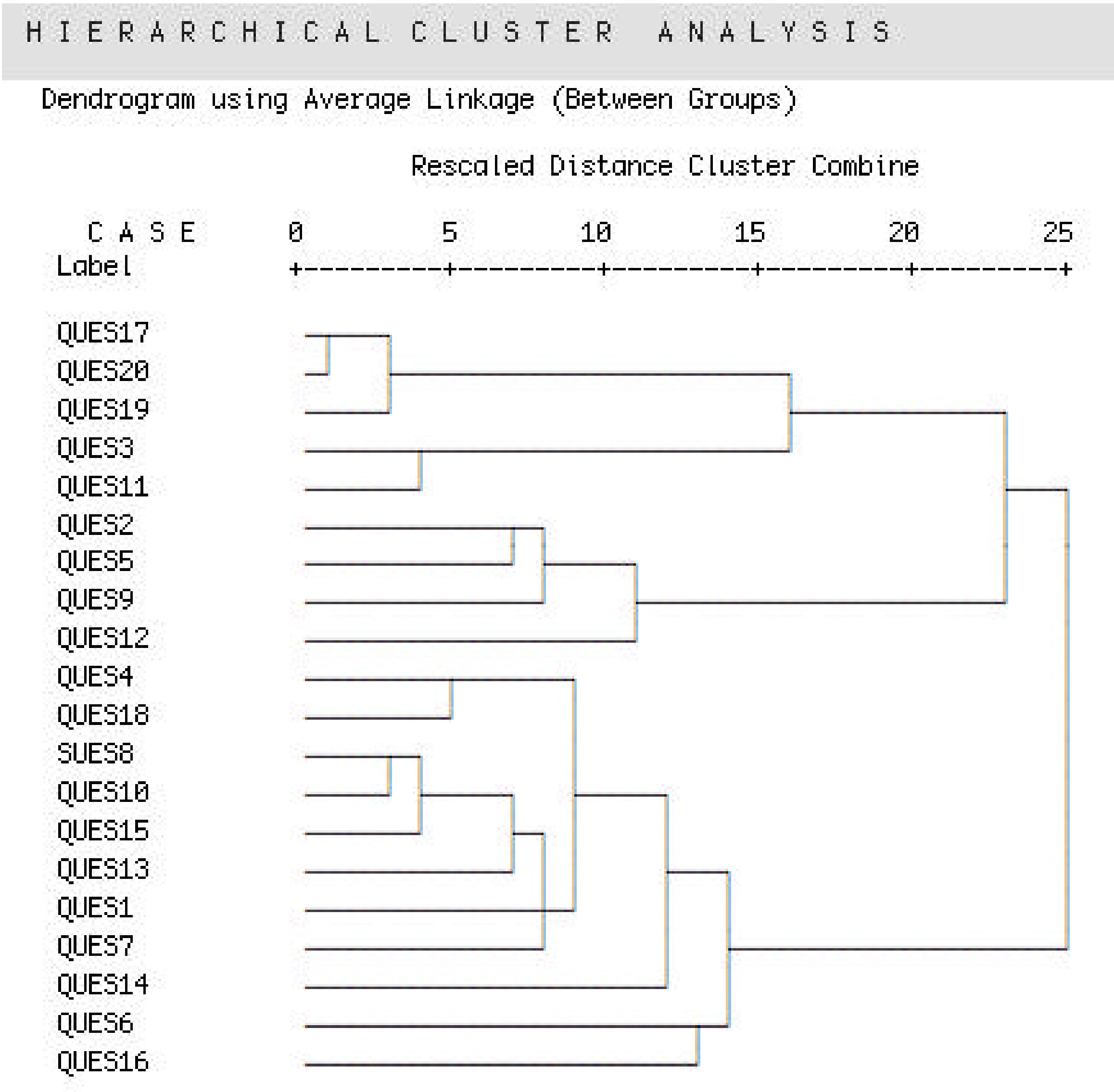


Figure 1: Cluster analysis diagram for questions 1 to 20

8. Appendix B: Details of the results from the final questionnaire

8.1 Questions 1 to 26

Table B1: Final questionnaire: Results for questions 1 to 26[a] (combined schools)

