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AUTHOR	Heywood, John; And Others
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ABSTRACT

This monographic series volume contains two separate monographs. "The Training of Student Teachers in Discovery Methods of Instruction and Learning," (John Heywood, Sarah Heywood) discusses the polarization of discovery learning and expository teaching. It describes a unit in the applied psychology of instruction, commonly known as "the student teacher as researcher programme," which is included in a secondary teacher education course at an Irish university. Students compared two methods of teaching, expository and guided discovery or discovery, utilizing experimental methods. The evidence indicates that, while guided discovery and discovery techniques produce no better pupil test results than expository methods, they do create a better learning environment, one that is more conducive to pupil motivation. Difficulties encountered by student teachers implementing discovery techniques included devising assessment procedures and confusion and reluctance on the part of pupils. The report includes statistical breakdowns on the results of student teachers' experiments and examples of their lesson plans. "Comparing Guided Discovery and Expository Methods: Teaching the Water Cycle in Geography," (Iain Donovan) involved teaching the same geography topic, the water cycle, to two secondary classes of approximately equal ability, using guided discovery learning for one class and expository teaching for the other. Each class was given the same test after the relevant lesson to ascertain which learning strategy was more effective in achieving the common objectives. Findings indicated that low ability students benefited more from the expository lesson whereas, to a less significant degree, high ability pupils benefited more from the guided discovery lesson. The results both confirm and contradict the findings of previous research on guided discovery and expository teaching strategies, both of which are discussed. (IAH)

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The Training of Student-Teachers in Discovery Methods of Instruction and Learning

by

John Heywood

Sarah Heywood

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Comparing Guided Discovery and Expository Methods: Teaching the Water Cycle in Geography

by

Iain Donovan
(Higher Diploma Student 1991-1992)

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S. Heywood, Department of Psychology, University of Leeds, U.K.

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The Training of Student-Teachers in Discovery Methods of Instruction and Learning

by

John Heywood
Department of Teacher Education
The University of Dublin, Trinity College
Ireland

Sarah Heywood
Department of Psychology
University of Leeds, U.K.

Research in Teacher Education Monograph Series No. 1/92. Department of Teacher Education, University of Dublin, Dublin 2, Ireland.

Introduction:

Education, because of its intrinsic importance to social and economic well-being, will always be subject to political pressure. In recent years, in some countries, hitherto unused to political intervention in the curriculum, politicians have extended their dictats to classroom management and teaching methods.

One polarisation is that of progressive versus traditional methods of teaching, although what is meant by these terms is seldom explained in meaningful language. Newspaper comment is singularly unhelpful since it so often picks on a special case or, if it advocates one side of the argument and then another, the space between them is so long that the former has been forgotten. One suspects that many if not the majority of teachers, muddle along with relatively traditional methods modelled, not on the results of research, but on what was successful for them in school and, or with which they feel comfortable adapted to suit the prevailing system of assessment. They will not have seriously experimented with alternative methods of instruction because neither their training or the system in which they find themselves encourages them to undertake such experiments.

This study discusses that dimension of teaching and learning which is polarised by discovery learning at one end of the spectrum and expository teaching at the other. It describes another aspect of a particular unit in teacher education reported to the 1991 annual conference of the Association for Teacher Education in Europe (Heywood, 1992).

This unit in the applied psychology of instruction, commonly known as the 'student teacher as researcher programme' is part of a one-year course for training graduates to become teachers in second-level education. The unit consists of five activities in which the students are asked to read the research on a specific instructional technique, to select a hypothesis for testing with their students,to implement a lesson, to test the hypothesis and subsequently test same (Exhibit 1). A detailed report of one of these activities which was not generally available at the time was circulated at the conference (Heywood, Fi zgibbon and Cameron, 1991).

Since 1984, when the course was introduced, students have always been asked to undertake a comparison of two methods of teaching for their last activity. With few exceptions, this has always been between discovery and expository learning and associated instruction. The exception was when early in the programme the students were asked to compare the certain methods of instruction advocated by Bruner on the one hand and Gagne on the other.(1)

While the problems of definition to which Shulman (1970) referred remain, it has been found that the student-teachers clarify their own thinking and no reason has been adduced to cause us to want to change the instructions or the required reading. It is yet another exercise which helps student-teachers to appreciate the potential of different approaches to instruction (Heywood 1992).

Apart from the learning experiences which these activities force on the student-teachers, their reports which have evolved into very substantial exercises, some of which have merited

publication (see, for example, Donovan, in this report), contain much information about the conditions for the likely success or failure of different methods of instruction. It is with an analysis of the student teachers' evaluations of discovery and expository teaching with which this study is concerned.

The Instructions to the Students:

The instructions to the students have been brief. Apart from a general direction to compare discovery (either guided discovery or discovery) with expository methods of instruction, written guidance is given on how comparisons might be made within their normal programme (e.g. splitting the class into two, sequential lessons with the same class) and, to a limited range of literature which focuses on such research as had been done on discovery learning This included a review article by Shulman (1970) which accounts for both the theory and most of the research to that date. It does not, however, outline any of the experiments in any great detail, for which reason the students are referred to Heywood (1982) on project work, and de Cecco and Crawford (1974) and MacDonald (1968) for accounts of experiments by such investigators as Kersh (1962) and Suchman (1961).

We also give them a paper that introduces them to the term "participatory learning" which, if they wish to develop as an issue the question of the definition of discovery in their evaluation, may be helpful (Boffy, 1985). However, the intention of the article is to provide examples of two different approaches to teaching, one which is expository or directed, and the other which is limited guided or directed discovery. These examples related to a common task in engineering training - that of marking a tool box.

> "1. Trainee A is told exactly what tools to use, how to use them, is given pre-formed parts to assemble, told how to assemble them, and is closely checked and corrected by the tutor during the assembly stage. In this case the trainee is little more than an adjunct to the tutor and it is questionable whether he really 'made' them at all. The range of core skills being used is very small - interpreting spoken instructions; adopting safe working practices; manipulating materials, and operating tools.
>
> 2. Trainee B is asked to consider various designs for toolboxes and to decide which one is the most suitable for the purpose; to select the appropriate tools and materials, to assemble the toolbox according to the chosen design specifications and to refer to the tutor for advice and guidance when problems occur. The tutor's response, typically, is to encourage the trainee to think of solutions to the problems and to come up with alternative strategies for solving them. Only then, if necessary, does he provide the answer."

If the students wish, they can take note of the idea competencies in the article and, at the same time, obtain an exemplar of transfer.

From the students point of view, the scheme of assessment is also an instruction about how they should complete the task. As indicated previously, the Government Department of Education requires that the Diploma awarded to graduates who pursue a one-year course of teacher education to qualify as secondary school teachers be graded in the same way that honours degrees are classified in the Anglo-Irish education systems. Technically, within such a scheme mastery learning is not possible, even though it might be desirable. For this reason, a semi-criterion referenced schedule was developed for all of the activities. Since the version published last year (Heywood, 1992) a new scheme was implemented for the last activity which is shown in exhibit 2. It is more specific to the activity in question. It was found to be helpful but in need of refinement.

Whether or not the students meet all the requirements of the scheme is a matter for them. Some areas might be omitted without detriment to the basic pass grade, particularly if other areas are done well. Moreover, since they have already done four activities, including four self-assessments, those who are under pressure immediately prior to their final examinations might risk a more limited report. This, however, has not appeared to be the case with the majority of the submissions which have been examined over the years. It does mean that the information given in the reports varies widely, even between very successful students. Thus, the reports have to be examined individually to discern trends.

Other important variables which intervene in the analysis are class size and level, gender of the pupils, subjects taken and the gender of the teacher. In this respect, the 1992 submissions are fairly typical of other years. With reference to Exhibit 3, it will be seen that the majority of students teach first and second years and that these classes are fairly evenly divided between single gender (male and female) and mixed genders (see also Exhibit 4). There is a reluctance on the part of Principals to give them third and sixth year classes, as these are the years when at their end, the students sit public examinations. There is also a reluctance to give them fifth year studies, except in economics, business studies and religious education. The Transition Year which is not, up to the present, taken in many schools has begun to provide teacher training places in the 15 plus years age group. It should be noted that classroom experiments are welcome in this year, since (i) it is not examined and (ii) its objectives are much concerned with the transfer of personal skills. The perceived achievement levels of these classes are shown in Exhibit 5. Students perceive them to be mixed ability in the main. There are very few very low achieving students in these classes. The student-teachers cope fairly well with them and the problems they create.

It will also be noticed that there are both mixed and single-gender groupings. The ratio of male to female student teachers varies from year to year, but there has always been a much larger number of females. In 1992 there were 51 females and 25 males among the 76 respondents.

We are required to offer the range of school subjects and are dependent on the qualities and interests of the students. The numbers studying methods in each subject varies therefore from year to year. The submissions for the final activity are further complicated by the fact that each student takes two methods subjects and can choose to undertake these particular activities in either.

At the very least, the information in the reports contains examples of success and failure which can be used in teacher training (e.g. Carroll, 1991). Together, the reports demonstrate the level of understanding which these student-teachers have of the different methods of instruction, as well as the perceptions they have of their pupils response to these methods. Moreover, as the assessment schedule requires a personal response, as well as a statistical response to their classroom work, information may be available from which the conditions for the successful implementation of different kinds of instructional strategy may be determined. It is with an analysis of this kind that this study is concerned. We have tried to check the belief that there is a consistent pattern in pupil response and teacher instruction from year to year. We believe that the analysis throws some light on earlier findings in the area discovery/inquiry learning.

Method of Analysis

As indicated above, these activities were introduced in the academic year 1984/85. Samples of the work undertaken in each year have been retained since then. An analysis of the 1984/85 sample by one of us (J.H.) led to the design of the semi-criterion referenced schedules, questionnaires to be administered after each activity and a framework for the analysis of the case studies. The total samples for 1989/90 and 1990/91 were re-analysed independently by a psychologist (SH) and it was concluded that the trends identified in 1984/85 were also to be found in the later reports. No attempt has been made, therefore, to analyse the intervening years, although samples of the reports have been retained for inspection. The report which follows is an agreed combination of the two studies. It has been roughly checked against the most recently submitted reports (in June 1992). Exhibit 6 shows the variation between the subjects present in each of the years analysed, while Exhibits 4 and 6 provide a more detailed breakdown of the 1992 reports (2). It is considered from spot checks that in any one year no more than 10% of the reports are unreliable and that this unreliability is caused mainly by the workload of the diploma programme. There will always be some students who believe the exercises are unnecessary and to be treated trivially. However, the major problem is in analysing fairly weighty reports from the majority of students. The discussion which follows takes this into account.

The Student Teachers' Interpretation of the Problem

The problem was presented to the students in the broadest of terms. It was accompanied by details of the literature which had to be read (see above). That is, compare two methods of teaching, one of which must be expository and the other guided discovery or discovery and evaluate the research on the basis of your findings.

Put in these over-simplified terms and even with the aid of the literature, the student teachers acted on a variety of different definitions relating to the mode and duration of instruction. These definitions were not only caused oy the inherent ambiguity in the term discovery (Shulman, 1970) but by certain prejudices on their part, to be discussed below. Just as the terms "discovery" and "guided discovery" were open to interpretation, so too was the term "expository". In extreme cases, the student-teachers interpreted this term to mean the continuous talking at the class, with little or no interaction between themselves and their students. No wonder they reported that the students found it "boring". Although the number of student-teachers who reported classroom performances of this kind was sm?'l, it became a matter for concern and in the 1992 seminar immediately prior to the implementation of this activity, it was made clear that a more didactic approach was necessary. This seems to have resolved the issue and there were no reports of this kind among the 1992 submissions.

One Science teacher, Ruadhan Hayes, explained his choice thus:

> "For this exercise, I chose to compare expository teaching with guided disco very. Expository teaching is where one gives the students everything: facts, concepts, principles, rules etc. Discovery teaching is where one sets them a problem to solve, perhaps, and gives them no help towards finding the solution. In guided discovery, one sets them a problem but guides their efforts along a certain channel which one hopes will help them to discover the solution.
>
> I chose guided discovery as a method because my experience with students in my teaching practice has been that they rarely arrive where one wants them to without a considerable amount of help. It has been my practice to refrain as much as possible from telling them what they will find in a particular experiment, in order to provide an element of discovery and the unknown for them. In these situations, it is usual for me to have to give considerable guidance in the interpretation of their results as they are frequently unable to interpret them for themselves.
>
> In the present instance, where the content matter involved the law of the lever, my expository group were led up the hierarchy of prerequisites through the concepts of lever, fulcrum, perpendicular distance, moment of a force, clockwise and anti-clockwise moments, equilibrium and the law of the lever. All this was given.
>
> For a pure discovery group, I would have given them the weights and suspended metre sticks, and directed them to see if they could discover any pattern when the stick was balanced with the weights in different positions chosen by themselves.
>
> Using the guided discovery approach, I stacked the odds in my favour by directing them to place the weights on one side of the metre stick at specific points. I hoped through this to have the simple numerical values they would find so obviously related that the law would be apparent after a few examples of equilibrium. Using only two weights, one of which was twice the other, was also an attempt to simplify things and stack the odds in my favour.
>
> I confess to finding it difficult to distinguish between the discovery and guided-discovery approach. Although the former is supposed to involve no help from the teacher, by his setting up of the problem in the first place, he is guiding the learners in a certain direction. If one simply left a metre stick, a piece of string, a retort stand and some weights on the bench and told students to find "a law connected with balancing the stick", it is unlikely that they would get very far. One has to guide them to some extent, even if it is only in terms of the hidden guidance involved in how you present the problem to them. For this reason, I would prefer to look at discovery methods as a spectrum running from more to less guidance, rather than from a guided/unguided point of view. (The description of Kersh's work recognises this fact by talking of strong and weak discovery conditions)".

However, the picture is confounded by the fact that at least twenty per cent of the students in 1992 and twenty-six per cent in 1991 reported the use of "brainstorming" in their expository lessons. A very small percentage allowed group work. Around a half in both years reported that they based their expository lesson on Gagne's hierarchical model.

If by "discovery" we mean an internal mental development (move) from notional to real assent (3) of an axiom or opinion then, of course, any mode of instruction has in it the potential to assist such a jump. The question is whether the chosen mode will create a lasting affirmation. So there will always be an element of discovery inherent in expository teaching and the argument

about the different methods resolves around retention of facts and understanding of concepts and principles and this is clearly stated in all the literature to which the students' attention was drawn.

In some respects, therefore, it is surprising to find that there remained confusion in students' minds. It is also surprising that they did not, by and large, use Wittrock's classification of method in respect of learning rules as a guide to their design of their lessons, even though it is cited in two of the recommended readings (Heywood, 1982; Shulman, 1970). Some examples of those that did are included in Appendix A.

At a late stage in the 1991/92 programme, the criterion referenced schedule was redesigned so as to focus on the activity directly and, in one section, a better understanding of the results of research in relation to these definitions was sought (e.g. Kersh, 1962; Suchman, 1961; Worthen, 1968). It was hoped that this would help students clarify their interpretations, aid the planning of their lessons and reduce the length of the reports. First impressions suggest that this was helpful to a number of students.

The Student Teachers' Choice of Techniques (i.e. Discovery, Guided Discovery, Expository)

Mention was made above of the prejudice which surrounds the student-teachers' approach to the selection of instructional techniques. In the Irish context, children in secondary schools have in the past more often than not been brought up within a highly structured system of teaching which aims to help them pass public examinations set by the State at 15+ and 17+. These examinations are used as agents of selection to the worlds of work and third level education. They are, therefore, all important and students and their parents expect teachers to use techniques of instruction which will get the students through those examinations. The examinations themselves have encouraged rote and expository teaching in the belief that over large syllabuses can only be covered in this way and that, in any event, memorisation is best achieved by such modes of instruction. The methods of lecturing and examining which they experience at university more often than not serve to reinforce this view. There is, therefore, every reason for them to copy the role-models to which they have been exposed. And these are not always helpful, as this description from one of the reports shows:

> "Unfortunately, many teachers exist who claim to 'know it all', their opinions and only their opinions are correct. Any insights offered by the pupils are 'shouted down'. I agree wholeheartedly that, in many cases, such a policy impedes the personal development and growth of our young people. In my own experience, I had an English teacher from first year to third year who 'spoonfed us' with information relating to such poets as Hopkins, Keats, Shelley, Kavanagh and Yeats, telling us the interpretation of each poem and discouraging us from forming our own viewpoints. However, when I found myself in her class for fifth and sixth year following the halfway stage marked by the Intermediate Certificate, a complete transformation of attitude took place within her class. Not once did she give us any inkling of her liking or disliking of any poem, as she had previously done, or give us her own interpretation of a particular sonnet or short story. I quickly set about discovering if she had changed her whole approach for each class, from first year to sixth year, but was extremely disappointed to learn that she had only adopted this tactic for her senior classes, obviously believing us to be mature enough now to come to our own decisions regarding the texts on our English course. It is my belief that because this particular teacher had discouraged the voicing of her students' opinions and interpretations at such a stage in their lives when they were at their most enthusiastic and productive, she scarred the students for life. When in my senior years in her class she encouraged us all to share our thoughts and views on certain literary works and masterpieces, we were hesitant and reluctant, wondering if our interpretations would coincide with what this teacher expected of us.
>
> Another such example presented itself in the form of my history teacher, who entered class without his own textbook, constantly borrowed one from his students, sat behind his desk at the top of the classroom and instructed the first pupil he set eyes on to read the first paragraph of the textbook. When the pupil had completed the particular paragraph, the teacher requested that she give a summary of it in her own words. Satisfied with her response, he would then proceed by asking the student beside her to continue with the reading of the following paragraph and immediately follow it with a summary in her own words. The class continued in the same manner for the entire forty-five minutes. It was a totally predictable class and most of the students were either bored or daydreaming. The class lacked stimulation and none of the students showed any signs of interest or motivation."

The idea that there may be alternative modes of instruction is obscured in this situation and for many students it comes as a shock to find that there are alternatives.

Mariele Hesper, a mature student with teaching experience, who was seeking entry to the Irish system, illustrates this point thus

> "I have found it quite difficult to engage them for any length of time in communicative games or imaginative play or in placing their language learning (German) in a meaningful cultural context. Usually, they would give me to understand that what they really wanted to do was follow the coursebook chapter by chapter and make sure that at the end they had condensed the content into frames and boxes that would record grammar points and set phrases in an easily accessible way. Given that this is the mental disposition of most of the pupils in that class - a disposition that is cultivated by their highly results-oriented school, as well as the national examination system".

Kate Willis, a student teacher of science, illustrates these points like this

> "The class was a bit put off when I asked them to find a definition by themselves and there was a lot of looking around to each other to see what to do, or whether to take the instruction. The suggestion that they should come up with a definition was apparently absurd - that's what textbooks are for and its their role to learn from the books, thinking isn't popular with this class. I gave everyone a half-metre stick to experiment with, about half the students never really started, they seemed intimidated by their task and, in their charming ways, suggested that I was an idiot to expect them to be able to come up with a conclusion".

Since these activities have to be carried out within their ordinary teaching programme, there is pressure on the student-teachers not to fail in their implementation. In these circumstances, it might be expected that many of them would approach this experiment with some trepidation. From both the 1991 and 1992 questionnaires, it appears that many of the student-teachers did not experience any apprehension (57% and 34% respectively) although 28% and 38% did experience a "little apprehension"(4). Given that this is their fifth experiment, these responses might be expected. However, inspection of the reports suggests that some student-teachers may avoid apprehension by choice of method in relation to the characteristics of the group to be taught. Many student-teachers would regard "pure discovery" ,as it came to be called, as a high risk strategy and therefore would not give it (or variants) any consideration at all. They are going to choose some form of guided discovery. Exhibit 7 illustrates this point. Since some guided discovery is inherent in most instructional situations, they will inevitably have experienced it during their previous teaching and thus they may use techniques which place the activity near the expository end of the continuum (e.g. worksheets). Not unreasonably, students will try to do that with which they are comfortable. Analysis of the 1992 data suggests that students may prefer deductive to inductive guided discovery.

Some student-teachers found security by telling their students that they were taking part in a research experiment for the university. This might have confounded the results by introducing a Hawthorne effect. But this argument may be countered by the fact that many motivational strategies are designed to have this effect which is to argue that such a stratagem is not a great departure from normal classroom behaviour by enthusiastic teachers.

Forty-four percent of the teachers who responded to the 1992 questionnaire believed that success in discovery learning depended a lot on the attitude (teaching style) of the teacher: and fifty percent responded "to some extent"(5).

Inspection of the reports shows that some students deliberately choose the expository method for the weaker students in their classes. In this way they deliberately avoid stress and therefore apprehension, neither would they perceive that a defence-mechanism was at work. At the same time, few students in response to both questionnaires are prepared to advocate that low achievers should not be exposed to expository teaching.

Methods of Comparison

The methods chosen to compare the two techniques are generally a function of the circumstances in which the students find themselves. By far the larger number divided the class into two and taught the same lesson twice in 1992, and this is the pattern of previous years. Those who split the classes or compare different classes usually try to match the pupils for achievement level.

Graham Hewston, a teacher of science:

"It was decided to split the class into 2 smaller equal groupings for the purpose of this comparison. This was carried out by dividing the class into high and low achievers and placing an equal number of each into each group insofar as this was possible.

The class was carried out during a double period slot, so this enabled the first group - the discovery group - to carry out the experiment, whilst the second group - the 'expository' group were supervised in the video room by another teacher. After the end of the first period, the discovery group left the lab. and the 'expository' group entered.

Lab. partners for the 'discovery group' were decided by the use of the sociogram (see Exhibit 8). This ensured that the partners worked well together and the experiment would not be affected by a conflict of interests.

Thus, it was attempted to ensure that the biosocial and psychosocial attributes of the control (expository) group and the experimental (discovery) group were essentially the same. It was also ensured that an equal amount of time was given to both groups (35 minutes). To facilitate this, the apparatus for the 'discovery' group was supplied at their benches before they entered the class.

A common test was given a week after the learning experiences to allow direct comparison of the classroom styles. This provided empirical research data but motivation and esteem levels were also considered.

Due to time limitations, it was not possible to offer both modes of instruction to both groupings so the compromise reached ultimately depends on the equality of the groupings."

One student, John Corry, went so far as to do a correlation analysis, even though his group of fifth year students of accounting, when split, was too small for this procedure. His calculations and comments are shown in Exhibit 9. Whatever else may be said about the weaknesses in the statistics, it does demonstrate that performing the statistical exercise helps students obtain insights into their teaching.

These student-teachers have been able to obtain the help of other student-teachers of teachers in the school. Over the years, one or two have been forced to carry out simultaneous activities in the same classroom. A small number have taught the same lesson with different methods of instruction to two different classes of the same level. Occasionally, teachers have taught the same lesson to classes of different levels. There was one example of this in 1992. A small number have taught the same class on two occasions in sequence with different methods and necessarily different content.

Two of the 1992 group used their students learning styles in their selection (see below). The students in these secondary schools, by and large, take the view that their classes are of mixed ability. There were few reports of their having to deal with remedial students in the 1992 reports, which has not always been the case. As indicated above, a few students made their selection so as to put low-achieving students in the expository class.

A few student-teachers reported that they had pre- and post-tested their pupils. One reported the following for a class of twenty-five twelve to thirteen year olds.

"Statistics of the Tests

Both pre-test and test were marked out of 100. The mean scores and standard deviations for the two groups (guided discovery/expository) are as follows:

Group 1 Guided Discovery Group		Group 2 Expository Group
	Pre-Test	
Mean = 40		Mean = 43
Standard Deviation = 15		Standard Deviation = 10
	Test	
Mean = 50		Mean = 55
Standard Deviation = 17		Standard Deviation = 8

The average pre-test mark in group one was lower than in group two, while the standard deviation, the spread of marks from the mean, is greater than in group two.

Avril Mac Farlane was very adventurous. She chose with a class of 29 female beginners in French to divide them into three groups and within the same lesson, to compare discovery, guided discovery and expository teaching. All were given the same test. Unfortunately, a few of the discovery group were missing, which marred the result. She found that the discovery group did best. Her results, which are reported below, suggest she found the experience rewarding. Her lesson plan is shown in Exhibit 10. She notes that one of the problems with split groups is that sometimes the halves are too small for the results to have meaning. However, if overall, the same trends emerge from year to year, it would seem possible to suggest some indicators of performance.

Not everyone was able to set the test at the same time distance from the class, but those who had this difficulty, did not, by and large, consider it effected their evaluation (see, for example, Donovan in this report). Niamh Meaney, who taught Irish vocabulary, taught the whole class by different methods on separate occasions. The mean score of the second test was considerably higher than the first (eight and twelve out of twenty respectively). In respect of the timing of the tests, she related her argument to her test design. She wrote:

> The first test was administered a fortnight after the class (because of the Easter break) whereas the second was given one week later. One would no doubt wonder whether the time factor was the deciding factor i.e. because the period between lesson 1 and Test 1 was longer than that between Lesson 11 and Test 11, the students were more likely to have forgotten the work being examined in Test 1.
>
> Although I do not rule out the possibility of the time factor having a bearing on the results I obtained, I do not think it was the overriding one. My reasons are thus. Firstly, a recognised maximum period of retention (i.e. after this, knowledge retained begins to fade from memory) is about two weeks. The difference in the strength of retention of the two sets of vocabulary should not, I feel, have been very dramatic.
>
> Secondly, the levels of difficulty of the two sets of vocabulary were more or less on a par. This was done deliberately because (of course) for the comparison of the two methods to be plausible, the material had to be of a similar level. However, I do acknowledge that, as with all things in life, the situation was not completely perfect. The first set of words contained items which were likely to have been encountered by most of the students in their previous experience (e.g. gruaige, suil, sron, beal and fiacla), whereas the second set contained a smaller number of these. "Lamha", "cosa" and "gluine" are the only items which I could say for sure had been encountered by most of the class. These factors should have served to make success in the second test more difficult. However, on the contrary, twenty-two out of twenty-six students increased their marks. These results, I think, prove that guided discovery learning can help greatly in the area of vocabulary retention. As with Kersh's experiment, it has provided the best results.

Test Design and Transfer

The design of the tests has become increasingly sophisticated and in the 1992 reports, several attend to the issue of transfer. This development in design is clearly a function of the exchanges which take place between the tutor and the student-teachers prior to the exercise. At the same time, there is considerable variation in the psychometric qualities of the tests. Some are easy: some are difficult: others focus on memory: others try to test for skill.

One attempt to test different skills in fifth year business studies is shown in Exhibit 9.

By the time the students come to these lesson activities, they are beginning to acquire skill in test design, implementation and interpretation. Many now recognise that their data is weak. For example, Fiona Brennan, in respect of her guided discovery test, noted that the students did well in spite of it being Monday morning!

> "This concept (in German) was a lot easier to grasp straight-away than the dative case and students had an example to work from. The gap of one week was the same for both between the lesson and the test, yet I feel the students applied themselves more to this concept, probably because of the shock the students got when they saw their marks fro the first test.
>
> Secondly, the format of this test was slightly different to the first test. Here, the students worked out the examples and then gave a definition, while it was the other way round in test one. Defining the dative case incorrectly in this test caused a lot of students to become confused when they had to write out

the sentences. This lowered their marks considerably. The fact that the dative cast test was called out orally, whereas the "Wennsate" test was given on a photocopy, may have been another contributory factor.

To compensate for the easier concept in test two, I marked quite hard, regarding spellings. Despite this, the statistical evaluation will indicate the huge improvement on marks, using the guided discovery technique, compared to the expository technique. Reliability is an important consideration, especially regarding content. The true test would have been to use the same content, teach one half, one way and the second half the other way and set a common test, to see which group scored better. As this was not possible, I selected samples of work from the same students. Student 1 scored only 32% in Test 1 and improved dramatically, scoring 77% in Test 2. I felt, overall, this student tried much harder following the shock she got with her Test 1 mark. The second sample came from the "weak" student, scoring consistently low throughout the year. She improved dramatically on her Test 1 mark and her marks all year by scoring 87%, surprising both myself and, more importantly, herself. Given the lapses in concentration, her interest and motivation levels have noticeably increased since. Finally, sample 3 comes from a good student and her result of 73% is consistent with her marks throughout the year. Perhaps it does require a "pure" expository method to inspire her to marks right at the top of the range of scores."

(N.B. The samples were provided in the report).

It will be noted that a particular problem for students when they have to set two tests is to ensure that they are of the same difficulty.

This does not mean that an easy test is not open to interpretation. Paul Gavin wished to teach the concept of an advertising slogan to first years.

In his comments on the test, he drew attention to the fact that the test was easy, but by analysing the marks per item, he was able to suggest that there had been some transfer, as well as to indicate that the discovery group understood the concept better. He wrote:

Firstly, the test was easy, in that it only examined a relatively narrow field of mastery, that of the one concept. I just wanted to see did everyone understand it and could they list some of the main values and attributes. Because the concept itself is to subjective, I did not want to get into the area of testing non-examples, as anyone could make a case for a non example being, in fact, an example.

Secondly, I did not want this to be a test of pupils' skills of advertising or necessarily of their versatility in the English language. I wanted it to be a test of how they could learn and how they could apply that knowledge. Most pupils were able to use the attributes and values they had listed in question 4, to explain why they had enjoyed certain ads in question 5. I take this as evidence that the pupils had learned some transfer skills. The third reason for the high scoring, I would argue, was the level of mastery the pupils had acquired and the closeness of the problems in the test to those encountered in real life "What do I buy?", being a pertinent question to children of this age. This test was not designed to allow pupils to show what they know, but rather to test a minimum level of competence in advertising jargon. Once pupils showed that level of competence, they scored highly.

Comparing the mean (M) and standard (∂) deviation of the two sets of scores, the level of scoring in the Discovery Class was higher than that of the expository class. The difference in the standard deviation is even more remarkable and we notice, if we standardize the marks, that a score of 95 in the Expository only has the value of 90% on the list of results for the discovery method.

There was one particular question where students exposed to the discovery method showed superior mastery of the concept. In question 4, pupils were asked to list attributes and values of the concept. Students under the expository mode gave answers that were often unclear of muddled. These were often snatches of phrases I had used, ill used or used out of context. These students had obviously been racking their brains to remember things I had said, rather than stating the obvious, which would have been the correct answer to the question (i.e. any coherently expressed characteristic of an advertisement) which is what the students exposed to the discovery mode seemed to do. Their answers were almost always clear, simple and showed an understanding of the concept. These answers hadn't been told to them by me, they hadn't overheard me because I hadn't mentioned them, but were an example of the pupils reflecting on their own experience in constructing advertisements and organising their own knowledge to meet this new challenge. Considering this, I would agree that the best way to encourage original thought is by a discovery method because students exposed to an expository method will attempt (as my tests have shown) to parrot what the teacher has said. No matter how hard you try, under any method, to instil in them the knowledge that no particular answer is right or wrong (as in the case of a concept as subjective and as open to new attributes as this one). Students resist being told this. The only way to make them aware of it is to expose them to an infinite range of solutions which they themselves generate. What I mean by this is that we, as teachers, simply set the problem and let discovery learning have its head."

And he did approach the discovery as a pure discovery lesson. However, it must be assumed that the student had some experience of and therefore knowledge of advertising.

As this example shows, an important change in student approaches to test design has been the recognition of the need to test for transfer. Geraldine Nolan, who taught French, explained how the third phase of her expository lesson plan would cater for transfer thus:

> "Application
> Content: Application and demonstration of concept introduced.
> Learning Strategy: Guided Discovery by the pupils.
>
> The concept of the formation of the perfect tense with avoir, as the auxiliary verb, has been introduced and explained. Now the pupils will have the opportunity to demonstrate what they have learned. It is here that the transfer of learning takes place. Pupils will read themselves the passage "les sandwiches de M. Corot" and, as a homework exercise, pupils will do an exercise on the piece, i.e. complete sentences and fill in blanks, using the passe compose."

In planning a lesson in English, Paul McGoldrick said,

> "For the discovery learning class, I will use the inductive process. This is the degree of guidance I have decided upon. Here the pupils will be given the 'solution' and must discover for themselves the rules or generalisations that apply to the solution. So they will be given direction in the form of the following. I will begin by telling the class that I want them to discuss the poem, but that I will firstly make various statements about it. I will begin by telling them the general theme of the poem, then move on to areas such as tone/mood; rhyme/rhythm; meaning of words/ phrases; and so on. Therefore, I will have given them the solution. What they will be required to do is fuel the rules, that is, the class will, for the statements I have made about the poem, back these up by reference to and examples from the text. In this respect, it is the pupils who are discovering for themselves the rules required to 'solve' the problem. They will have an opportunity to play an active role and participate in the task presented to the. Hopefully, this will lead to learning of a range and level of core skills that they can employ or transfer to other situations involving the discussion of a poem."

The recognition of transfer is not always in the lesson plan or theoretical statement but in the analysis of results. Gemma O'Connor, who taught Irish, commented thus:

> "Results from the test I gave did not show that the guided discovery group did better when presented with the principle in new situations. Seven of the ten verbs were verbs that had not been used in examples, everybody got the three verbs that had been used in examples correct. As the expository group did better overall, this suggests that the expository group did better in transferring principles to new situations. However, it is worth noting that the sample group consisted of only eleven evenly matched pairs and I believe that results could easily have been different if the group was larger.
>
> The fact that the expository taught group did better would also seem to indicate that this group were able to retain information longer, but perhaps if a similar test was to be given in a further two or three weeks, results would be different. Both expository and discovery methods seem to have produced similar strengths of retention as regards immediate learning, as shown in written exercises administered as homework."

And this also illustrates recognition of the limitations of the experiment.

Entering Characteristics

The need to understand the entering characteristics of the students (that is, what they bring to their learning) is apparent in many of these reports. This point is illustrated by Niamh Clarke, who taught geography. She discussed the performance of some of her students in both the expository and discovery classes. The illustrations below were made in respect of the expository class and relate to the two-part test which was set.

Isobel

This student, as the personal description shows, was to think she is above the class. She failed to listen accurately to my plan and, as a result, fell down. Her work on farming, as a system, was very weak indeed, due to the fact that she had not concentrated.

Marks	1st part of paragraph about bakery	5/10
	2nd part of paragraph about farming	2/10
	Overall grade	7/20

Emma

This student is a very bright young girl. As always, she followed the lesson plan exactly. She participated actively in the brainstorming session. Her paragraph shows that she followed the plan exactly from the board. The second part, because she participated well, seemed easy for her to understand.

Marks	1st part of paragraph about bakery	10/10
	2nd part of paragraph about farming	8/10
	Overall grade	18/20

Paul

A good student, but always late into class, so missed the brainstorming session, which I felt was particularly important for the second half of the paragraph on farming. Managed to get definitions and principles right but was unable to think on his own, without my help; he likes to be spoon-fed.

Marks	1st part of paragraph about bakery	8/10
	2nd part of paragraph	4/10
	Overall grade	12/20

David

Very hard worker, likes everything to be laid out for him in point form, he did particularly well on the first part of the paragraph, but he does not trust his own opinion, even though he is often correct, so he scored average on the second part.

Marks	1st part of paragraph about bakery	10/10
	2nd part of paragraph	5/10
	Overall grade	15/20

Alan .

The weakest student in the class, pays as little attention as possible, does not enjoy taking down points, as he is a very bad speller but he does like thinking on his own. This may explain why he scored quite well on the second half.

Marks	1st part of paragraph	5/10
	2nd part of paragraph	6/10
	Overall grade	11/20

Overall Comment on Expository

The class, in general, received high grades in part one of the paragraph, but were unable to apply their knowledge accurately to the second part. This, I feel, was expected, because I used the example of the bakery myself and they followed my example very well indeed. But, because I only mentioned farming as a system and did not apply it to systems as well as I did to baking. They, in turn, did not think for themselves, but gave me back what I gave them. This was an eye opener for me because now I realize that they take what I give them as gospel, but are hesitant to think for themselves, apart from the top section of the class, which I think would learn anything, no matter what way I gave it to them.