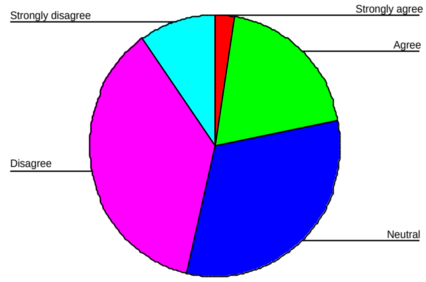
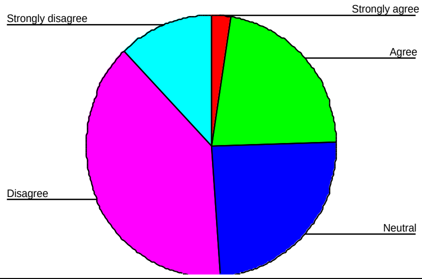
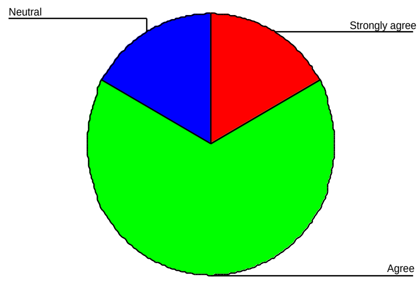
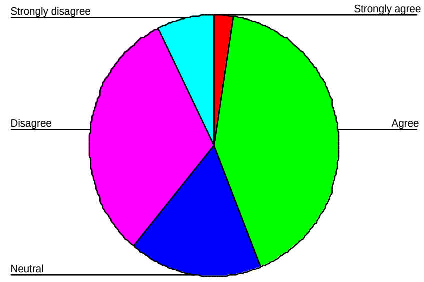
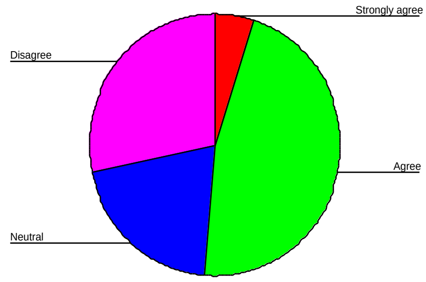
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	*Choice 5*	
1	1 2.4%	8 19.5%	13 31.7%	15 36.6%	4 9.8%	
2	1 2.4%	9 22.0%	10 24.4%	16 39.0%	5 12.2%	
3	7 17.1%	27 65.9%	7 17.1%	0 0%	0 0%	
4	1 2.4%	17 41.5%	7 17.1%	13 31.7%	3 7.3%	
5	2 5.1%	18 46.2%	8 20.5%	11 28.2%	0 0%	

Table B1: Final questionnaire: Results for questions 1 to 26[a] (combined schools)

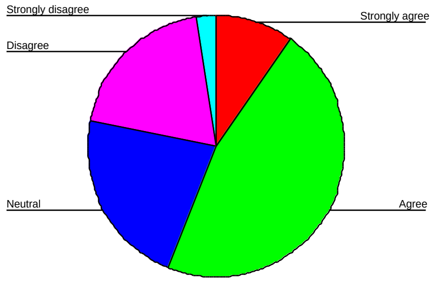
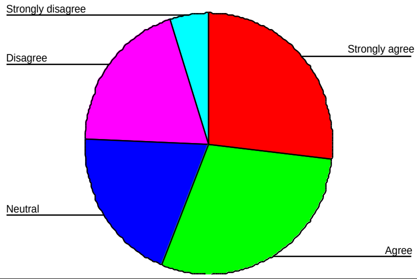
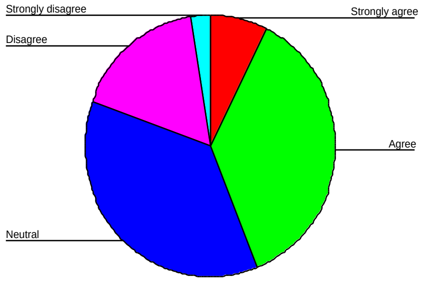
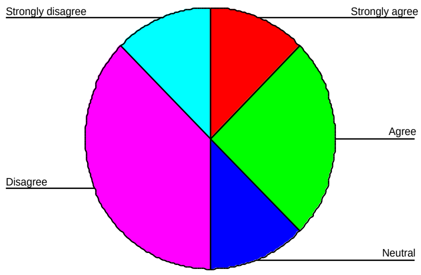
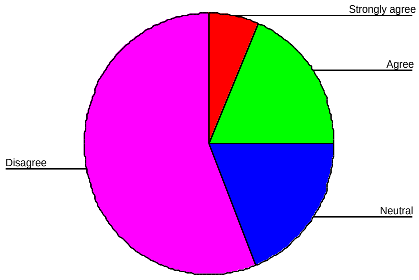
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	*Choice 5*	
6	4 9.8%	19 46.3%	9 22.0%	8 19.5%	1 2.4%	
7	11 26.8%	12 29.3%	8 19.5%	8 19.5%	2 4.9%	
8	3 7.3%	15 36.6%	15 36.6%	7 17.1%	1 2.4%	
9	2 12.5%	4 25.0%	2 12.5%	6 37.5%	2 12.5%	
10	1 6.3%	3 18.8%	3 18.8%	9 56.3%	0 0%	

Table B1: Final questionnaire: Results for questions 1 to 26[a] (combined schools)