It will make me work harder to get their minds broadly stimulated in further "lateral thinking", rather than narrow-minded work. Due to the fact that the Junior Cert. is very much akin to thinking for yourself, I will have to mix my discovery lessons more with my normal method of expository.

The suggestion that personality is probably important to success was made by several teachers. In a section on what happened to the pupils, Catherine Roche, who taught English, wrote,

> "I think this class was quite demanding for the pupils, in that it blended teac' guidance with 'discovery' methods and thus the pupils had to move from being quiet, attentive, and led by the teacher, to working by themselves, trying to solve a "problem" for which they had only the rule. The pupils responded well, however, and made the transition easily - at the start, they were, as is usual, quiet and well-behaved and worked well throughout the expository parts at giving the 'rule', although some were a little bored. This was probably due to the fact that the pupils were used to a somewhat more active class and some seemed a little restless or distracted as a result of having to 'be taught' something, rather than learning it for

themselves. However, when we moved on to the more "discovery"- based part of the lesson, the pupils performed very well, adapting quickly. Many approached the examples eagerly, quite enthusiastic to see if they could find the examples of the required clause or sentence-type etc. As the class went on, and some went closer to their goal, the class atmosphere was very good and healthy, with pupils calling animatedly for their "solutions" to be endorsed or rejected. Many pupils found this very motivating and it increased their enthusiasm and level of involvement. Others, however, while working steadily, sought guidance much more frequently and seemed less comfortable with this type of learning than other pupils. When they found something confusing or when they could not find the right answer, these pupils, rather than reacting by becoming more determined and motivated, as other pupils did, instead tended to be very frustrated and some tried to give up completely. With help and guidance, however, these problems were solved. It seems that personality has much bearing on the success or failure of a particular strategy of learning/teaching for particular pupils. Some pupils seemed to feel more confident and able when helped and others could only really work effectively when asked to perform a task themselves. The implications of this may only be really evident in the test results, to be discussed later."

Some students, as the section on Connections between Activities shows, were conscious of the fact that the work they had done on learning styles was important in this respect.

Trends

As explained previously, the onus is on the students to submit the data which they think will get them the grades in the assessment they seek. Thus, a few go so far as omit statistical data. Some give bald data which enables a minimal interpretation of the differences, while others give means and standard deviations which they discuss. An example of the latter is shown in Exhibit 9.

Nevertheless, when these are taken into account, we think the students' judgements of their work are, within the constraints of the activity, reasonably safe.

Inferences may be obtained from other parts of the reports. Analysis of the available data (by J.H.) for the 1989/90 and 1990/91 reports is shown in Exhibit 7. The preliminary analysis of the 1992 data is shown in Exhibits 11, 12 and 13 (by J.H.). Unfortunately, as Exhibit 13 shows, the data does not enable us to study gender differences in any great detail.

We asked Niamh Clarke, a Higher Diploma student, to extract from the reports the statistical data for the last two years, on which we have based our conclusions, as this provides another dimension of objectivity. Her tables which are necessarily incomplete, are shown in Exhibits 14 and 15.

Overall, the earlier data suggested that guided discovery is statistically better than expository in terms of the test results. However, not all the differences were substantial, many being of just a few marks. This pattern seems to have been repeated in the 1992 reports. There is some evidence to suggest that in most cases the guided discovery produces a lower standard deviation even when the difference in marks is small. It would be all to easy to suppose that, for the most part, expository teaching will suffice, particularly when they find some form of discovery teaching to be more exhausting than expository approaches.

However, Avril Mac Farlane, to whom we have already referred, was truly surprised by her results which showed the discovery group to do best. She reported that:

"Group 3 results are quite amazing. It seems as though my presence in the classroom is not necessary for these students to learn French! They performed very well in the test, with an average score of 16.7, very high indeed and far superior to either of the other groups. This result was amazing. I expected the group to perform quite badly, as I was very sceptical about "pure discovery" teaching or learning. These results have certainly disproved or dispelled any reservation. I can honestly see the argument now for such an approach."

However, apart from a number of technical objections, the students themselves consistently advocate variety in teaching and this may be attributed to their general experience of the five activities which are designed to help them develop this perspective.

Fionnuala Carolan, a student-teacher of science, wrote:

"Although, in this case, the guided discovery class "won out" over the expository class, I do not feel that this will necessarily always be the case. I think that, if planned properly, an expository type lesson could yield as good, if not better, results as a guided discovery lesson. The guided discovery, I feel, can vary greatly, depending on the amount of guidance and type of guidance given during the lesson. As mentioned in the introduction (Wittrock), the deductive method of guided discovery involves giving the principle, but not the problem solution. The inductive method of guided discovery involves giving the problem solution, but not the principle. I feel it would be unproductive to use "pure" discovery in the classroom, especially with junior cycle students. Perhaps it would be possible with the senior cycle, but it would be important that the students had reached a certain level in regard to knowledge and experience in relation to the topic involved in the lesson.

Having carried out the two types of teaching methods, I cannot decide whether one type is better than another. I feel that both methods are of use in the classroom, one not necessarily better than the other. One particular insight I had was that we need to think more about motivating our students in the classroom, motivation leads to better learning. I also feel that these two types of teaching methods can be used to complement each other".

Nevertheless, inspection of the reports shows that some have a predisposition to guided discovery learning and others to exposition. Although some student-teachers were disappointed by the inability of some of their pupils to achieve all the objectives of the guided discovery, they were, nevertheless, concerned to give it a try. Paul McGoldrick, a student-teacher of English, hoped to provide his pupils with the core skills required to discuss all the aspects of a given poem. He used Gagne's approach in the expository class and Bruner's approach in the guided discovery and, on testing, obtained a mean score of 60% for the expository and 40% for the Guided Discovery. He concluded his report thus:

"The guided discovery "solutions" were definitely more varied and original yet, in certain cases, statements made were not backed up by appropriate examples from the poem. Therefore, the pupils involved in the guided discovery class didn't achieve the objectives as much as I hoped, that is, not all the rules were employed to solve the problem. The expository group were more systematic and almost calculating in their responses. You could see they were following a pre-determined sequence or schedule. Ultimately, they performed better and therefore it could be argued these pupils learned more during their class than the discovery group. Personally though, I don't believe this means we should embrace the expository method but more a case of redefining the degree of guidance with a discovery class, that is, make it more deductive than inductive. Once we do this, not only will the discovery method be on an equal footing with the expository method, it may arguably surpass it because in its wake comes originality; creativity, interest, enjoyment, active participation and allows the pupil to stop and think for himself/herself."

Others also highlight the fact that different kinds of knowledge are learnt. Susan Cunningham taught a mixed class of fifteen to sixteen year olds some basic electricity and magnetism. (the differences between current flow and magnitude in series and parallel circuits). Our view is that her guided discovery was fairly directed. Nevertheless, she was led to write

"It was obvious from the two different classes that two different types of knowledge had been learned (although the objectives for both lessons were the same). The group of students in the discovery lesson learned or appeared to learn more about electricity in the practical sense than the expository class did. Their hands on experience was of more benefit to them than my demonstrating the same thing. This I felt was directly linked to Bruner's idea of disequilibria and equilibria. The students had certain theories/ideas about electricity in their heads (this was obvious from the worksheet I gave them) when they tried to apply these they found in general that they didn't work. They were forced to reject the misconceptions they had, such as the electricity flowing through a broken circuit, when it simply didn't work. They were more open to accepting the new ideas.

In an attempt to back-up what I saw in the two lessons, I worked out the different percentages scored by the two groups for question 1 in the test and question 2. Interestingly, 25% of the expository group answered question 1 (both parts) correctly, as opposed to 50% of the discovery group. Perhaps in struggling to connect the circuits themselves, more of the discovery group really learned the difference in structure between a parallel and a series circuit. The percentage difference for question 2 was not as great, with expository group scoring 50% correctly, as opposed to 66% correct for the discovery group. Again, the discovery group may perhaps have learned what switches need to be closed the hard way, by doing it themselves."

Ursula O'Brien, a student-teacher of English, who had a disposition to the discovery approach, as did several others who taught English, came to the conclusion that there was a case for Expository teaching. She reported of her 12 to 13 year olds:

> "I now feel that expository teaching has a place in the English class. From my experience over the year, I believe that Gagne's hierarchical theory is very effective in teaching grammar points (i.e. noun - adjective/ verb - adverb) and also in teaching technical terms in poetry class, such as simile - metaphor/image - symbol. I think it is also true to say when I approach a poem in class by examining the meanings of the words, sounds of words - rhythm and then style, I am actually conducting the class along expository lines. However, I have employed this method on only a few occasions. My personal preference is for a more discovery oriented approach.

Martine O'Brien noted that some of her class of twenty five "discovery" students had to be pushed to think for themselves.

> "I noted that 12/13 discovery students needed to be pushed to think for themselves and to make/see/establish a relationship between contexts. They didn't see the connection readily. Children of that age seem to prefer "learning off" definitions. I have no doubt that if the discovery students had taken the information on board and learned/verified the vocabulary at home, they would have performed better. The need for revision/reinforcement is important. I also maintain that if I gave the test a third time, the results of the discovery group would increase. An interesting exercise, and one which I will find useful in the future."

It is not always clear from the reports that students see the need for repetition and reinforcement of any new approach to learning.

Some student teachers drew attention to the fact that weak students easily get bored in expository teaching. For this reason, guided discovery might help them. Mary Hogan, who taught music to first years, wrote:

> "Looking at the results of the tests, I noted that the Guided Discovery style of teaching helped the weaker students much more because those in Group A (Expository) were the first to lose attention and, therefore, didn't understand fully the concept. The weak students in Group B (Guided Discovery) seemed to achieve higher results because, firstly, the class wasn't so demanding on them in that I wasn't talking 'at them' for so long and, secondly, they had to discover the form of the song for themselves and, therefore, involve themselves and understand the concept more.
>
> The good students in both groups achieved more or less the same results. Because the topic was quite straightforward, both groups achieved great results but I, personally, think that if the topic had been more difficult, the students in group A would have achieved better marks, simple because their information would have been more complete in the sense that they were shown exactly what to do.
>
> In the long term, I feel that Group B would retain the knowledge better because they had practice in actually figuring out and solving the problem.

Teachers in other subjects reported similarly. Karen Dwyer, who also taught music composition, suggested that the expository group were more cautious. She wrote:

> "Both these groups were far more cautious in applying the rules I had put forward and seemed less creative. They produced sound work, however, and were commended for it.
>
> Overall, while the guided learners seemed to have "jumped the gun", so to speak, they had grasped the concept of phrasing, opened and closed phrases etc. The only problem they really had was to put it into theoretical form.
>
> The expository learners had no real problems in writing out their compositions but had a bit of trouble in their performances. This may have something to do with the fact that not a lot of time was allotted to practice, whereas the guided learners had more time to practice. It may also have to do with the fact that they spent to long adhering to my rules that they spent less time experimenting."

It is important to investigate the effectiveness of expository teaching on the cautious/risk/creativity dimensions, since industry claims that students are often unable to take the

risks that are required or are insufficiently creative. This finding is in keeping with Perry's developmental theory, which suggests that particular kinds of teaching method might inhibit development through the effects it has on learning.

Paul McGoldrick, who was one of those who believed that subject matter influences the method of instruction, wrote:

> "The nature of the subject matter also has an influence on the method of instruction used. English is subjective and I believe that subjects in which pupils are called upon to discover rules and solutions are likely to be more fruitful with tasks in which the discipline is logical and rational. Therefore, I would not be surprised if those H.Dip students who were assessing the methods via mathematics came to the conclusion that Bruner's discovery method worked best."

Catherine Maxwell, who taught German to second years, came to the conclusion that ultimately the answer as to which method to use was dictated: "There was no choice". In her analysis, she wrote:

> "The results of the tests generally back up what I initially felt at the end of the lessons. No student did worse than I would have expected. A few low achievers in both classes did better. On closer analysis of the results for individual questions, I discovered that students from the expository learning lesson, who answered questions which contained a verb which I had given as example, almost all got it correct in the test. They had seen me use it and learnt it. Fewer students from discovery learning lesson got the same questions consistently correct. No such pattern of correct answers emerged. However, questions in which the verbs were easier to form were more often correct than incorrect, especially in the case of discovery-taught students. Expository-taught students had big problems with difficult verbs which they had not been given previously as examples.
>
> I believe that these results would be repeated with other classes if the actual conditions remained stable. By this I mean that if I was able to allow as much time as was required to ensure proper and complete understanding and learning in both lesson types, but in particular in the discovery lesson, which seemed more time-consuming.
>
> In language teaching, certain elements lend themselves very well to either expository learning or discovery learning, while other elements can be adapted to suit either type. Thus, I do not think that the teacher has a choice all the time."

The view which some teachers have that some subjects are more suited to discovery learning than others is not sustained by the evidence over the years. This is particularly true of business studies and commerce when, in 1992, their reports confounded the view of student-teachers in these subjects who, in previous years, held that they are primarily best taught by expository methods.

An important technical problem in the analysis arises from the fact that it is often difficult to interpret the "distance" from expository which a student takes. It could be that the closer the guided discovery is to expository teaching, the less difference in the marks. To what extent is the setting of questions in mathematics guided discovery? One student thought it was.

One approach might be to try and determine the level of involvement. Many students over the years of the study have made the point that discovery involves the students more than expository. Patricia Burns draws attention to the fact that there must be some involvement, even in expository teaching. Contrasting a divided class for the purpose of the study, she said about teaching the time in German:

> "The class began with a quick revision of numbers which appeared to have been well internalised by most. The group which learnt by the expository method were clear from the outset on what they would be learning. I found myself through the class explaining a lot more than I usually would and I didn't feel the approach did much to stimulate and enhance the pupils' motivation and interest. This I attribute to the fact that pupils were more involved in writing down the new information than in actively participating. This did not occur in the class in which discovery learning took place, as pupils were aware from the start that expectations were high and the pupils attentiveness was higher as a result. I also thought they were more highly motivated because they were immediately given a task on which to work. Yet I found that pupils learning through exposition seemed to have a more concrete idea of telling the time and I found it

easier to follow a step by step procedure from start to finish and felt it was also less difficult for pupils to follow. Despite this, it could be said that the pupils were not challenged enough, as everything was given to the,, from the rule to the solution. I am not an advocate of spoonfeeding, but this is what I felt I was doing in the expository lesson.

Contrary to this, in the guided discovery lesson, pupils were much more actively involved and I found a much less occurrence of inattentiveness and a higher degree of thought and reflection. As I learnt from the lesson plan on decision-making, a lot can be gained by getting the pupils to think things out for themselves and discovery learning does allow them to do this. I must admit however, that I found myself guiding pupils slightly more than I had intended, as there are some very weak pupils in the German class."

She was one of the students who came to the conclusion that weak students were better taught by expository methods.

A major variable is the type of content. It might be that the more a lesson is content oriented, as for example, in teaching a sequence of historical events, the less the difference in the marks. One or two historians in each year believe that their subject is more suited to expository methods. If Bruner is correct that history should be about understanding how historians work, then this goal will hardly be achieved by expository teaching.

At the same time, one teacher of history felt that non-expository methods of teaching help the poorer students retain knowledge better. She reported

"In terms of what happened to me in the two periods given over to this lesson plan, I felt that the expository nature of the teaching made the group easier to control. There were no discipline problems, nor was there any sense that the class was not motivated to learn or revise. However, I feel that this is related to the timing of the lessons and their relationship to the forthcoming exams. As such, it does not clearly reflect how the use of expository teaching influences the teaching-learning experience throughout the school year. As I explained in my evaluation of the Kolb test lesson plan, I feel this class responds better to a higher ratio of guided discovery to expository teaching than the other way round. Certainly for these pupils, who usually perform well in history, the method of teaching has not significantly affected their scores one way or another. But for those pupils whose ability to retain facts and dates is poor, the non-expository methods I have used this year have given them an opportunity to perform to the best of their abilities, whether those abilities lie in drawing, interpreting facts from material or using imagination to put themselves in historical settings."

Joanne Sullivan supported this view thus,

"This class can be lively, and may have taken advantage of the guided discovery lesson. This influenced my decision, as to which lesson I would teach to each class. The expository method leads to a more controlled atmosphere and more effective discipline. I feel that we got through more work than in the guided discovery lesson. I feel that this approach suited the weaker pupils in the class. They feel more confident when the teacher is controlling, whereas the weaker pupils in the guided discovery lesson seemed a bit intimidated by the discussion techniques. On the other hand, the expository method probably inhibited the output of ideas of the more able pupils. The expository method gives little scope for the development of the pupils' own ideas and when students are not asked for their ideas, it could lead to the pupils feeling that their own ideas are not worthwhile, which leads to reticence and a lack of participation by the pupils in future lessons. I did not enjoy this lesson as much, because the pupils' contribution was minimal and I feel that it is essential that the children are not just talked at."

Mary Begley, who taught German, wrote

"It is clear that both methods are appropriate for the learning of the formation of the compound perfect tense in German, as has been demonstrated by my own implementation of the two approaches. However, as I already mentioned in my introduction, the characteristics of the subject matter to be taught are a major determinant of the suitability of expository or guided discovery forms of instruction. I feel that, in the case of teaching grammatical structures to students, the expository method is perhaps the most efficient, but not necessarily any more effective than the guided discovery method. It saves valuable time in the classroom and prevents complete confusion among 'slow' learners. I am teaching mixed ability classes and, therefore, feel it is very important to explain concisely and coherently complex structures including verb formation and word order for the benefit of my less able students."

Some support for this view is to be found in a comment by a Latin teacher. She found that expository was better than discovery and was disappointed. But she was not put off discovery and preferred to blame the material.