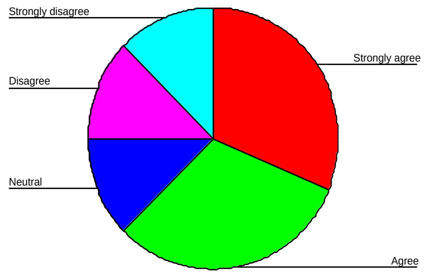
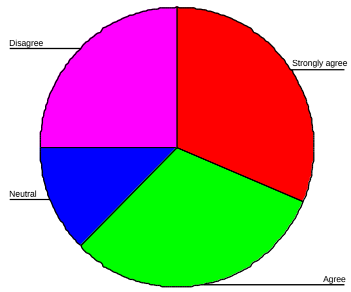
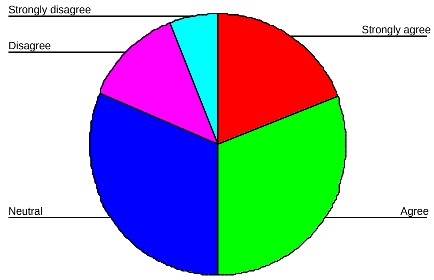
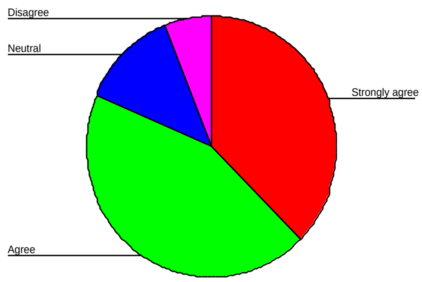
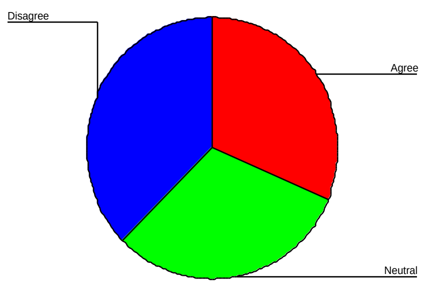
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	*Choice 5*	
11	5 31.3%	5 31.3%	2 12.5%	2 12.5%	2 12.5%	
12	5 31.3%	5 31.3%	2 12.5%	4 25.0%	0 0%	
13	3 18.8%	5 31.3%	5 31.3%	2 12.5%	1 6.3%	
14	6 37.5%	7 43.8%	2 12.5%	1 6.3%	0 0%	
15	0 0%	5 31.3%	5 31.3%	6 37.5%	0 0%	

Table B1: Final questionnaire: Results for questions 1 to 26[a] (combined schools)

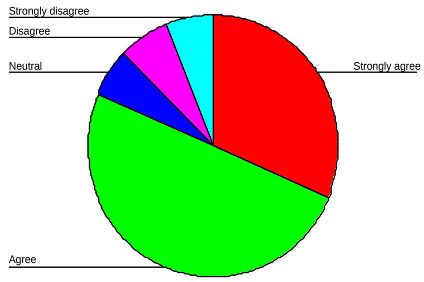
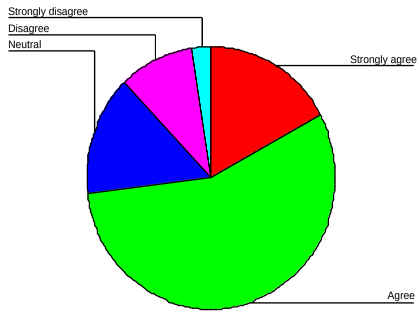
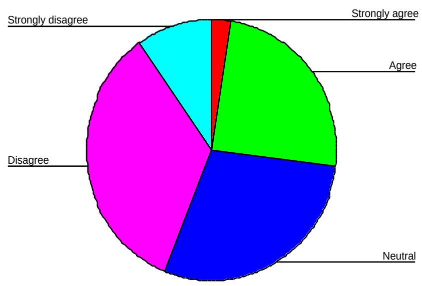
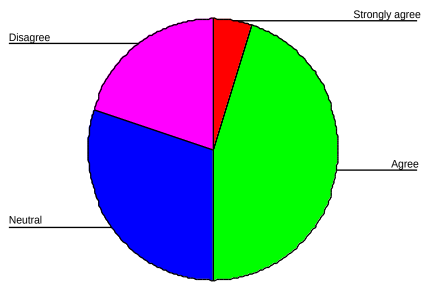
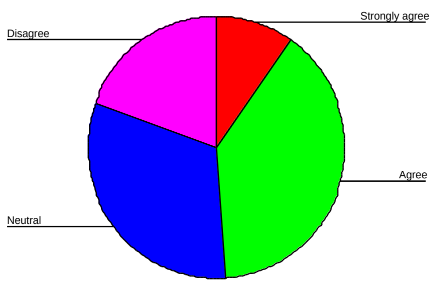
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	*Choice 5*	
16	5 31.3%	8 50.0%	1 6.3%	1 6.3%	1 6.3%	
17	7 17.1%	23 56.1%	6 14.6%	4 9.8%	1 2.4%	
18	1 2.4%	10 24.4%	12 29.3%	14 34.1%	4 9.8%	
19	2 5.0%	18 45.0%	12 30.0%	8 20.0%	0 0%	
20	4 9.8%	16 39.0%	13 31.7%	8 19.5%	0 0%	

Table B1: Final questionnaire: Results for questions 1 to 26[a] (combined schools)