> "The Self Discovery learning method must not be discarded, I felt, just because of its failure in one particular instance. I have felt the interest and motivation as positively tangible in the classroom. Certainly, the method is less obviously of benefit to the learning of an ancient inflected and construction-full language. Nonetheless. it is a method I found challenging, which the class found stimulating. I intend to use it in the future for less recalcitrant material than the Accusative and Infinitive. Would that it had been tried earlier.
>
> Finally, the teacher's motto -
>
> "docto homini et erudito vivere est cogitare"
>
> (Cicero)
>
> "To the educated and learned person, life equals thought"
>
> - so we must search for the thoughtful approach to methodologies that will enable us to be truly reflexive practitioners (Vale)."

Similarly, work-sheets might be nearer to expository teaching than we might think. Students might perceive them to be in the expository mode. These are all matters for investigation. This applies also to the understanding of concepts and principles. Thus, while more students in the 89/90 and 90/91 studies reported that guided discovery was associated with greater understanding of concepts and principles, their tests were in the main conducted one week after the lesson, rather than between three and four weeks distant, and many failed to consider the implications of the span of time between the class and the test.

There seems to be substantial agreement over the seven year period of this study that the more able students learn equally well through both methods.The small differences in scores which were obtained in some reports might be accounted for by the fact that the groups were considered to be mixed ability.

The point is sometimes made that guided discovery gives students scope to probe and, in English, in particular, may enhance creativity. Ursula O'Brien wrote:

> "I think that this is partly due to my own experience of school, where there was little scope for independent thinking. Discovery and guided discovery learning refer to a set of methodologies aimed at stimulating inquiry and invention. Research has shown that learning by independent discovery is likely to facilitate more comprehensive understanding. From my experience of teaching Group II (by the guided discovery method), I have found that the level of intelligence and the time provided for attempts at discovery must be taken into account.
>
> In Group II, girls such as Caroline (we show her answers in Exhibit), who are very bright, did extremely well because they had sufficient freedom to probe that bit further (they were not limited to the progress being made by other members of the group). Caroline - 'I think there is not one but several themes running through the story - the choice between what's wrong and what's right, comparisons between different things (i.e. schools), corporal punishment, and when fiction becomes reality. I cannot take one of these interesting ideas out to hold up and say that this is the overall message the writer wants to get across, or the main storyline. These are interesting for me because I have not come across any of these ideas before, either in real life or fiction."

It might be thought that teachers of language would prefer to teach vocabulary either by rote or the communicative approach than discovery. On the contrary, as Niamh Meaney demonstrates, in respect of a vocabulary class:

> "The spot test was a simple vocabulary one. The pupils were given the fifteen items of vocabulary which I had taught in lesson 1.
>
> During the next phase, the pupils had to work on their own at the worksheet containing fifteen more items of vocabulary (see bottom half of vocabulary sheet). As can be seen, the vocabulary is in the same subject area. I was obliged to add in an extra item (namely, the duck's beak!) because I needed the very same number of vocabulary units in both lessons in order to be able to compare results successfully. This

constituted the "guided discovery" part of the whole exercise. The students were required to fill in the missing words. The above-mentioned "limited amount of guidance" I gave them was on the sheet in the form of pictures and letters. As I felt this was sufficient, I simply observed their work during this fifteen minutes.

Once they had all finished this exercise, we moved on to the final phase of the lesson. Here, in order not to break the atmosphere and to keep the attention firmly focused on the pupils, I asked for three volunteers to go to the top of the class and read out what they had written. Three girls thus took it in turn to read out five of the vocabulary items. My only intervention was to say whether items were correct or not and if incorrect, either ask for or give the corrected version myself. Luckily, I did not have to give many of them (only one or two) as the brighter students in the class were able to come up with them."

Having said that the weak were massacred by the discovery class, Sean Ruane, who had obtained better marks for the expository teaching of French to a class of thirty twelve year olds, came down in favour of much more discovery learning. He wrote:

"My results would seem to confirm that discovery strategies are favoured by stronger members of the class, although they may well not perform as strongly as equally able members might in an expository situation. The weak were massacred in my discovery class.

I tried to make the whole exercise as water-tight as possible. I managed to split the class along even lines; both classes were given the same day; I introduced an element of competition to avoid "cross-pollination"; I gave an expository class and a discovery class which were 'pure' if not extreme forms of the strategies; I gave an objective test.

Some qualifications are necessary, however: there does seem to have a been a quantum leap, a spark of realisation in those girls who were in the discovery group: this would indicate that perhaps if a little longer time were allowed, many of them might improve considerably; the question would then become: is it worth spending the extra time to allow pupils to discover for themselves? This is where I take my stand - I belive it is, because discovery itself is an art which can be anatomized, and a faculty which will improve with practice. It must form a greater part of our teaching. We can even educate for discovery" using expository methods!"

There is some evidence that relatively low achieving students are helped by guided discovery but the reports do not, when compared with each other, indicate the conditions under which success might be achieved. It may be that these exemplars will be as helpful to student teachers as a carefully constructed schema of what and when to do and, what and when not to do. The important finding is that by and large, teachers found they could do other things and recognised that their attitudes both towards their students and the technique contributed to both success and failure.

This point also needs to be explored. These attitudes extend to the conduct of the discovery classes, for teachers find it difficult not to interfere in their progress. They may also be inhibited by the fact that discovery classes can be noisy and have discipline problems. However, this does not seem to be a problem since many of these student-teachers utilise group methods of teaching.

One problem with discovery learning is that students can easily learn the wrong thing. It is important, therefore, that what it learnt is evaluated. Gemma O'Connor not only illustrates this point, but demonstrates how difficult it is to design lessons which do not lead students astray. She wrote:

"The first task the pupils had to do was to divide all the given verbs into two groups. The desired output was that students would notice that some verbs had an -eo/o- and others -f-. Most pupils could spot this as the difference. However, one pupil decided to group the verbs according to whether they were in plural or singular form. She was quite correct and this pointed out to me that in planning such a simple study again, that there should be only one difference. This incident will open my eyes wider to see a fuller picture which will enable me to examine examples more thoroughly and see if there are other factors which could lead pupils astray in given examples. Fortunately,, this pupil was sitting in the front desk and I could announce to the rest of the class they they were not to take the number of the verb into account, before I proceeded to examine what each individual child was producing.

As indicated above, the examination system encourages rote and expository methods of teaching. In these circumstances, it is not surprising to find that many student teachers report

expository teaching to be more useful for the preparation of students for the public examinations. This would match student expectations (see above).

Aileen Goode, who taught one class of 13-14 year olds and another of 14-15 year olds, reported that:

> "During the expository lesson, I felt that I was an important resource giving out information. The pupils were relying on the validity of this information for their exams. At this last fortnight, they perceived me as the key to a good exam result. It put me as the focus of attention and they were the parasites.
>
> During the guided discovery lesson, there was give and take between myself and the pupils. While they were working out the rules, I could relax and simply be present. I gave them a sense of power, by feeling they were taking their learning a step further."

She goes on to show how her role changed when she moved to a discovery approach. This change of role is noted by many teachers. Discovery learning, in its different disguises, was found to be very demanding.

Aideen O'Riordan wrote about her experience of guided discovery class in commerce that

> "This particular instructional strategy was far more demanding on me as a teacher than the expository method. I was in constant demand as many of the weaker students were simply unable to apply themselves to thinking things through. This is probably as a result of being weak students and also being used to being spoon-fed at school. At the same time, I was experiencing constant questioning from the brighter students, who were attempting to race ahead and were impatient for quick answers to the various hurdles they were meeting. I also had to attempt to evaluate the work of the middle of the road students who would be encountering problems but who would not ask questions. I assumed the role of a helper, evaluator and feed-back device, rather than that of an instructor.
>
> This method I found particularly time-consuming, as the whole procedure and understanding required for bank reconciliations is quite complex and many of the students were very slow to progress on the path of discovery, without a very substantial input and guidance from me. Therefore, at the end of the double period, very few students had managed to identify all the sources of information for the bank reconciliation. Very few people left the class with an understanding of or a general rule to apply to a bank reconciliation statement."

In particular, the change in role demands that in the discovery mode of learning more responsibility is given to the students. Andrew Purcell, who taught music, wrote,

> "It seemed that the boys and girls learned quickly, most of them, at least. They seemed to appreciate the responsibility that I placed in them though. One cheeky pupil said, on the way out, that I had not done anything during that class!

One of the reasons why students want expository learning is that even if the influence of the examination is discounted, they, like most of us fear change. This point was made by another teacher of German, Jacqueline Summer, who wrote:

> "Among the most successful of the class tests, those who were taught by the discovery method were able to replace articles and nouns e.g. die Arbeit = the work, with pronouns e.g. sie, es, ihn - it, while those who learned by the expository method were not able to induce or apply this grammatical point when doing the test. The word order was also more correct in most cases, as a result of the discovery teaching method.
>
> It seems, by focusing on the changes which must be made to the sentences and allowing the pupils to induce a rule, the pupils become more aware and less scared to change and alter the sentence. Because they work alone on inducing the exercise/sentence, they attain better results and understanding of the knowledge. Most pupils were obviously more involved and enjoyed this involvement which naturally is very advantageous and beneficial when learning. This did not appear to be the case when I was using the expository teaching method. The pupils were less active and therefore passive while attaining the knowledge. This appears to be disadvantageous for pupils with high achievement levels, who require a challenge and interaction in the learning process. This explains why those taught by the expository method performed less well in comparison to those who learned through the use of the discovery method. It must also not be ruled out that the discovery method was a new and different method to the usual teaching style

used by teachers (expository methods), so this variety always creates interest in the learners and helps them be more alert and retain the new knowledge. Adapting teaching styles to learning styles is also very vital. In concluding the relative effectiveness of inductive and deductive learning processes, one must emphasis that the differences in performance cannot be explained solely. Teaching processes must be distinguished by teachers between explaining processes and understanding processes. Inductive and deductive strategies can be used in combination with a variety of other instructional procedures. They can be used for only some of the learning desired."

She notes that new teaching methods can excite children, and others reported this to be the case. Of interest is her distinction between 'explaining processes' and 'understanding processes'.

Sean Ruane learnt that consultation with twelve to thirteen year old girls was profitable.

"As I began to despair of my ever being able to give the lesson to two groups of fifteen, one of the girls in my class came up with the answer.
She pointed out that the division between my class (Room 1) and the adjacent Room 2 was of the type which can be slid back and forth, like a curtain on a rail. What is more, the group which had up until then been using Room 2 for lessons at the same time as I was in Room 1 would not be there for the next Thursday - a day on which we have two periods of French together in Room 2. Even if this piece of research proves nothing, I have learnt that sharing problems with your pupils is not always to be regarded as a sign of weakness and may produce a solution the teacher might never otherwise find."

Ordinarily, both the student-teachers and their pupils find expository methods boring. Nevertheless, because of pupil expectations of the best methods for preparing them for their examinations, student-teachers find it very difficult to motivate them in the early stages of discovery or guided discovery learning. At the same time, once the initial difficulties have been overcome, children are much more enthusiastic to learn through either discovery or guided discovery, provided that they are not intimidated when they are left to use their own resources in discovery learning.

The work of these student-teachers provides overwhelming evidence that if discovery and guided discovery methods are to be successful, that children need continual training in them and that as they become older and approach and pass the Piagetian stage of formal operations, such training should embrace the fundamentals of learning how to learn.

It was found consistently in all the reports analysed that discovery methods of teaching, particularly those at a distance from expository methods, take more time for the same amount to be learnt than expository methods. Some students found it necessary to allocate more than one period. If it is eventually confirmed that principles and concepts are best learnt through discovery techniques, this finding will have immense implications for the construction of the curriculum and the design of the syllabus. In any event, the inclusion of discovery techniques in programmes of instruction is evidently justified by the motivation which they create alone.

Few students discussed gender. Kevin Molloy, who taught physics, found that at first girls lacked confidence in their practical work. He also found that in a difficult class of 15-16 year olds that guided discovery improved their attitude. There was an improvement in discipline. He wrote:

"I decided to use guided discovery and the method I used to achieve this was a worksheet. The material to be covered was electric circuits. I thought that the worksheet contained too much material but the students went through this material quickly and completed the worksheet a lot quicker than I expected. They liked the challenge of filing in the right words on the sheet and they were also 'doing something' all the time. I found a marked improvement in attitude, with some of the less able students. Their circuits worked and they gained motivation to fill in the worksheet. I also noticed that the girls were lacking a bit in confidence when setting up the circuits, they asked me for help more often, whereas the boys worked with a certain amount of confidence. This was a slightly worrying factor, because the girls in the class are intelligent. Overall, the worksheet was a success, the students like it and they worked at filling it in. I personally found the class less tense than normal.

Connections between the Activities:

No deliberate attempt has been made to encourage lateral transfer between the five lesson activities. In each year, some students do, however, make connections between them. Several of

the most recently reporting group drew a connection between the exercise on learning styles (Fitzgibbon, Heywood and Cameron; 1991) and this exercise. One wrote

> "Referring to the learning styles data collected during the first term, I found that both students in the discovery group who performed significantly better than expected were convergers, while the under-performing student in the expository group was an accommodator, which would seem to support the notion that learning styles do influence responses to different teaching styles. The numbers are, however, too small to base any firm conclusions on. It is, nonetheless, a very interesting observation".

Another took the student's learning styles as obtained from the Kolb inventory into account when allocating them to the experimental groups.

Three analyzed their data in terms of their students' learning styles. One, like the previous student, found that the convergers scored highest on the guided discovery section of her test, whereas the accommodators scored highest in the expository section. The other reported that in

> "the guided discovery class, the assimilators, convergers and accommodators did better than the divergers. For example, Aileen, the first student to crack the rule, is an assimilator .... on the other hand, Elaine, a diverger, who had great difficulties with the exercise, obtained the lowest mark. I would be of the opinion, judging from the results obtained, that students who have an enquiring mind and like to solve problems would benefit much more from guided lessons than students like divergers, who do not like having to solve problems and develop theories. Assimilators and convergers would enjoy this aspect while accommodators, I feel, would also prosper from discovery methods, as they would enjoy the variety and activities required of them. I think the person who enjoys theories and problems would benefit, not only as regards having better understanding of the new concept, but also by developing their problem-solving skills and theorising capabilities...."

Yvonne Moher wrote of her class in English that

> "It was very interesting to observe the differences in performance amongst the various learning styles. Although accommodators enjoy risk-taking, their reliance on other people for information, rather than their own analytic abilities, made the discovery task in group "B" quite daunting. They seemed more unsure of what was expected of them than the other girls in the group and some of them asked for help on several occasions. The opposite was the case in group "A:, where I guided the exercise by giving the students help with the prerequisite concepts and definitions. The assimilators, who are concerned with abstract ideas and concepts with practical application, seemed to work more comfortably in group "B" than in "A". Those in "B" enjoyed the groupwork activity and the opportunity to assimilate their observations into an integrated explanation. The assimilators in "A", I believe, found my close guidance a little suffocating, as they are less focused on people and more concerned with the abstract. The convergers, who enjoy problem-solving, decision-making and the practical application of ideas, seemed to gain more from the discovery exercise in group "B". They enjoyed the opportunity to focus on a problem, formulate a theory and discuss it in groups. The convergers in "A" were not given the same chance to develop their own explanation. The divergers made full use of the concrete experience in both groups (i.e. the photocopied sheet and their short-story books). Students in "A" and "B" were initially highly motivated. However, as the task unfolded, the divergers in "B" seemed to maintain their level of interest longer than those in "A". The girls in "A" were not given the same opportunity to develop their own ideas by observation as those in "B".

Esther Doyle, who taught accounting to a mixed group of boys and girls, found

> "the girls more enthusiastic and their results were better than boys of imilar ability in the discovery group - perhaps girls are more inquisitive and learn more than boys by this method?"

She went on to remark about their learning styles

> "I did discover that the converger in the discovery group was particularly good at solving the problem. Divergers in both groups got things done and put forward most alternative methods of doing the problem.
>
> Perhaps we must infer that certain learning styles will be better suited to different teaching styles."

These are interesting conjectures and, in spite of the problems encountered by students in the learning and teaching styles activity, it would seem that more structured studies of the influence

of learning styles on performance in different instructional environments would increase our understanding of the processes involved.

Concluding Comments:

Teachers bring knowledge, skill and attitudes to the classroom but so too do their students. Effective teaching, therefore, depends on the way in which teacher and class interact. This simple but important point is illustrated over and over again in these case studies. In a society which stimulates instant response, motivation becomes increasingly important in classroom learning, especially for low achievers who can become easily bored and lose attention. The perceptions of those students who seek success in public examinations conditions their attitudes to new approaches to learning. Over and over again these student-teachers report that such pupils expect to be passive in order to remember and in consequence, demand rote/expository teaching. It is self-evident that such teaching is not conducive to the development of independent learning. Therefore, changes in the technique of examining and assessment should help the teachers introduce alternative approaches to learning. The evidence suggests that while guided discovery and discovery techniques produce no better test results than expository methods, they do create a better learning environment more conducive to motivation.

Since many student-teachers use group-work in the discovery mode, this is an important contribution to that presently popular aim of higher education which is to encourage team work.

It is evident that just as the student-teachers need training in the different methods of instruction, so too do the pupils. The data in the 1992 reports shows that the student teachers are able to illustrate Wittrock's definitions within their own subjects at all age levels and that these may be sufficiently precise and helpful in the design of lessons. But it is also clear that they need to state the degree of involvement which they are prepared to allow their students to have.

If, over a period of time, they were to show the pupils these parameters of learning and get them to understand their importance in transfer, some improvement in the results of one method, as opposed to another, might be expected. Within this particular environment, teachers can be helped in this respect by the design of (public) examination questions which seek understanding and transfer, rather than memory. This dictum also applies to the structure of the presentations in textbooks. They can also help themselves by increasing the sophistication of their own designed tests. That they can do this is demonstrated in several of the reports.