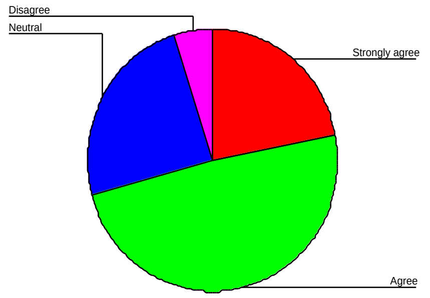
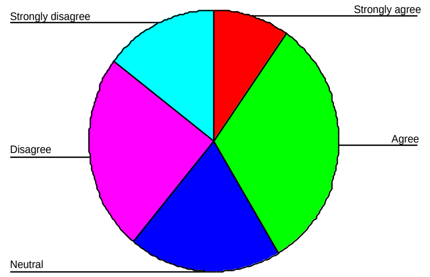
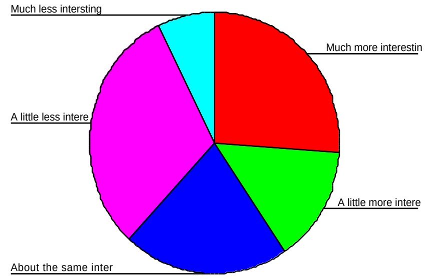
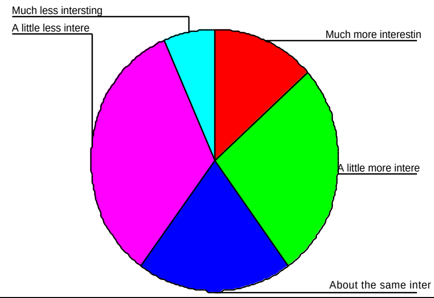
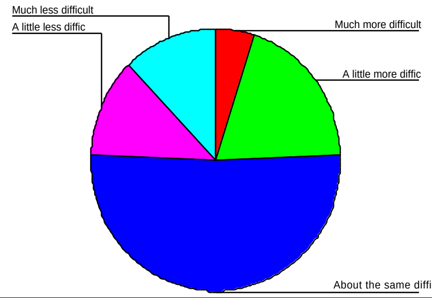
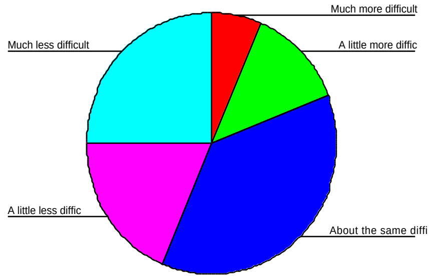
Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	*Choice 5*	
21	9 22.0%	20 48.8%	10 24.4%	2 4.9%	0 0%	
22	4 9.8%	13 31.7%	8 19.5%	10 24.4%	6 14.6%	
23	11 26.2%	6 14.3%	9 21.4%	13 31.0%	3 7.1%	
24	2 13.3%	4 26.7%	3 20.0%	5 33.3%	1 6.7%	
25	2 4.9%	8 19.5%	21 51.2%	5 12.2%	5 12.2%	

Table B1: Final questionnaire: Results for questions 1 to 26[a] (combined schools)

Question	*Choice 1*	*Choice 2*	*Choice 3*	*Choice 4*	*Choice 5*
26	1 6.3%	2 12.5%	6 37.5%	3 18.8%	4 25.0%



a.Questions 1 to 8: n = 42; questions 9 to 16, & 26: n = 16; questions 17 to 23, & 25: n = 42; question 24, n = 15. Invalid entries have been excluded from calculations of percentages.

8.2 Analyses of results of final questionnaire by school

Table B2: Final questionnaire: Means of responses to questions 1 to 8 by school[a]

Question	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Agree or disagree*[b]	*Question*	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Agree or disagree*
1	1	3.55	–	5	1	2.80	+
	2	3.10	–		2	2.63	+
2	1	3.75	–	6	1	2.65	+
	2	3.00			2	2.52	+
3	1	1.90	+	7	1	2.35	+
	2	2.10	+		2	2.57	+
4	1	3.15	–	8	1	2.85	+
	2	2.86	+		2	2.57	+

a. St Wolstan's C. S., 20 students; Lucan C. C., 21 students.
b. Compared to the expected mean of 3.0, "+" means students tended to agree rather than disagree with the statement (and vice versa for "–").

Table B3: Means of responses to questions 9 to 16 by school[a]

Question	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Agree or disagree[b]*	*Question*	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Agree or disagree*
9	1	3.14	–	13	1	2.86	+
	2	3.11	–		2	2.33	+
10	1	3.57	–	14	1	2.00	+
	2	3.00			2	1.78	+
11	1	2.29	+	15	1	3.29	–
	2	2.56	+		2	2.89	+
12	1	2.71	–	16	1	1.71	+
	2	2.00	+		2	2.33	+

a. St Wolstan's C. S., 7 students; Lucan C. C., 9 students.

b. Compared to the expected mean of 3.0, "+" means students tended to agree rather than disagree with the statement (and vice versa for "–").

Table B4: Final questionnaire: Means of responses to questions 17 to 22 by school[a]

Question	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Agree or disagree[b]*	*Question*	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*Agree or disagree*
17	1	2.60	+	20	1	2.90	+
	2	1.90	+		2	2.33	+
18	1	3.55	–	21	1	2.15	+
	2	2.95	+		2	2.10	+
19	1	3.05	–	22	1	3.50	–
	2	2.29	+		2	2.57	+

a. St Wolstan's C. S., 20 students; Lucan C. C., 21 students.

b. Compared to the expected mean of 3.0, "+" means students tended to tended to agree rather than disagree with the statement (and vice versa for "–").

Table B5: Final questionnaire: Means of responses to questions 23 and 24 by school

Question	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*More interesting, or not*[a]	*Question*	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*More interesting, or not*
23[b]	1	3.35	–	24[c]	1	3.57	–
	2	2.27	+		2	2.38	+

a. Compared to the expected mean of 3.0, "+" means students tended to tended to find D&D more interesting than JC Science for question 23, and more interesting than JC Technology for question 24 (and *vice versa* for "–").

b. Question 23. St. Wolstan's C. S., 20 students; Lucan C. C., 22 students.

c. Question 24. St. Wolstan's C. S., 7 students; Lucan C. C., 8 students.

Table B6: Final questionnaire: Means of responses to questions 25 and 26 by school

Question	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*More difficult, or not*[a]	*Question*	*Code* 1=St Wolstan's 2= Lucan	*Mean*	*More difficult, or not*
25[b]	1	3.40	–	26[c]	1	4.00	–
	2	2.76	+		2	3.00	

a. Compared to the expected mean of 3.0, "–" means students tended to tended to find D&D less difficult than JC Science for question 25, and less difficult than JC Technology for question 26 (and *vice versa* for "+")

b. Question 25. St. Wolstan's C. S., 20 students; Lucan C. C., 21 students.

c. Question 26. St. Wolstan's C. S., 7 students; Lucan C. C., 9 students.

Table B7: Final questionnaire: Question 32 responses from both schools

Career	*St Wolstan's C. S.*	*Lucan C. C.*	*Total*	*Percentage of all responses*
teacher	3	2	5	9.8
law	4	0	4	7.8
medicine	4	0	4	7.8
nursing	3	1	4	7.8
psychology/psychiatry	3	1	4	7.8
accountancy	1	1	2	3.9
audio/visual/media/music	2	0	2	3.9
Gardai	1	1	2	3.9
mechanical engineer	0	2	2	3.9
acting	1	0	1	2.0
architect	0	1	1	2.0
carpenter	0	1	1	2.0
cars	0	1	1	2.0
child care	1	0	1	2.0
civil engineer	0	1	1	2.0
design (unspecified)	1	0	1	2.0
engineer	0	1	1	2.0
fashion	1	0	1	2.0
hair/beauty	0	1	1	2.0
journalism	1	0	1	2.0
lab tech	1	0	1	2.0
physiotherapy	1	0	1	2.0
science	1	0	1	2.0
social worker	1	0	1	2.0
soldier	0	1	1	2.0
something practical	0	1	1	2.0
something with physics/maths	1	0	1	2.0
speech & language	1	0	1	2.0
sport	0	1	1	2.0
train driver	0	1	1	2.0
veterinary	0	1	1	2.0

Note: only responses to the following questions showed a significant difference between the schools at the 5% level:
2 (p = 0.019); 17 (p = 0.016); 19 (p = 0.004); 20 (p = 0.047); 22 (p = 0.016); 23 (p = 0.042).

.