In the context in which our student-teachers are trained, these classroom activities come as a shock to many. Not only are they faced with a different method of teaching, but with a different role. And for some, this role adjustment is considerable. It is only when they have completed this last activity that many come to appreciate that there are different styles of learning and teaching which have equal potential. Almost without exception, they demand more examples of what is required of them than is provided. By and large, the textbooks do not provide sufficient information about what is possible (except perhaps in the case of imagery) and they seek more examples of the reports than are provided (one per subject).

All learning depends on prior information. Even when a large amount of information is given, these lesson activities are exercises in discovery in almost the 'pure' mode. And as the reports show, these student-teachers need to have their work evaluated if there is to be meaningful, as opposed to nonsense learning.

Possibly discovery at the 'pure' end of the dimension is only possible in coursework which extends over a period of time. In any event, it is clear that discovery at any point in the continuum takes longer than expository teaching for the same thing. Therefore, those who advocate the understanding and skills which discovery supposedly develops need to take this into account in the design of syllabuses. In this context, the syllabus for the public examination dominated the attitudes of the teachers and the expectations of their pupils.

Although the majority of these reports cover the age range 12-15, inspection of the others over the eight years in which this activity has been undertaken suggests that these findings apply equally to the 16-18 year group. Neither is there any evidence to suggest that success/failure is

subject-specific. There are good examples of discovery and expository teaching to be found at all levels and in all subjects in these reports.

However, success depends on the particular concepts, principles and ideas chosen, rather than on any inherent difficulty in the matter of the subject.

By the time the course is completed, the student-teachers have only just begun to appreciate the potential of these different approaches to teaching. There is a need for them to continue with such studies in this probationary year if they are to be able to design lessons which will meet a wider range of objectives with confidence.

Learning depends on reinforcement. It seems, from the reports, that some of these student teachers do not sufficiently appreciate that a single attempt at a new method of teaching and learning is inadequate, both for them and their students. Both need to become accustomed to the new approach. There is also a need to reinforce what is learnt continually. Thus, one might expect students to benefit from the different modes of discovery learning if they understand what it is they have to do in terms, say, of Wittrocks table, and are guided to understand its meaning.

Shulman (1988) writes "An invisible college is created when the boundaries of the collegium are stretched beyond the walls of a shared building or department. A serious problem for teaching as a profession has been the absence of opportunities to communicate what has been learned from experience through literature that can be shared with colleagues at remote sights". The reports of our student-teachers which have been published and will be published in our monograph series do, in our opinion, make a substantial contribution to this invisible college.

Acknowledgements

References

Boffy, R. (1985) YTS Core Skills and Participative Learning *NATFHE Journal* November pp 22-23.

De Cecco, J.P. and W.R. Crawford (1974). *The Psychology of Learning and Instruction.* Prentice Hall; Engelwood Cliffs, N.J.

Heywood, J. (1991) Leaving Insularity Behind: A European Comment on the Lawlor Report in Coolahan, J. (Ed) *Teacher Education in the Nineties: Towards a New Coherence.* Association for Teacher Education in Europe/Mary Immaculate College of Education, Limerick. Brussels/Limerick.

Heywood, J. (1982) *Pitfalls and Planning in Student Teaching.* Kogan Page; London.

Heywood, J. (1992) Student Teachers as Researchers of Instruction in J.H.C. Vonk and H.J. van Helden (Eds) *New Prospects for Teacher Education In Europe* Universitaire Lerarenopleiding Vrije Universiteit: Association for Teacher Education in Europe: Amsterdam and Brussels.

Heywood, J., Fitzgibbon., A. and L.A. Cameron (1991) Experience versus Theory in Teacher Education. Student Teachers as Researchers pp 2-23. *Monographs of the Department of Teacher Education* No. 2, University of Dublin, Dublin: Ireland.

Kersh, B.Y. (1962) The motivating effect of learning by directed discovery. *Journal of Educational Psychology* 53,65.

McDonald, F.J. (1968) *Educational Psychology* Wadsworth; Belmont, Cal.

Shulman, L.J. (1970) Psychology and Mathematics Education in E.G. Begle (Ed) *Mathematics Education.* 69th Year Book of the National Society for the Study of Education Part 1. NSSE. University of Chicago Press: Chicago. Ill.

Shulman, L.J. (1988) Teaching Alone, Learning together: Agendas for reform in T.J. Sergiovanni and J.H. Moore. *Schooling for Tomorrow. Directing Reforms to issues that count.* Allyn and Bacon: Boston.

Suchman, J.R. (1961) Inquiry Training: Building Skills for Autonomous Discovery, *Merrill-Palmer Quarterly of Behaviour Development* 7, 147-169.

Wittrock, M.C. (1963) Verbal Stimuli in Concept Formation: Learning by Discovery *Journal of Educational Psychology* 54, 183-190.

Worthen, B.R. (1968) Discovery and Expository Task Presentation in Elementary Mathematics. *Journal of Educational Psychology Monograph supplement 11, 59.*

Notes

1) in the case of Bruner, to implement the enactive, ikonic and symbolic phases in a lesson and, in the case of Gagne, to design and implement a hierarchical model of instruction.

2) it will be possible to correct for the omissions in these tables from other reports at a later date. In any event, they are so few in number that they do not detract from the general findings.

3) notional and real assent as in J.H. Newman's *Essay in aid of a Grammar of Assent:* Longmans Green, London.

4) the sample size for the 1990/1991 questionnaire was 64: at the time of writing, the analysed sample for the 1991/1992 group was 50. No questionnaires on this lesson plan were administered previously.

5) This question was not included in the 1990/1991 questionnaire.

Exhibit 1

The Sequence of Each Lesson Plan Activity (Heywood, 1991)

1. ACADEMIC COURSE: Introduction to the Activity (2-4 hours)

2. STUDENT PREPARATION:

   a) Reads the literature on the designated topic;
   b) Select a small topic from the literature for investigation
   (This may be to replicate one of the studies reported in the literature)
   c) Design a lesson to test the hypothesis shown in b);
   (This to include the entering characteristics of the pupils, a statement of aims and objectives, the instructional procedures showing how they will test the hypothesis, etc.);
   d) Design a pupil test of knowledge and skill which is directly related to the objectives of the lesson.

3. ACADEMIC COURSE: (only if students require seminar) to iron out difficulties (2 hours)

4. STUDENT IMPLEMENTATION
   a) Implement Class as designed.
   b) Immediate Evaluation
      i) what happened in the class?
      ii) what happened to me?
      iii) what have I learned about myself?
      iv) what have I learned about my pupils?

5. ONE WEEK (OR SO) LATER
   a) Test students
   b) Substantive evaluation
      i) how does what I have done relate to the theory which I set out to evaluate?
      ii) how, if at all, will this influence my teaching in the future?
   c) Submit report at the required time.

6. ACADEMIC ACTIVITY
   Reports assessed using a criterion reference scheme.

7. ACADEMIC COURSE (two to three weeks later)
   a) Return assessed reports.
   b) Exercise in self-assessment with some lesson plans; return reports without assessment. Ask them and one other student, to mark their reports and compare with tutor's assessment.
   c) Ask students to complete an evaluation schedule.
   d) Overall evaluation in seminar by the tutor (1-2 hours).

ASSESSMENT SCHEDULE Lesson Plans 5 and 6.

NAME:.....

		Self Assessment OUT OF 10	Tutors Assessment
1.	*Methodology and Entering characteristics:* Detailed description of the methodology used for the comparison related to your ability ratings of the students, gender etc. (N.B. detailed descriptions of the students are not required as in the past.) (maximum score 10 up to 7 for Methodology up to three for entering characteristics.)		
2.	*Theoretical Understanding:* Brief Review of early research (i.e. as in Shulman, De Cecco and Crawford, or MacDonald) (maximum 10) Provision of Examples to illustrate Wittrock's table (See Shulman or *Pitfalls* p. 108) Examples *must not* be those used in the comparison. (maximum 10)	out of 20	
3. *Either or*	*Statement of objectives.* A common set of objectives. Two sets of objectives if the lessons are to be separate. (N.B. See 5 below)	out of 4	
4. *Either or*	*Test* A common test of the concepts or principles to be learnt. Two tests of the concepts / principles to be learnt if the lessons are to be separate.	out of 10	
5.	*Lesson Plans.* Outline Schema as in p. 152 of *Pitfalls* (Do not repeat objectives. Inclusion in the schema covers question 3 above) Each lesson plan must show clearly the strategy employed. Use definitions in the Wittrock table (p. 108 Pitfalls). Maximum of 8 marks for each lesson plan.	Lesson Plan 5 (8) Lesson Plan 6 (8)	
6.	*Statistics of the Test(s)* General statistics. Mean / S.D. of each group or lesson. (10 marks maximum) Interpretation of results. Are there gender / age differences?	out of 15	
7.	*Evaluation I* What happened to the students? What happened to yourself?	out of 10	
8.	*Evaluation II After test.* Do your results confirm or contradict the findings of previous research? How reliable are your results? Would you expect them to be repeated with other classes (similar, different age, different gender)? What insights into teaching have you gained from this activity?	out of 15	
9.	*Presentation:* Use of standard format (e.g. one side of A4, writing) grammar, spelling, neatness etc. *Deduct* up to 10 marks for poor presentation.		

Exhibit 3

a) Classes taught in the Comparison of Expository with Discovery Learning Exercise.

Year (approx. yrs)	1989/90	1990/91	1991/92
1 (12-13 yrs)	34	39	34
2 (13-14 yrs)	22	12	26
3 (14-15 yrs)	5	2	3
Transition year (Tyo)(15-16 yrs)	1	6	4
5 (15-16/16-17 yrs)	8	-	4
6 (16-17/17-18 yrs)	1	1	-
Adults	1	-	-
No information	2	6	-

b) Gender of Classes taught

	1989/90	1990/91	1991/92
Female	31	17	25
Male	9	22	19
Mixed	23	22	27
data not provided	10	16	5

Exhibit 4

Gender of Classes by subject, as indicated in the 1992 Reports.
(F = Female. M = Male and Mx = Mixed Fmale and Male).

GENDER OF CLASSES BY SUBJECT

	1st Year			2nd Year			3rd Year			4th Year/ TYO			5th Year			
	F	M	Mx	F	M	Mx	F	M	Mx	F	M	Mx	F	M	Mx	
R.E.		2	1													3
Irish	2		1													3
English	2	1			2	1									1	7
German	4	1			4				1							10** (12)
French	2			1	1											4
Spanish					2	1										3
Latin							1	1								2
Science	3		1	1	1	5						1				12
Maths		1	1	1	1							1				5
Econ./ Bus Stds.	1		2	1		2								1	1	8*(9)
Geog.	1		1							1						3
History		1	1			2						1			1	6* (7)
Music	4		1													5* (6)
	19	6	9	4	11	11	1	1	1	1	0	3	0	1	3	
Totals	F	25														
	M	19														
	Mx	27														

* data not provided for one 5th year Group in Econ. and one group in History and one in Music

** data not provided for two first year groups

Exhibit 5

Student Teacher Perceptions of the Achievement level of the classes.
(N.B. These questions were not asked in 1992).

Achievement Level	1989/90	1990/91
High	10	7
Low	7	2
Average	5	1
Mixed Ability: tending to high	13	15
Mixed Ability: equally balanced	34	24
Mixed Ability: tending to low	1	8
Remedial	1	0
Data not given	2	11

Exhibit 6

Subjects Taught in the Comparison
of Expository with Discovery Learning Exercise.

	1989/90	1990/91	1991/92
Religious Education	8	1	4
Irish	2	2	3
English	15	3	8
German	4	8	12
French	5	5	14
Spanish	-	2	3
Latin	-	-	2
Science	9	5	13
Maths	6	6	6
Economics/Business Studies	3	1	10
Geography	2	13	3
History	9	8	7
Music	9	7	7
Italian	-	2	-

Exhibit 7

The Student Teacher's Choice of Methods for Comparison
as analysed from the Reports.

Comparison between	1989/90	1990/91
Expository and Discovery	16	12
Expository and Guided Discovery	53	49
Discovery and Guided Discovery	2	3
Data not amenable to analysis	2	2

* In addition, in 1989/90, 9 students stated a particular method but conducted another.

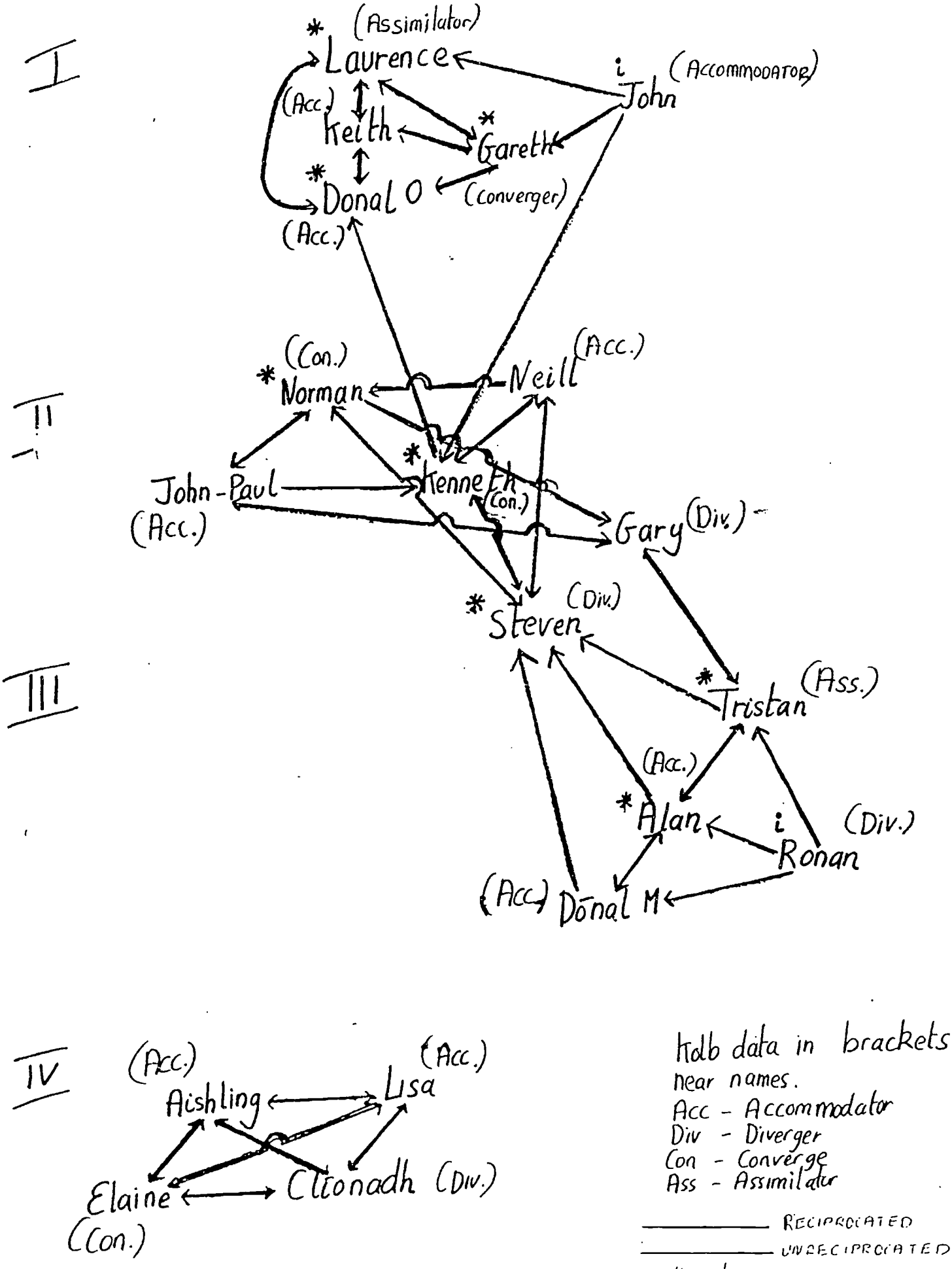

I
* (Assimilator)
Laurence
i (Accommodator)
John
(Acc.)
Keith
*
Gareth
*
Donal O
(converger)
(Acc.)
II
(Con.)
* Norman
Neill (Acc.)
* Kenneth
(Con.)
John-Paul
(Acc.)
Gary (Div.)
III
(Div.)
* Steven
* Tristan (Ass.)
(Acc.)
* Alan
i (Div.)
Ronan
(Acc)
Donal M
IV
(Acc.)
Aishling
(Acc.)
Lisa
Elaine
Clionadh (Div.)
(Con.)
Kdb data in brackets near names.
Acc - Accommodator
Div - Diverger
Con - Converge
Ass - Assimilator
RECIPROCATED
UNRECIPROCATED
* - stars
i - isolates

Exhibit 9

The test is divided into two parts, corresponding to the two evaluation measures referred to in the theoretical understanding section above. The first seeks to test the students' recall of the ratios referred to in class. The second asks the students to manipulate the ratios and use them to make an evaluation of a company based on figures drawn from its final accounts.

Q 1 (a) Write down the Return on Investment Ratio
(b) Write down the Stock Turnover Ratio
(c) Write down the Acid Test or Liquid Ratio

Q.2 (a) You are a Bank Manager and a company with the following figures comes to you, looking for a loan of £250,000 at 3% per annum. Do you give them the loan?

Capital Employed	£100,000
Net Profit	£20,000
Tax	£4,000

(b) If Debtors are £10,000 and average period given to debtors is 30 days, how much is Credit Sales?

Solution:

Q.1 (a) Net Profit/Capital Employed
(b) Cost of Sales/Average Stock
(c) Current Assets-Stock/Current Liabilities

Q.2 (a) The relevant Ratio is in the Interest Cover Ratio, which tells the Bank Manager the firm's capacity to pay back the loan. It is Net Profit/Fixed Interest Charges. I accept an answer of Yes or No, depending on the reason given.