8.3 Cluster diagram for responses to final questionnaire

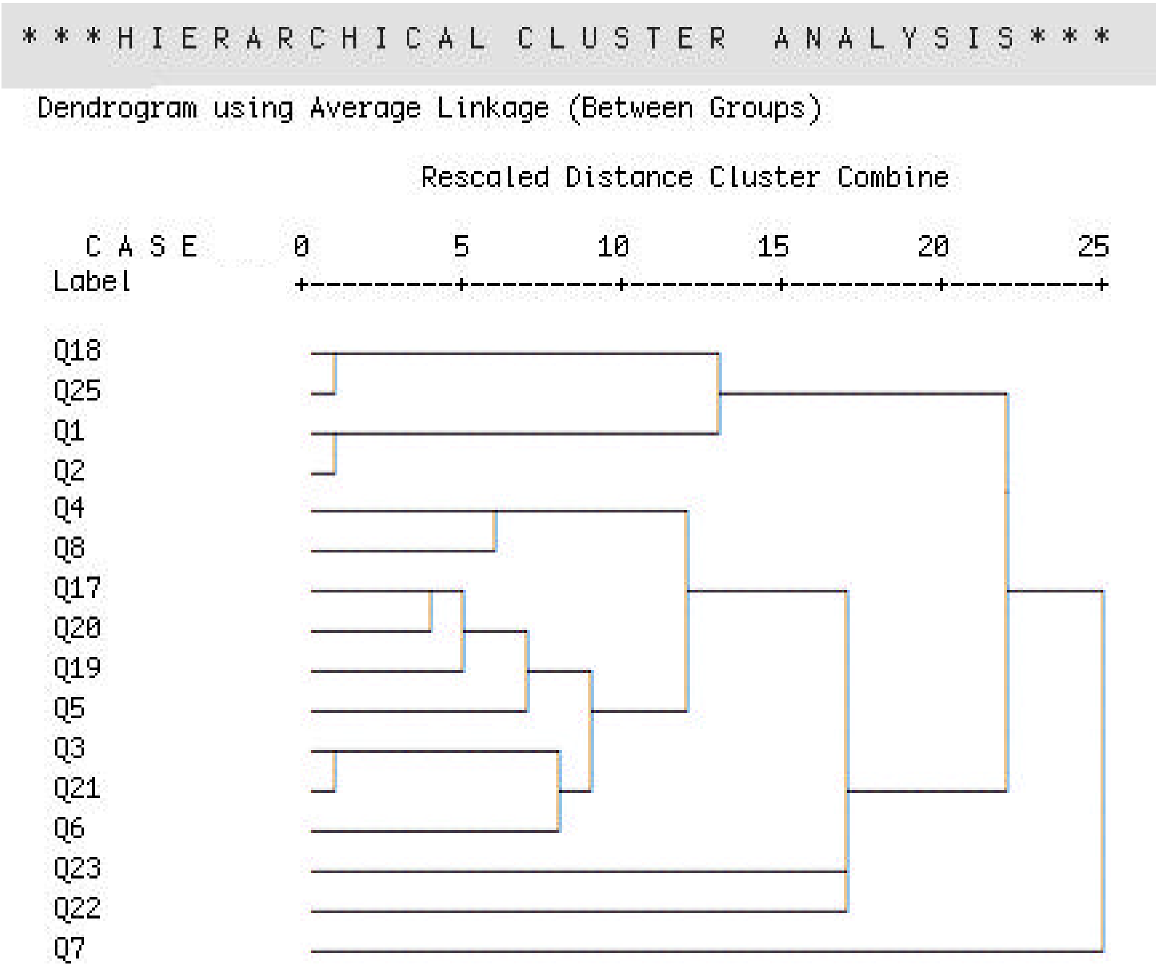


Figure 2: Cluster analysis diagram for questions 1 to 8, 17 to 23, and 25

9. Appendix C: Copy of initial questionnaire

Design and Discovery Pre-Survey

Please answer the questions below honestly There are no right or wrong answers. Your survey will be kept confidential. Select the number indicating your level of agreement with the statements. Thank you for sharing your thoughts.

	Disagree	Disagree a little	Agree a little	Agree
1. I like taking things apart and putting them back together again.	1	2	3	4
2. I am interested in my maths class.	1	2	3	4
3. I am good at designing things.	1	2	3	4
4 I like to know how things work.	1	2	3	4
5. I enjoy doing projects in school that involve maths and science.	1	2	3	4
6. I often think about what I want to do after I graduate from school.	1	2	3	4
7. I know what an engineer does.	1	2	3	4
8. I am good at solving problems.	1	2	3	4
9. I would like a career that requires a maths or science background.	1	2	3	4
10.I can explain my ideas to someone else so they can understand them.	1	2	3	4
11.I would like a career that involves designing things.	1	2	3	4
12. It is important for me to be good at science.	1	2	3	4
13. Creative thinking is one of my strengths.	1	2	3	4
14. I try to think of different ways to solve a problem before deciding on a solution.	1	2	3	4
15. I like to find out things on my own.	1	2	3	4
16. I like working with a team to create things or solve problems.	1	2	3	4
17. I could be a successful engineer.	1	2	3	4
18. I try to solve problems first before asking for help.	1	2	3	4
19. I consider myself mechanically inclined.	1	2	3	4
20. I am interested in pursuing a career in engineering.	1	2	3	4

Design and Discovery Pre-Survey (continued)

21. Describe what you think an engineer does at work. What kinds of skills are needed to become an engineer?

____

____

____

22. Name some things that have been created by an engineer?

____

____

23. What type of career are you interested in?

____

24. The courses/skills that you most need for your career choice are (check all that apply):

art ☐ computers ☐ English ☐ maths ☐ science ☐ writing ☐

other (what?____)

26. What types of things do you think you will learn while participating in this program?

____

____

First two letters of your:

___ ___	___ ___	___ ___ ___
first name*	last name*	Date of birth*

Thank you for your time and thoughts.

**This information will allow us to follow your responses over time.*
We will summarize all data, however, and no one will be identified.

10. Appendix D: Copy of final questionnaire

INTEL DESIGN & DISCOVERY QUESTIONNAIRE (Name of School)

This questionnaire asks you for your opinions and ideas about the work you have been doing in this project during Transition Year, and your plans for study and work in future years. It would be a help to us if you would put your name at the top of this page. That will allow us to ask you about your ideas in more detail later on. However, if you want to remain anonymous, you can leave your name out.

Summaries of the answers from your group will be given to your teacher and the project leaders at INTEL. However, I assure you that the way that the information is presented *will not* allow them to identify you with your particular answers. We hope that your answers will be useful in improving the course for students in the future.

Thank you for your help.

Instructions

In most of the questions you should tick one of the boxes that best fits your opinion. Please be careful not to tick more than one box unless the question makes it clear that you should do so. In some of the questions, the name Design and Discovery is shown as 'D & D'.

Questions

Section A. Did you study Junior Certificate Science? Yes ☐ No ☐

If you answered 'Yes' please answer questions 1 to 8

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
1. I think JC Science was a difficult subject	☐	☐	☐	☐	☐
2. I think JC Science was more difficult than most other subjects	☐	☐	☐	☐	☐
3. I think JC Science was an interesting subject	☐	☐	☐	☐	☐
4. JC Science opened my eyes to the types of jobs and careers available in industry	☐	☐	☐	☐	☐
5. The things I learnt in JC Science are helpful in my everyday life	☐	☐	☐	☐	☐
6. The things I learnt in JC Science would be helpful in a career in engineering	☐	☐	☐	☐	☐
7. JC Science made me want to study a science subject at Leaving Certificate	☐	☐	☐	☐	☐
8. I think that studying JC Science has helped me in doing the D & D course	☐	☐	☐	☐	☐

Section B. Did you study Junior Certificate Technology? Yes ☐ No ☐

If you answered 'Yes' please answer questions 9 to 16

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
9. I think JC Technology was a difficult subject	☐	☐	☐	☐	☐
10. I think JC Technology was more difficult than most other subjects	☐	☐	☐	☐	☐
11. I think JC Technology was an interesting subject	☐	☐	☐	☐	☐
12. JC Technology opened my eyes to the types of jobs and careers available in industry	☐	☐	☐	☐	☐
13. The things I learnt in JC Technology are helpful in my everyday life	☐	☐	☐	☐	☐
14. The things I learnt in JC Technology would be helpful in a career in engineering	☐	☐	☐	☐	☐
15. JC Technology made me want to study a science subject at Leaving Certificate	☐	☐	☐	☐	☐
16. I think that studying JC Technology has helped me in doing the D & D course	☐	☐	☐	☐	☐

Section C. These questions are about the Design & Discovery course that you are doing at present

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
17. I find the D & D course interesting	☐	☐	☐	☐	☐
18. I think the D & D course is more difficult than most other subjects in Transition Year	☐	☐	☐	☐	☐
19. The D & D course has opened my eyes to the types of jobs and careers available in industry	☐	☐	☐	☐	☐
20. The things I am learning about in the D & D course are helpful in my everyday life	☐	☐	☐	☐	☐
21. The things I am learning about in the D & D course would be helpful in a career in engineering	☐	☐	☐	☐	☐
22. The D & D course makes me want to study a science subject at Leaving Certificate	☐	☐	☐	☐	☐

How does your interest in the D & D course compare with:	*The Design and Discovery course is:* *Much more interesting*	*A little more interesting*	*About the same interest*	*A little less interesting*	*Much less interesting*
23. your interest in JC Science?[a]	☐	☐	☐	☐	☐
24. your interest in JC Technology?[b]	☐	☐	☐	☐	☐

How difficult do you find the D & D course compared to:	*The Design and Discovery course is:* *Much more difficult*	*A little more difficult*	*About the same difficulty*	*A little less difficult*	*Much less difficult*
25. JC Science[a]	☐	☐	☐	☐	☐
26. JC Technology[b]	☐	☐	☐	☐	☐

a. Leave this blank if you did not study JC Science.
b. Leave this blank if you did not study JC Technology.

	Physics	*Chemistry*	*Biology*	*Physics & Chemistry (combined course)*	*Agricul-tural Science*	*None*
27. Before you started Transition Year, which science subjects did you think you would study for Leaving Certificate?	☐	☐	☐	☐	☐	☐
28. Now that you are over half-way through Transition Year, which science subjects do you think you will study for Leaving Certificate?	☐	☐	☐	☐	☐	☐

29. Has your experience of the Design and Discovery course influenced your choice of science subjects to take at Leaving Certificate? Yes ☐ No ☐

If you answered 'Yes', please write down your reasons below.

____

____

____

____

30. If you were able to do so, would you like to study Engineering at university? Yes ☐ No ☐ Not sure ☐

Section D. In this section you will find that some questions were part of the questionnaire that you filled in at the start of the course. By asking you the same questions now, we can compare your answers with those you gave before and see if you have changed your mind.

31. Describe what you think an engineer does at work.

What kinds of skills are needed to become an engineer?

32. What type of career are you interested in?

33. The courses/skills that you most need for your career choice are (check all that apply):

art ☐ computers ☐ English ☐ maths ☐ science ☐ writing ☐

Other, please state:

34. What do you think you have learnt while participating in this program? (You might write down some important ideas, e.g. about designing things in general, or specific things about electric circuits etc.)