(b) (10,000/Credit Sales) x 365 = 30
So Credit Sales = (10,000/30) x 365 = £121,666,67

Exhibit 10

Lesson Plan:
Entering Characteristics: As in previous lesson plans.
Class: 1B first year beginners French class. Ability range: Mixed - good. Sex:Female
Number: 29
Subject: French
Aids required: 1 collage of picture of food- labelled with the partitive article
1 collage of pictures of food,
1 labelled with the definite article
1 poster with the ruler for using the partitive printed on it, and examples.
1 tape with a recording of a restaurant conversation
Time: 40 minutes

Non-behavioural objective:

1. to make students aware of the use of the partitive article, where we would use the word 'some' in English or write nothing at all.
2. to give the students the opportunity to observe either, the rule for using the partitive article, or examples of it, or both, and hear the practical use of the article in a real situation.

Behavioural objective:

1. to describe when to use the partitive article
2. to construct a conversation in a restaurant or shop

Research aim:

to assess the effectiveness of expository, gui 1 discovery and discovery teaching in terms of class motivation and behaviour.

Lesson Phases	**Content**	**Learning Strategies**
Introduction	Explain to the class that we are continuing our study of French food. That we will learn how to order food in a restaurant and that we will divide the class in three groups of ten (approx) before we begin.	
Presentation	Group 1 will be given the collage with pictures and examples of the partitive articles in use. This is the 'guided discovery' group. Group 2. will receive the collage with the rules and examples of the partitive article in use. This is the 'expository' group. Group 3 will receive the collage with pictures and the definite article beside them. This is the 'pure discovery' group. The students are told that in French, instead of using the word 'some', they use the partitive article, either "des, de la, du or de l'". They must decide from looking at the collages which they should use and why.	3 groups but they work individually
Application	After 15 minutes of discussion. Students will listen to a recording, using the articles. They will be asked to listen and write down what each person orders. Then students from each group will carry out their own conversation and order something.	Listening and receiving Role playing
Conclusion	1.Students will be asked to write down what was ordered and whether du, de la, du or de l' was used. 2.Students asked to explain to me when and how to use the partitive article.	
Questioning	How do you say: "Some milk please" "Some sugar please" "I would like some coffee please"	

Exhibit 11

Analysis of Test Data Provided

	1989/90	1990/91
Little or no difference between the two methods	10	2
Guided Discovery much better than Expository (over 10% difference)	10	3
Expository much better than Guided Discovery	5	4
Guided Discovery a little better than Expository	24	16
Expository a little better than Guided Discovery	9	9
Guided Discovery much better than discovery in terms of % marks gained, even though little difference in the pass rate.	2	0
Discovery better than Guided Discovery	9	10
Not able to draw conclusions either way	1	1

Exhibit 12

Subjects taught, Instructional techniques and performance as indicated in the 1992 Reports.

Year 1— Diff. in Marks	Rel. Educ	Irish	English	German	French	Spanish	Latin	Science	Maths	Eco/ Bus Stud	Geography	History	Music	TOTALS
D> E				1					1	1				3
D≏E										1		1*		2
D < E					1					1				2
GD > E	3	1	1	3				3			1			12
GD≏E		1	1	2					1			1		6
GD < E		1	1	1				1			1			5
D > GD - E					1									1
Year 2—Diff in Marks														
D > E														
D≏E								1		1				2
D < E				1		1				2				4
GD > E			1		1	2		3				2**	5*	14
GD≏E				1				2	1			2		6
GD < E			2	1	1			1	1					6
D > GD≏E														
Year3—Diff in Marks														
GD > E							1							1
GD≏E				1			1							2
GD < E				1***										1
Year 4/TYO— Diff. in Marks														
GD > E								1	1					2
Year 5—Diff in Marks														
GD > E			1							1				2
GD≏E										1		1		2
GD < E										1	1			2
	3	3	7	12	4	3	2	12	5	9	3	7		75

Notes

Latin — taught to 14-15 year olds.

History/Music — * Test date not in one report. Based on Comments.

** Details of class not given: assigned from content.

German — *** Comparison between a large 2nd year class and a small first year class.

> score greater than; ≏ score approximately equal to < score less than

D=discovery GD = Guided Discovery E=Expository

Exhibit 13

Gender of the classes taught versus instructional techniques and performance

Gender of Class versus Performance

	Year & Performance	Female	Male	Mixed
1	D > E	1	1	0
	D - E	0	0	1
	D < E	1	0	2
	GD > E	8	3	4
	GD - E	3	0	3
	GD < E	6	0	0
2	D > E	0	0	0
	D - E	2	0	0
	D < E	0	3	2
	GD > E	0	4	4
	GD - E	1	2	3
	GD < E	2	4	2
3	GD > E	0	1	0
	GD - E	1	0	0
	GD < E	0	0	0
4/TYO	GD > E	0	0	1
	GD - E	0	0	0
	GD < E	0	0	1
5	GD > E	0	1	1
	GD - E	0	0	1
	GD < E	1	0	1
		26	19	26
	Gender not given	2 GD>E and GD/E	1 D>E	1 D<E

For Codes see Exhibit 8 footnotes.

NO	D	GD	EXP	CLASS	NO IN EACH TEST	MALES TOTAL	FEMALES TOTAL	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
1		✓	✓	Two separate classes 1.1 = Dis 1.2 = Exp	(1.2)=27 (1.1)=27	✓ ✓		First Year	Mixed Ability	Mean Exp 70.2 Mean GD 56.48	SD Exp 15.77 SD GD 14.58	Geography	100
2		✓	✓	One class divided into two groups	exp.=15 g.dis=15	1 1	14 14	First Year	Mixed Ability	Mean GD 60.00 Mean Exp 12.29	SD GD 12.70 SD Exp 12.29	Business Studies	100
3		✓	✓	Divided one class into two groups	exp.=13 g.dis=13		✓ 26	First Year	Mixed Ability	Mean GD Class as a Whole Mean Exp Mean=15.3	SD EXP SD=66	German	23
4		✓	✓	Divided one class into two groups	exp.=12 g.dis=12		✓ 24	First Year	Mixed Ability	Mean GD 6.9 Mean Exp 5	SD GD 1.50 SD EXP 1.58	German	10
5		✓	✓	Two classes used for each part of test	exp=25 g.dis.=24	✓ 14 13	✓ 10 17	First Year	Mixed to Poor Ability	Mean Gd 9 Mean Exp 4.9	SD EXP 2.7 SD EXP 2.7	German	10
6		✓	✓	Divided one class into two groups	exp=10 g.dis=10	✓ 20		First Year	Mixed Ability	Mean Gd 5.8 Mean Exp 6.8	SD GD 0.7 SD EXP 0.5	History	10
7		✓	✓	Divided one class into two groups	exp.=13 g.dis=14	✓ 27		First Year	High Ability	Mean Gd 37.64 Mean Exp 33.91	SD GP 6.11 SD EXP 8.21	History	10
8		✓	✓	Divided one class into two groups	exp.=9 g.dis.=8		✓ 17	First Year	Mixed Ability	Mean GD 12.6 Mean Exp 9.4	SD GD 1.53 SD EXP 1.56	Music	50
9		✓	✓	Divided one class into two groups	exp =16 g.dis=16		✓ 16	Second Year	Mixed Ability	Mean Gd 57% Mean Exp 70%	SD GD 17.7 Sd Exp 20.06	Music	
10		✓	✓	Split the class into two groups	exp =12 g.dis =12		✓ 24	First Year	Medium Ability	Mean GD Results all together Mean Exp Mean =3	Sd GD All together SD EXP SD = .7	History ?	5
11		✓	✓	Divided one class into two	exp =15 g.dis =15		✓ 30	First Year	Mixed Ability	Mean GD 63.7 Mean Exp 59.5	SD GD 11.54 SD EXP 12.54	Music	80
12		✓	✓	Two classes split in half	exp =29 g.dis =27	NA	NA	First Year	Mixed Ability	Mean GD 48.94 Mean Exp 51.74	SD GD 18.1 SD EXP 15.06	Music	100

D	D	GD	EXP	CLASS	NO IN EACH TEST	MALES TOTAL	FEMALES TOTAL	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
13		✓	✓	One class split in half	exp =8 g.dis =8		✓ 16	Trans-ition Year	Mixed Ability	Mean Gd 53.75 Mean Exp 80.25	SD GD 15.06 SD EXP 13.68	Maths	100
14		✓	✓	One class split into two	exp =4 g.dis =5		✓ 9	Trans-ition Year	Mixed Ability	Mean Gd 34.4 Mean Exp 61.25	SD GD 3.3 SD EXP 2.8	Maths	100
15		✓	✓	Divided one class into two	exp =16 g.dis =15	6 8	10 7	First Year	Mixed Ability	Mean Gd 79 Mean Exp 63.1	SD GD 13.22 SD EXP 13.6	Maths	100
16		✓	✓	Two separate classes	exp =23 g.dis =22	12 13	11 9	First Year	Mixed Ability	Mean Gd 69.6 Mean Exp 76.8	SD GD 20.82 SD EXP 18.72	Maths	100
17		✓	✓	Divided one class into half	exp =13 g.dis =13		✓ 26	First Year	Mixed Ability	Mean Gd 7.0% Mean Exp 7.2%	SD GD NA SD EXP NA	Science	10
18		✓	✓	Divided one class into half	exp =23 g.dis =13	✓ 26		First Year	Mixed Ability	Mean Gd 6.6 Mean Exp 53	SD GD 13 SD EXP 12..8	German	100
19		✓	✓	Same class did both methods	12		✓ 12	Second Year	Mixed Ability	Mean Gd 5.5 Mean Exp 2.6	Sd-GD 5.7 SD-Exp 2.8	Spanish	7
20		✓	✓	One class split intwo groups	1=15 2=15		✓ 30	First Year	Mixed Ability	Mean GD 66% Mean Exp 66%	SD-GD NA SD Exp NA	Maths	100
21		✓	✓	One class split into two groups	(1)=10 (2)=10	✓ 20		First Year	Mixed Ability	Mean GD 67.5 Mean Exp 71.25	SD GD NA SD Exp NA	Science	100
22		✓	✓	Divided one class into two groups	(1)=10 (2)=10		✓ 20	First Year	Mixed Abiliy	Mean GD 64.9 Mean Exp 84.5	SD-GD 16.9 SD-Exp 16.1	Science	100
23		✓	✓	Divided one class into two groups	(1)=13 (2)=12	✓ 25		First Year	Above Average	Mean GD Mean & SD Mean Exp Group mean=60.5	SD-GD for Whole SD Exp SD =11.2	Electronics	100
24		✓	✓	One class did both methods			✓ 12	Third Year	Mixed to V. Weak Ability	Mean GD Mean & SD Mean Exp Group mean =19	SD-GD For Whole SD-EXp SD=4	Irish	26

NO	D	GD	EXP	CLASS	NO IN EACH TEST	MALES TOTAL	FEMALES TOTAL	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
25		✓	✓	One class did both methods		✓ 16		First Year	Mixed Ability	Mean Gd 74.68 Mean Exp 68.75	Sd-Gd 11.8 SD-Exp 14.41	Irish	100
26		✓	✓	Split the classs into two	Exp=8 Gd=10		18 ✓	First Year	Low Achievers	Mean Gd 8.05 Mean Exp 7.94	Sd-GD 2.23 Sd Exp 1.59	Science	12
27		✓	✓	One class split into two	Exp=10 Gd=12	8 ✓	19 ✓	First Year	Mixed to High Achievers	Mean GD 43.04 Mean Exp 39.2	SD-GD 19.52 SD Exp 21.22	Irish	90
28		✓	✓	One class did both			✓ 23	Second Year	Mixed Ability	Mean Gd Mean and Mean Exp Mean=17.4	Sd-GD Sd together SD-Exp Sd=2.3	Geography	20
29		✓	✓	One class divided into two	Divided in two (1)=8 (2)=8	✓ 2	✓ 17	First Year	Mixed Ability	Mean GD 4.33 Mean Exp 4.3	Sd-GD 1.27 SD-Exp 1	Geography	7
30		✓	✓	Two classes, one for each method	30 in each group	✓ 30 ✓ 30		First Year	Low to Middle Ability	Mean GD 4.5 Mean Exp 6.3	SD-GD 15 Sd-Exp 10.4	French	10
31		✓	✓	Divided one class into two groups	15 in each	✓ 20	✓ 10	Second Year	Top Stream	Mean GD 6 Mean Exp 6	Sd-Gd 1.5 SD-Exp 1.7	French	10
32		✓	✓	One class did both tests	24	✓ 12	✓ 12	First Year	Mixed Ability	Mean GD 43 Mean Exp 45	SD-GD 14.5 SD-Exp 35.17	English	100
33		✓	✓	One class split into two groups	13=D 13=Exp			Second Year	Mixed Ability	Mean GD 69 Mean Exp 78	SD-GD 12.73 SD-Exp 21.67	Maths	100
34		✓	✓	Two classes for the two different methods	2.1=G 2.3=Exp	2.1=31 2.3=28		Second Year	Mixed Ability	Mean GD NA Mean Exp NA	SD-GD NA SD-Exp NA	Geography	100
35		✓	✓	Two separate lessons, but with same class	(1)=28	✓ 19	✓ 9	First Year	Mixed Abiliy	Mean GD 55.6 Mean Exp 58.57	SD-GD 9.06 SD-Exp 9.29	Geography	100
36		✓	✓	One class divided into two groups	(1)=11 (2)=11	✓ 11	✓ 11	First Year	Mixed Abiliy	Mean Gd 16.09 Mean Exp 16.63	SD-GD 2.06 SD-Exp 2.38	Geography	20

D	D	GD	EXP	CLASS	NO IN EACH TEST	MALES TOTAL	FEMALES TOTAL	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
37		✓	✓	One class divided into groups	'1)=14 (2)=14	✓ 28		Second Year	Mixed Abiliy	Mean GD 5.08 Mean Exp 5	SD-GD 1.65 SD-Exp 1.35	History	10
38	✓		✓	One class divided into two	(1)=10 (2)=10			NA	Mixed Ability	Mean GD 57.44 Mean Exp 34.39	SD-GD 5.75] SD-Exp 5.48	Irish	50

Exhibit 15 (1991-1992)

	D	GD	EXP	WHOLE/SPLIT CLASS	NO IN EACH TEST	MALES TOTAL	FEMALES TOTAL	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
1		✓	✓	Two whole classes Exp (1) Xavier G. Dis. (2) Loyola	 25 25	 ✓ ✓		NA	NA	Xavier 5.32 Loyola 8.3	Xavier 4.86 Loyola 5.45	Latin	20
2	✓		✓	Two whole classes (1) Aylmer (2) Finlay	 25 25	 ✓ ✓		First Year	Mixed Ability (Both)	Finlay Exp Mean 8.7 D. Mean 6.5	Finlay Exp 1.6 Discovery 1.79	English	
3		✓	✓	One class split into two groups Group A = Exp Group B = Dis	Exp 16 Dis 16		✓	Fourth Year	NA	Mean =4.7 class as a notcompar e(incomple te statistics	But takes whole does	English	
4		✓	✓	One class used both methods with every student	30	14	16	Second Year	Mixed Ability	Boys mean 41.91 Girls mean 52.38	SD Boys 22.63 SD Girls 17.46	History	100
5		✓	✓	One class used both methods with every student	18	7	11	Fifth Year	Pass Level	GD Mean 56.72 Exp Mean 54.9	No S Deviation	History	100
6		✓	✓	Lesson A Expository Lesson B G Dis.		12 10	6 2	Second Year	Very capable Less Confident	Group A 46 Group B 59.9	Group A $\frac{577}{11}^2$ Group B $\frac{599}{10}^2$	History	
7	✓		✓	One class split in two Group A = Dis Group B = Exp	 14 14	 ✓ ✓		First Year	Mixed Ability	Dis Mean 37.8 Exp Mean 40.5	Dis SD 15.7 Exp SD 15.7	Religion	100
8		✓	✓	One class split in half Group A = Dis Group B = Exp	13	14	12	First Year	Mixed Ability	Dis Mean 6.23 Exp Mean 5.85	Dis SD 1.85 Exp SD 2.03	History	
9	✓		✓	Divided the class in half, both studied Exp and Dis	14 14	✓ ✓		First Year	Above Average	Group A 58 (Exp) Group B 69 (Dis)	Group A 16.9 (Exp) Group B 4.8 (Dis)	RE	100

	D	GD	EXP	WHOLE/SPLIT CLASS	NO IN EACH TEST	MALES TOTAL	FEMALES TOTAL	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
10	✓		✓	One class divided into two Group A Dis Group B Exp	 11 11	 5 6	 6 5		Average	Dis Group A 21 Group B 18 Exp	No S.D.	RE	100
11		✓	✓	Two classes 1S Dis 1H Exp	 22 20	 14 9	 9 11	First Year	Above average	DIS Group A 51.31 Exp Group B 158.78	Group A 319.45 Group B 309.45	Geography	100
12	✓		✓	Same class Both methods used, two different days	12		✓	Fifth Year	Average and below average	Exp Section A 32.30 Dis Section B 24.6	Section A 7.45 Section B 8.6	Geography	100
13	✓		✓	Same class divided into two groups	15 15		✓ 30	First Year	Mixed Ability	Group (1) Exp 54 Group (2) Dis 71	Group (1) Exp 20.5 Group (2) Dis 20.1	Music	100
14		✓	✓	Same class divided into two groups	8 (A) 8 (B)		✓ 16	First Year	Mixed Ability	Group A Exp 65 Group B Dis 79	Group A NA Group B NA	Music	100
15		✓	✓	Same class divided into two groups	12 (A) 13 (B)	20	5	First Year	Mixed Ability	Group A Exp 58.3Group B GD 66.2	Group A 11 Group B 13.5	Music	100
16		✓	✓	Divided one class into two halves Group 1 and Group 2			✓	First Year	High	Group 1 6 Group 2 (SD) 9.1	Group 1 1.48 Group 2 (SD) 2	Music	10

	D	GD	EXP	WHOLE/SPLIT CLASS	NO IN EACH TEST	MALE	FEMALE	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
17		✓	✓	One class divided into 2 groups Group A and Group B	13 in each test	11	15	First Year	Mixed Ability to good	Group A GD 5.7 Group B Exp 6.3	Group A 2.6 Group B 2.1	Maths	10
18		✓	✓	Same class used both methods 1 class G, 1 class Exp	30		✓ 30	Second Year	2nd Stream	Exp 13.32 GD 11.67	Exp 2.2 GD 2.5	Maths	20
19		✓	✓	Divided the class into two groups Group A = 15 Group B = 14	Test A = 15 Test B = 14	✓ 29		Second Year	Higher Band of Mixed Ability	Exp GroupA 35.21 Group B GD 40.1	Group A 28.96 Group B 20.27	Maths	100
20		✓	✓	Same class given both methods	25	✓ 8	✓ 17	Transitio n Year	Mixed Ability	Mean Dis 84% Mean Exp 72%	Gd-Dis .916 SD-Exp 17.59	Maths	100
21	✓		✓									Religion	100
22	✓		✓	Two classes taught in two different methods	Dis Learning 25 Exp 11	10 NA	15 NA	Second Year	Mixed Ability	GD Mean 88 Exp Mean 76	EXp Sd 18 SDGD 16	French	Marks out of 70 converted into %
23				One class taught both methods- Lesson 2 - GD Lesson 1 - Exp	30		✓ 30	First Years	High Achievers	GD Mean 8 Exp Mean 12	GDSD 3 Exp SD 3.5	Irish	20
24		✓	✓	One group divided into 2 parts, 15 in each group 1=Exp Group 2=Dis	15 15		✓ 30	First Years	Very high	1 Mean Exp 19.4 Mean Grp11 17.3	SD Exp 2 SDGD 2.73	English	30
25	✓		✓	One class used both methods Divided into two	30÷2 =15	12	18	Fourth Years	Mixed Ability	Mean GD 69 Mean Exp 59	SDGD 24.73 SD Exp 24.64	Physics	100
26		✓	✓	One class divided into two	Exp 11 Dis 10	5	16	Second Years	Mixed to High Ability	Mean G B 50.5 Mean Exp 67%	SDGD 16.9 SD Exp 20.6	Commerce	100

	D	GD	EXP	WHOLE/SPLIT CLASS	NO IN EACH TEST	MALE	FEMALE	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
27		✓	✓	Divided the class into two groups (Pre-tested as well as post-tested)	12 13		✓ 25	First Years	Mixed Ability	Pre Test Mean Gd 40 Mean Exp 43 Test Mean Gd 50 Mean Exp 55	Pre Test SDGD 15 SD Exp 10 Test SDGD 17 SD Exp 8	German	100
28		✓	✓	Two classes used, one for each method	28 (1) 28 (2)	✓ 28 in each		Second Years	Mixed Ability	Mean GD 5.4 Mean Exp 6.3	SDGD 1.2 SD Exp 1.8	German	10
29		✓	✓	One class split into two groups	13 (1) 14 (2)	16 ✓	11 ✓	Second Year	Mixed Ability	Mean GD 4 Mean Exp 6	SDGD 1.47 Sd Exp 1.04	English	10
30		✓	✓	One class split into two groups 1 = Exp. 2 = GD	6 (1) G (1)	✓ 12		Second Year	High Ability	Mean GD 67% Mean Exp 68%	SDGD 11 SD EXP 12	German	20 converted to %
31		✓	✓	One class split into two groups	8 (1) 8 (2)		✓ 16	First Year	Mixed Ability	Mean GD 78% Mean Exp 68%	SDGD 15.3 SD EXP 20.2	Science	100
32		✓	✓	One class split into two groups	Group 1 Dis 10 Group 2 Exp 10	16 ✓	4 ✓	First Year	Low to Average Ability	Mean GD 66.6% Mean Exp 58%	SDGD 13.7 SD EXP 11.7	Science	100
33		✓	✓	One class split into two, 8 and 9	8 9	✓ 15	✓ 2	Second Year	Good	Mean GD 5.9 Mean Exp 6.1	SDGD 1.6 SD EXP 1.5	Science	10
34		✓	✓	Divided one class into two groups	6 (1) 6 (2)	✓ 12		Second Year	Mixed Ability	Mean GD 6.15 Mean Exp 4.5	SDGD 1.72 SD Exp 1.36	Spanish	10
35		✓	✓	Divided the class into 2 groups Group (1) = Exp Group(2)= GD	15 (1) 15 (2)	✓ 17	✓ 13	First Year	Mixed Ability	Mean GD 64.57 Mean Exp 62.13	SDGD NA SD EXp NA	Irish	100

	D	GD	EXP	WHOLE/SPLIT CLASS	NO IN EACH TEST	MALES TOTAL	FEMALES TOTAL	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
36	✓	✓		Divided the class into two Group (1) = Exp Group (2) = Dis	8 (1) 8 (2)		✓ 16	Second Year	Mixed Ability	Mean D 73 Mean Exp 74%	SD G 14 SD Exp 18	Science	100
37		✓	✓	Divided class in two	NA			Second Year	Mixed Ability	Mean GD 64 Mean Exp 56	SD GD 7.2 SD Exp 9	Science	100
38		✓	✓	Used two separate first year classes	15 (1) 15 (2)		Class (1) 15 Class (2) 15	First Year	Mixed Ability	Mean GD 58% Mean Exp 62%	SD GD 22 SD Exp 18	Science	100
39		✓	✓	One class divided into two Group A = Dis Group B = Exp	9 (1) 9 (2)			Second Year	Mixed Ability	Mean GD 75% Mean Exp 17.35 11	SD GD 81% SD Exp 15.49 11	Science	100
40	✓		✓	Divided the class into two halves	12 (1) 12 (2)	✓ 10	✓ 10	Second Year	Mixed Ability	Mean D 68.5 Mean Exp 59	SD D 8.76 SD Exp 11.5	Science	100
41		✓	✓	One class divided into two halves (1) Exp (2) Dis	10 (1) 10 (2)	✓ 20		Second Year	Mixed Ability	Mean GD 70 Mean Exp 62.9	SD GD 5.55 SD Exp 11.42	Spanish	100
42		✓	✓	One class, both methods	30		✓ 30	First Year	High Ability	Mean GD 76.03 Mean Exp 55	SD GD 12.9 SD Exp 21.7	German	
44		✓	✓	Same class taught in both manners	Tested all in both	✓ 31		First Year	Mixed Ability	Mean Gd 17.9 Mean Exp 12.25	SD GD 2 SD Exp 2	German	30
45		✓	✓	Divided the class into two	12 (1) 12 (2)		✓ 24	First Year	Mixed Ability	Mean GD 6.5 Mean Exp 6.4	SD GD 2.3 SD Exp 2.1	History	10
46		✓	✓	Divided one class into two halves	NA	NA	NA	First Year	Top Stream	Mean GD NA Mean Exp NA	SD GD NA SD Exp NA	German	21
47		✓	✓	Divided one class into two halves	7 absent 11 (1) 11 (2)		✓ 29	First Year	High Ability	Mean GD 45.5 Mean Exp 48.23	SD GD 13.48 SD Exp 8.62	Irish	60
48		✓	✓	Divided one class into two halves and one group into 3	13 (1) 13 (2)	NA	NA	First Year	Mixed Ability	Mean Gd 78 Mean Exp 75	SD GD 6 SD Exp 10	Commerce	100

	D	GD	EXP	WHOLE/SPLIT CLASS	NO IN EACH TEST	MALES TOTAL	FEMALES TOTAL	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
49		✓	✓	Two first year classes were used	32 (1) 32 (1)	NA	NA	First Year	Mixed Ability	Mean Exp 18 Mean GD 18	SDGD 8 SD Exp 8	German	100
50		✓	✓	Used two separate first year classes	30 (1) 30 (2)	NA	NA	First Year	Mixed Ability	Mean GD 4.56 Mean Exp 4.23	SDGD 0.89 SD Exp 0.83	German	6
51		✓	✓	Same group twice but only one set of stats.		✓ 11	✓ 13	Second Year	Mixed Ability	Mean GD 7.4 Mean Exp NA	SDGD 2.2 SD Exp NA	Science	12
52		✓	✓	One class divided in two halves	5 (1) 5 (2)	2	8	Fifth Year	Mixed Ability	Mean GD 6 Mean Exp 7.5	Sd GD 2.28 Sd Exp 2.05	Accounting	10
53		✓	✓	The class divided into two but tested on two separate occasions	15 (1) 15 (2)	16 ✓	✓ 14	Third Year	Mixed Ability	Mean GD NA Mean Exp 12.3	SDGD 0.69 SD Exp 0.75	German	20
54		✓	✓	Split one class in two halves	(1) = 13 (2) = 13	✓ 12		Second Year	Mixed Ability	Mean GD 9.92 Mean Exp 8.08	SDGD 6.95 SD Exp 5.38	German	20
55		✓	✓	Two classes used for the two tests	(1) = 15 (2) = 17			First Year	Mixed Ability	Mean GD 73% Mean Exp 66%	SDGD 12.8% Sd Exp 17.97	Science	100
56		✓	✓	One class divided into two groups	(1) = 15 (2) = 15		✓ 30	First Year	Mixed Ability	Mean GD 33.3 Mean Exp 68.8	Sd GD 27.23 SD Exp 16.02	French	100
57	✓		✓	Two separate classes, two tests each. 3rd years taught by D and E	2nd (1)=26 (2)=27 3rd (1)=6 (2)=5	✓ 17		2nd and 3rd Year	Mixed Ability	Mean D (15.2)-(16) Mean Exp 64 (14)	SDD 12.4(2.7) Sd Exp 5.12(3.8?)	German 2nd Year 3rd Year	70 and 22 22 and 21
58	✓	✓	✓	Three groups in one class (French)	1-5 GD 2-10 Exp 3-10 PD		✓ 29	First Year	Mixed to Good Ability	Mean GD 10.6% Mean Exp 10.89%	SDGD 4.3% SD Exp 3.4	Mean D 16.7% D - SD 2.4%	20
59		✓	✓	Two classes, one for each method	(1) 18 (2) 18		✓ 18 18= 36	First Year	Mixed Ability	Mean GD 60.0 Mean Exp 61.52	SDGD 3.78 SD EXp 2.55	Sentence Maths English	100
60		✓	✓	One class divided into two	(1) 13 (2) 13		✓ 26	First Year	Mixed Ability	Mean GD 45 Mean Exp 44	SDGD 3 SD Exp 6	German	100
61		✓	✓	One class studied both methods	(1) 10	✓ 6	✓ 10	Second Year	Mixed Ability	Mean Gd NA Mean Exp 5.54	SDGD NA SD Exp 5.53	Spanish	10

	D	GD	EXP	WHOLE/SPLIT CLASS	NO IN EACH TEST	MALE	FEMALE	YEAR	ABILITY	MEAN	SD	SUBJECT	TEST MARKS OUT OF
62	✓		✓	Two classes, separate method to each	(1) 20 (2) 21	4.1A 11 4 3B 13	9 8	Trans - ition Year	Mixed Ability	Mean D 74.5 Mean Exp 75.57	SD D 7.11 SD Exp 12.08	Business Studies	100
63		✓	✓	One class split into two halves	(1) 7 (2) 7		✓ 14	First Year	Mixed Abiliy	Mean Gd NA Mean Exp NA	SD GD NA SD Exp NA	Business Studies	100
64	✓		✓	One class split into two halves	(1) 11 Exp (2) 10 Dis		✓ 21	Second Year	Mixed Abiliy	Mean GD 8.7 Mean Exp 16.4	SD GD 7.4 SD Exp 7.3	Business Studies	30
65		✓	✓	Same class did both methods	29	16	13	Fifth Year	Mixed Ability	Mean GD 6 Mean Exp 4.5	SD-GD 1.5 SD-Exp 2	English	10
66		✓	✓	Divided class into two halves	(1) 13 (2) 13	✓ 26		Second Year	Mixed to Low Ability	Mean GD 14.5 Mean Exp 12	SD-GD 2.2 SD-Exp 2.8	English	20
67		✓	✓	Into two groups one class	(1) 9 (2) 16		✓ 24	Second Year	Mixed Ability	Mean GD 67.16 Mean Exp 71	SD-GD 17.24 SD-Exp 19.70	French	100
68		✓	✓	Split the class into half	(1) 14 (2) 14	NA	NA	NA	Mixed Ability	Mean GD 87 Mean Exp 87	SD-GD - SD-Exp -	Business Studies	100

Appendix A Examples of Statistical Presentation

Example 1. From two lessons in French by Geraldine Nolan

Discovery Method Group

	X	F	FX	d	d	Fd
91-100	95.5	1	95.5	23.5	812.25	812.25
81-90	85.5	2	171	18.5	342.25	684.5
71-80	75.5	1	75.5	8.5	72.25	72.25
61-70	65.5	5	327.5	-1.5	2.25	11.25
51-60	55.5	2	111	-11.5	132.25	264.5
41-50	45.5	0				
31-40	35.5	0				
21-30	25.5	1	25.5	-41.5	1722.25	1722.25
			806			3567

$$\text{Mean} = \frac{806}{12} = 67.16$$

$$\text{S.D.} = \sqrt{3567} = \sqrt{297.25} = 17.24$$

$$\text{SD} = \underline{17.24}$$

Expository Method Group

	X	F	FX	d	d	Fd
91-100	95.5	3	286.5	24.5	600.25	1800.75
81-90	85.5	1	85.5	14.5	210.25	210.25
71-80	75.5	2	151	4.5	20.25	40.5
61.70	65.5	0	-	-	-	-
51-60	55.5	4	222	-15.5	240.25	961
41.50	45.5	0	-	-	-	-
31-40	35.5	1	35.5	-35.5	1260.25	1260.25
21-30	25.5	0	-	-	-	-
			780.5			4272.75

$$\text{Mean} = 780.5 = 70.95 = \underline{71}$$

$$\text{SD} = \sqrt{\frac{4272.75}{11}} = \sqrt{388.43} = \underline{19.70}$$

Example 2.

From lessons in Economics given to two separate transition (fourth year) classes by Alan Cox.

Lesson Plan 5 Fourth Year Transition Class A - Pure Discovery

Student	% Mark	$\lvert x_i - \bar{x} \rvert$ (=x)	x^2
1	76	1.5	2.25
2	78	3.5	12.25
3	82	7.5	56.25
4	69	5.5	30.25
5	63	11.5	132.25
6	70	4.5	20.25
7	83	8.5	72.25
8	86	11.5	132.25
9	72	2.5	6.25
10	74	0.5	0.25
11	81	6.5	42.25
12	68	6.5	42.25
13	62	12.5	156.25
14	67	7.5	56.25
15	78	3.5	12.25
16	67	7.5	56.25
17	87	12.5	156.25
18	72	2.5	6.25
19	78	3.5	12.25
20	77	2.5	6.25
N = 20	$\sum x$=1490		$\sum x^2$ =1011

Mean

Using the formula;- $\frac{\sum x}{N} = \frac{1490}{20} = 74.5\%$

Standard Deviation

Using the formula;- $\sqrt{\frac{\sum x^2}{N}} = \sqrt{\frac{1011}{20}} = \sqrt{50.55} = 7.11$

Example 3 Fourth Year Transition Expository

(Student	% Mark	$\|xi-\bar{x}\|(=x)$	x^2
1	83	7.43	55.20
2	94	18.43	339.66
3	72	3.57	12.74
4	61	14.57	212.28
5	76	0.43	0.18
6	82	6.43	41.34
7	58	17.57	308.70
8	78	2.43	5.90
9	92	16.43	169.94
10	85	9.43	88.92
11	78	2.43	5.90
12	80	4.43	19.62
13	95	19.43	377.52
14	69	6.57	43.16
15	65	10.57	111.72
16	63	12.57	158.00
17	49	26.57	705.96
18	70	5.57	31.02
19	67	8.57	73.44
20	81	5.43	29.48
21	89	13.43	180.36
N = 21	$\sum x=1587$		$\sum x^2 =3065.24$

Mean

Using the formula;- $\frac{\sum x}{N} = \frac{1587}{21} = 75.57$ (to two decimals)

Standard Deviation

Using the formula;- $\sqrt{\frac{\sum x^2}{N}} = \frac{\sqrt{3065.24}}{21} = \frac{\sqrt{145.96}}{} = 12.08$

Thus, the mean and this distribution is 75.57 and the standard deviation 12.08 (both correct to two decimal places).