Name ____

INTEL DESIGN & DISCOVERY QUESTIONNAIRE
St Wolstan's Community School

This questionnaire asks you for your opinions and ideas about the work you have been doing in this project during Transition Year, and your plans for study and work in future years. It would be a help to us if you would put your name at the top of this page. That will allow us to ask you about your ideas in more detail later on. However, if you want to remain anonymous, you can leave your name out.

Summaries of the answers from your group will be given to your teacher and the project leaders at INTEL. However, I assure you that the way that the information is presented *will not* allow them to identify you with your particular answers. We hope that your answers will be useful in improving the course for students in the future.

Thank you for your help.

Instructions

In most of the questions you should tick one of the boxes that best fits your opinion. Please be careful not to tick more than one box unless the question makes it clear that you should do so. In some of the questions, the name Design and Discovery is shown as 'D & D'.

Questions

Section A. Did you study Junior Certificate Science? Yes ☐ No ☐

If you answered 'Yes' please answer questions 1 to 8

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
1. I think JC Science was a difficult subject	☐	☐	☐	☐	☐
2. I think JC Science was more difficult than most other subjects	☐	☐	☐	☐	☐
3. I think JC Science was an interesting subject	☐	☐	☐	☐	☐
4. JC Science opened my eyes to the types of jobs and careers available in industry	☐	☐	☐	☐	☐
5. The things I learnt in JC Science are helpful in my everyday life	☐	☐	☐	☐	☐
6. The things I learnt in JC Science would be helpful in a career in engineering	☐	☐	☐	☐	☐
7. JC Science made me want to study a science subject at Leaving Certificate	☐	☐	☐	☐	☐
8. I think that studying JC Science has helped me in doing the D & D course	☐	☐	☐	☐	☐

Section B. Did you study Junior Certificate Technology? Yes ☐ No ☐

If you answered 'Yes' please answer questions 9 to 16

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
9. I think JC Technology was a difficult subject	☐	☐	☐	☐	☐
10. I think JC Technology was more difficult than most other subjects	☐	☐	☐	☐	☐
11. I think JC Technology was an interesting subject	☐	☐	☐	☐	☐
12. JC Technology opened my eyes to the types of jobs and careers available in industry	☐	☐	☐	☐	☐
13. The things I learnt in JC Technology are helpful in my everyday life	☐	☐	☐	☐	☐
14. The things I learnt in JC Technology would be helpful in a career in engineering	☐	☐	☐	☐	☐
15. JC Technology made me want to study a science subject at Leaving Certificate	☐	☐	☐	☐	☐
16. I think that studying JC Technology has helped me in doing the D & D course	☐	☐	☐	☐	☐

Section C. These questions are about the Design & Discovery course that you are doing at present

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
17. I find the D & D course interesting	☐	☐	☐	☐	☐
18. I think the D & D course is more difficult than most other subjects in Transition Year	☐	☐	☐	☐	☐
19. The D & D course has opened my eyes to the types of jobs and careers available in industry	☐	☐	☐	☐	☐
20. The things I am learning about in the D & D course are helpful in my everyday life	☐	☐	☐	☐	☐
21. The things I am learning about in the D & D course would be helpful in a career in engineering	☐	☐	☐	☐	☐
22. The D & D course makes me want to study a science subject at Leaving Certificate	☐	☐	☐	☐	☐

How does your interest in the D & D course compare with:	*The Design and Discovery course is:* *Much more interesting*	*A little more interesting*	*About the same interest*	*A little less interesting*	*Much less interesting*
23. your interest in JC Science?[a]					
24. your interest in JC Technology?[b]					

How difficult do you find the D & D course compared to:	*The Design and Discovery course is:* *Much more difficult*	*A little more difficult*	*About the same difficulty*	*A little less difficult*	*Much less difficult*
25. JC Science[a]					
26. JC Technology[b]					

a. Leave this blank if you did not study JC Science.
b. Leave this blank if you did not study JC Technology.

	Physics	*Chemistry*	*Biology*	*Physics & Chemistry (combined course)*	*Agricul-tural Science*	*None*
27. Before you started Transition Year, which science subjects did you think you would study for Leaving Certificate?						
28. Now that you are over half-way through Transition Year, which science subjects do you think you will study for Leaving Certificate?						

29. Has your experience of the Design and Discovery course influenced your choice of science subjects to take at Leaving Certificate? Yes ☐ No ☐

If you answered 'Yes', please write down your reasons below.

30. If you were able to do so, would you like to study Engineering at university? Yes ☐ No ☐ Not sure ☐

Section D. In this section you will find questions that you have seen before: they were part of the questionnaire that you filled in at the start of the course. By asking you the same questions now, we can compare your answers with those you gave before and see if you have changed your mind.

31. Describe what you think an engineer does at work. What kinds of skills are needed to become an engineer?

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32. Name some things that have been created by an engineer.

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33. What type of career are you interested in?

____

34. The courses/skills that you most need for your career choice are (check all that apply):

art ☐ computers ☐ English ☐ maths ☐ science ☐ writing ☐

35. What do you think you have learnt while participating in this program? (You might write down some important ideas, e.g. about designing things in general, or specific things about electric circuits etc.)

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