Example 4 from two lessons in German

Marks, Percentages and Grades of Test Results for Expository Method of Teaching:

1	46/50	92%	A
2	46/50	92%	A
3	42/50	84%	B+
4	44/50	88%	A-
5	24/50	48%	D
6	50/50	100%	A+
7	44/50	88%	A-
8	44/50	88%	A-
9	48/50	96%	A+
10	40/50	80%	B+
11	44/50	88%	A-
12	46/50	92%	A
13	48/50	96%	A+

Marks, Percentages and Grades of Test Results for Guided Discovery Method of Teaching:

1	42/50	84%	B+
2	46/50	92%	A
3	42/50	84%	B+
4	44/50	88%	A-
5	46/50	92%	A
6	48/50	96%	A+
7	46/50	92%	A
8	42/50	84%	B+
9	44/50	88%	A-
10	48/50	89%	A+
11	40/50	80%	B+
12	48/50	96%	A+
13	50/50	100%	A+

Mean Mark for Expository Method:

46
46
42
44
24
50
44
44
48
40
44
46
48
566 ÷ 13
43.5 Mean = 44

Mean Mark for Guided Discovery Method:

42
46
42
44
46
48
48
42
44
48
40
48
50
588 ÷ 13
45.2 Mean = 45

Standard Deviation for Expository Method:

X	f	d	d^2	fd^2
50	1	6	36	36
48	2	4	16	32
46	3	2	4	12
44	4	0	0	0
42	1	-2	4	4
40	1	-4	16	16
24	1	-20	400	400
				500

$$\frac{\sqrt{500}}{13} = \sqrt{38.46} = 6.2$$

Standard Deviation = 6

Standard Deviation For Guided Discovery Method:

x	f	d	d^2	fd^2
50	1	5	25	25
48	3	3	9	27
46	3	1	1	3
44	2	-1	1	2
42	3	-3	9	27
40	1	-5	25	25
				109

$$\frac{\sqrt{109}}{13} = \sqrt{8.38} = 2.89$$

Standard Deviation = 3

The Frequency with which the marks occur using the Expository Method

x	f
50	1
48	2
46	3
44	4
42	1
40	1
24	1

The Frequency with which the marks occur using the Guided Discovery Method:

x	f
50	1
48	3
46	3
44	2
42	3
40	1

Appendix B Examples of the application of Wittrocks Tables

(a) Wittrock's Table

Type of Guidance	Rule	Solution
Expository teaching	Given	Given
Guided discovery	Given	Not given (deductive)
Guided discovery	Not given	Given (inductive)
'Pure' discovery	Not given	Not given

(b) Examples

Example (i) German due to Martin O'Brien

1. Expository: Giving the student the knowledge required to decline the present tense of a German very, e.g. begin, and the answer, also verb. begin - auf deutsch- beginnen. beginnfen. beginn - stem (without 'en')

	Rule			Solution
I	ich	stem	+ e	ich beginne
(informal) you	du	stem	+ st	du beginnst
he	er	stem	+ t	er)
she	sie	stem	+ t	sie) beginnt
it	es	stem	+ t	es)
we	wir	stem	+ en	wir beginnen
you (pl)	ihr	stem	+ t	ihr beginnt
they	sie	stem	+ en	sie beginnen
you (formal)	Sie	stem	+ en	Sie beginnen

Memorize the above pattern and apply rule to the verb arbeiten (work) - thus making rote learning meaningful learning.

Example 2.
Guided Discovery (deductive)
Rule is given. Solution is not.

Present tense of learn i.e. lernen.
lerner = infinitive
Rule

1) Remove the 'en' ending from the verb in its infinitive state.
You are left with the stem.

2) Add the following endings to the stem

Present Tense	
ich	stem + e
du	stem + st
er	stem + t
sie	stem + t
es	stem + t
wir	stem + en
ihr	stem + t
sie	stem + en
sie	stem + en

3) Applying the above rule, decline the verb lernen in the present tense, i.e. solve the problem = solution.

Example 3
Guided Discovery (inductive)
Rule is not given. Solution is.

Below please find the present tense of the German verbs - schreiben (write) and sagen (say). Using the information, decipher a rule for the declining of the present tense.

	Schreiben		Sagen
ich	schreibe	ich	sage
du	schreibt	du	sagst
er	schreibt	er	sagt
sie	schreibt	sie	sagt
es	schreibt	es	sagt
wir	schreiben	wir	sagen
ihr	schreibt	ihr	sagt
sie	schreiber	sie	sagen
Sie	schreiben	Sie	sagen

Example 4
'Pure' Discovery
What are the present tense endings for german verbs?
Students must investigate and arrive at the rule and the solution, without interference from the teacher/

"I regard guided discovery as being more manageable than 'pure' discovery. I wonder if one risks thinking without learning in this case. I wonder also if, in the case of discovery, could a false rule or incorrect solution be discovered and considered correct by a student who is unsupervised, hence the question of guide, as opposed to expository teacher." (M. O'Brien)

Example (ii) Mathematics due to Rosario Quigley

Example (scientific)	Instructional type	Rule	Solution
physical calculation: To calculate area of a square, give students rule [area = L x B] e.g. $250cm^3$ =50x50 cm	Exposition	Given	Given
students deduce rule by applying the rule of [area = length x breadth] samples ie. length =12, breadth = 12cm	Guided Discovery Deductive	Given	Not given
Give students a sample question as follows [length = 5cm, breadth = 5cm] area = 25 cm^3 (inductive)	Guided Discovery Inductive	Not Given	Given
Provide children with several wooden squares, let them calculate area by 1) measuring length and breadth, then measure area, using ruler	Pure Discovery	Not Given	Not Given

Example (iii) Mathematics due to Patricia O'Brien

"In between expository and 'pure' discovery is a method of guided discovery and, along with the degree of guidance, we also have different sequences of instruction which contribute to the variety of methods. Four possibilities, as stated by Wittrock, are explained here.

Expository both rule and solution given, commonly called 'chalk and talk' method. An example would be to teach differentiation by firstly demonstrating differentiation by first principles, say $y = x^2 + 4x$, $y + sy = ...$, then $sy = ...$, allow pupils to practice. Then teach rule $y = x^m$,, $dy = mx^{m-1}$ etc. and do and explain examples clearly on board, again allowing pupils to practice and reinforce ideas by correcting all questions on board and allowing pupils to take down corrections.

Guided discovery is split into two methods defined by sequence of instruction: Deductive, rule given but solution not. Using the topic above, we would supply the rules for differentiation, giving no examples. The pupils would work through question of increasing difficulty. Inductive, rule not given but solution is. The pupils would be given a table functions and their derivatives. e.g.

y^2	$2x$
x^4	$4x^3$
$2x^2$	$4x$
$2x^4$	$8x^3$

and asked to find the rule.

'Pure' discovery, since differentiation would be very hard to explain as discovery. I will give a more simple example. Take the concept of commutativity, the pupils are given a sheet of sums, say

1+2, 2+1, 2 + 3, 3 + 2.
1 x 2, 2 x 1, 2 x 3, 3 x 2.
1 - 2, 2 - 1, 2 - 3, 3 - 2.
1/2, 2/1, 2/3, 3/2

and asked to draw some conclusions about the operations."

Example (iv) Spanish due to Phyllis Steffanazi

Examples (Spanish)
An example of Expository would be to conjugate the verb 'tener' on the board and ask the pupils to repeat and then question the different 'persons' of the verb.

An example of
Deductive Guided Discovery would be to give the students the rule: tener que + the infinitive = to have to do something, and ask the pupils for examples.

Guided Discovery Inductive. An example would be to give the students several sentences involving "ser" and "estar" which both mean "to be" and ask the students to induct when they use one or the other.

Pure Discovery. Ask the students to work out the meaning of a new Spanish word in a sentence, without using a dictionary.

Example (v) Language Teaching Generally, due to Geraldine Nolan

"The term, 'discovery' itself is instructionally ambiguous when attempting to define 'discovery learning', two dimensions must be distinguished. The first is the degree of Guidance. Wittrock has suggested that we characterize the degree of guidance in terms of whether the rule and the solution to the problem being taught are given. There are four possibilities. When both the rule and the solution are given, the teaching method is thoroughly expository. For example, a teacher wishes to teach the grammatical point "Adjectives describe or qualify nouns". Using the expository approach, he would give the definition of an adjective to the students and, as in the case of French language, he would tell them the position of the adjective in a sentence and the fact that it agrees with the noun and then follow it up with plenty of examples. The teacher could also choose to define what is meant by an adjective, its position etc. and then get the students to identify various examples. This approach is labelled as guided discovery, where students use deduction to develop an understanding of the principle. Also, using the guided discovery approach, the teacher might present a series of words describing nouns and then ask the children to infer the definition of an adjective and the children will use inductive processes to arrive at this definition. The last possibility is called "pure" discovery. In this case, neither the rule nor the solution is given. As in the 'adjectives' example, a teacher might present the students with a piece to read, which contains various examples of adjectives and pupils will discover the definition (rule) and when they are used, i.e. examples (solution)".

Example (vi) Economics and Business Studies due to Alan Cox

"In economics, for example, inflation may be taught in a number of ways.
(i) Exposition -
the teacher could explain the effects of rising prices and how they are caused.

(ii) Deductive Guided Discovery -
the teacher explains the causes and types of inflation and leaves the class to work at the effects and consequences.

(iii) Inductive Guided Discovery -
the teacher elaborates the inflation-dominated situation and encourages the class to determine why this came about.

(iv) Pure Discovery -
the teacher employs the T.W.P. (Totally Worthless Paper) simulation game to allow the students to discover for themselves inflation, as well as its effects and consequences.

Similarly, in Business Organisation, the topic of marketing may be conveyed using,
(i) Exposition -
the teacher explains how markets work and why it is important for firms to adopt the correct marketing mix to maximise sales revenue.

(ii) Deductive Guided Discovery -
the teacher explains how markets work, but encourages pupils to decide the appropriate response (which, in my experience, will always be something very close to adopting the appropriate marketing mix).

(iii) Inductive Guided Discovery -
the teacher explains the marketing mix concept to the class, but asks them to establish why this approach should be tried.

(iv) Pure Discovery -
the teacher gives the class a product and asks them to market it using whatever methods they like around the school. Afterwards, in class discussion, the teacher reiterates the relevant material for comprehension and learning. I tried this approach last year and it worked very well. The children marketed charity Christmas cards around the school and learnt a lot from their experience and from my demands for them to use the proper marketing mix.

Example (vii) History for a Junior Class due to Deirdre Power

Examples to illustrate Wittrock's Table

Expository
Presentation (lecture/paper) on the interpretation of archaeological remains, illustrated with examples of finds/evidence from a simple house site and the interpretation of the individual pieces of evidence
*Both rule (evidence) and solution (interpretation) given.

Guided Discovery (deductive)
A number of finds and details of features from a simple house site are presented. Pupils are told that conclusions can be drawn and guided by questions. What shape was the house? Where was the fire? What food did the people eat?
*Rule (evidence) given but solution (interpretation) not.

Guided Discovery (inductive)
Descriptive account (or mock archaeological synthesis report) of a simple house site with various conclusions - size, plan of house position of fire, diet of inhabitants. Pupils to suggest how the archaeologists knew?
*Rule (evidence) not given, solution (interpretation) given.

Discovery
Pupils to research life in medieval or pre-medieval Ireland (e.g. someone living in a simple house in Viking Dublin). Direct pupils towards books, the National Museum for sources.
*Rule (evidence) not given, solution not given.

Example (viii) English due to Catherine Roche

In English, one simple set of examples to illustrate this table could be given using the learning aim of "pronouns take the place of nouns in a sentence". The table would then be as follows:
Expository teaching
In class, I would tell pupils that pronouns replace nouns and subsequently offer examples, demonstrating the rule at work. Probably a series of positive and negative examples would be most useful, as in concept-teaching previously. Moreover, throughout the class, instructions would be teacher-oriented, as I would be the person giving the pupils both the "rule" of pronouns and the "solution" of examples of the usage. The pupils do not "solve" the examples for themselves, largely, although this could still be a part of expository teaching, which is not synonymous with rote learning.
Guided Discovery: (Deductive)
In this situation, I would again give the pupils the rule about pronouns replacing nouns and then let the pupils 'solve' the 'problem', without telling them the 'solution' mutually. Thus, the pupils would have to use deductive reasoning, working from a series of examples and learning to identify examples of pronouns, knowing only that they replace nouns. This is a common teaching method and is certainly not synonymous with leaving children alone to work out everything with the teacher not offering assistance or help.
Guided Discovery (Inductive)
Similar to deductive guided discovery. In this method, the pupils would again be given an initial 'help' and left to work in some measure by themselves. In this particular situation, I would present a series of examples to the pupils, which show words replacing nouns (the 'solution') and then ask the pupils to use inductive reasoning to define 'pronoun' - thus working out the 'rule' for themselves, with limited guidance from me.
Pure Discovery
For this strategy, I would not tell the pupils what a 'pronoun' is or does, but rather let them work with words and examples until they could identify a particular type of word which was acting in a certain way. Only after they had 'solved' the problem for themselves and realised the 'rule' would I volunteer the word 'pronoun' and refine the definition they had discovered through the 'solutions'.

Example (ix) Irish due to Gemma O'Connor

This example involves the use of the preposition "do" which means "to" in Irish and which aspirates most nouns that follow, depending on the initial consonant of the noun. Before a vowel the preposition will lose its vowel and noun and preposition allide, e.g. do + Aine = d'Aine. These are two rules to be found therefore.
In expository teaching, I would give pupils the rule i.e. tell them "do" aspirates, or allides and give the solutions i.e. examples of nouns where this does and doesn't happen for each consonant and vowel. Using guided discovery, deductive mode, I would tell the class the rule that "do" aspirates but allow them deduce from examples what consonants do not become aspirated and what happens to vowels. Adopting the guided discovery, inductive method, I would present the class with examples of nouns aspirated and unaspirated by "do" in sentences or as part of a short-story and ask them to create the rule concerning the effect of "do" on nouns beginning with different consonants and vowels. With pure discovery, I would group pupils, ensuring that there is at least one pupil of high ability in each group. I would then ask pupils to write as many sentences as they can, using "do" (about 15) and see if they can see a pattern. Hopefully, the high ability student will be able to help weaker students by providing correct examples. Pupils should then be able to see the effect of "do" on nouns and form the rules.

Example (x) Business Studies due to Miriam McDermott

Rule	Solution	Type of Guidance
"Gross Profit" equals, [Net sales - Cost of sales]	Handout of an example	Exposition
"Working capital" in the Balance Sheet equals [Current Assets - Current Liabilities]	Not given No sample	Guided Discovery (Deductive)
Not given No specification that the difference between the N.P. and the Dividend goes to a Revenue Reserve A/C	Handout of an example of a "Profit and Loss Appropriation account" Displaying: that net profit Less: Dividend = Balance is posted to the Revenue Reserve A/C	Guided Discovery (Inductive)
Not given Dividend calculation = X% x figure for issued share capital	Not given No sample	Pure Discovery

11
Comparing Guided Discovery and Expository Methods: Teaching the Water Cycle in Geography

by

Iain Donovan
(Higher Diploma Student 1991-1992)

1. Entering Characteristics

The research method adopted for the lesson plan project involved teaching the same topic to two classes of approximately equal ability, using guided discovery learning for one class and expository teaching for the other. The intention was to give each class the same test one week after the relevant lesson in order to ascertain which learning strategy was more effective in achieving the common objectives.

1T and 1M are first year Junior Certificate classes. I teach geography to the former three lessons a week but I teach the latter only once a week as another teacher takes their two other geography lessons. The school is a fee-paying secondary school run by nuns and all the pupils are female. There is no entrance examination nor is streaming practised; thus, 1T and 1M are mixed ability classes.

The topic chosen for the project was the water cycle. This was part of the final section of the first year course as organised by myself, namely 'weather'. 1T had covered somewhat more of this section than had 1M by the time of the water cycle lesson, but I did not deem this to be significant: the water cycle is a relatively straightforward topic that requires only basic previous information, which all pupils had acquired. 1 M were taught the water cycle lesson in an expository manner whereas 1T were given a guided discovery lesson on the topic.

There are 26 pupils in 1T and 25 in 1M. 24 pupils in 1T were present for the water cycle lesson and all these pupils were also present for the test. Only 20 pupils out of 1M were present for both the lesson and the test.

2. Theoretical Background

2.1 Introduction

The differences between discovery, guided discovery and expository methods of teaching and learning are usefully summarised in Merlin Wittrock's schema presented in Heywood (1982, p. 108) (table 1 below).

Table 1: Differences between discovery, guided discovery and expository methods (after Wittrock)

Type of Guidance	Rule	Solution
Expository	Given	Given
Guided Discovery (deductive)	Given	Not given
Guided Discovery (inductive)	Not given	Given
Pure discovery	Not given	Not given

The purpose of this chapter is to expand upon the differences between these various teaching methods. The discussion will begin with a treatment of the characteristics of discovery learning and the ideas of its principal exponent, J.S. Bruner. The expository method will then be examined, with particular reference to the theories of D.P. Ausubel and R.M. Gagne.[1] Examples of each method will be supplied and the evidence of comparative research will be presented. Finally, an overall evaluation will be attempted by way of conclusion.

2.2 Discovery learning

> Mastery of the fundamental ideas of a field involves not only the grasping of general principles, but also the development of an attitude toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own.... To instill such attitudes by teaching requires something more than the mere presentation of fundamental ideas. Just what it takes to bring off such teaching is something on which a great deal of research is needed, but it would seem that an important ingredient is a sense of excitement about discovery - discovery of regularities of previously unrecognized relations and similarities between ideas, with a resulting sense of self-confidence in one's abilities (Bruner 1960, p. 20).

Thus wrote Jerome S. Bruner, the 'prophet' of discovery learning, over three decades ago. Discovery learning did not originate with Bruner but he has been its most prominent supporter and theorist (Shulman 1970). In the tradition of Platonic idealism, he views the most abstract ideas as inherently simple and, indeed, believes that any subject matter can be taught in some intellectually honest form to a child of any age (Heywood 1982, 1984). This is because, according to Bruner, understanding is based on reason, not experience. Students should not be taught what is "out there" but encouraged to discover "what is in their own heads" (Bruner 1972, p. 72). Thus, skills are more important than content, education is about process not product, and the process of knowing is the process of discovery. Beyond such general theoretical outlines, discovery learning is not easily defined. Shulman (1970) calls the term "instructionally ambiguous" (p. 65), while De Cecco and Crawford (1974) ask whether discovery is a method of teaching, a method of learning, or something that you learn. Even Bruner himself rather too glibly remarked that "I am not quite sure I understand anymore what discovery is and I don't think it matters very much" (Bruner 1972, p. 68). This is nonsense: of course it matters, it matters a great deal. Unless we know what we are talking about when we refer to 'discovery learning', we cannot estimate its place or value in education.

"In its broadest interpretation," observes Heywood (1982), "discovery seems to relate to the presentation of a problem to a pupil which the pupil then solves on his own" (p. 109). As Heywood implies, however, there are varying degrees of discovery. De Cecco and Crawford (1974) recognise this explicitly: "Discovery learning refers to those teaching situations in which the student achieves the instructional objective with limited or no guidance from the teacher" (p. 355). Pure discovery involves no guidance; guided discovery involves limited guidance.

Exponents of discovery learning say that it improves the intellectual potency and intrinsic motivation of the child, and that it leads to better retention of knowledge. But some subjects may be better placed to avail of such putative advantages than others. Discovery learning seems to be best suited to mathematics, science and environmental studies (Cohen and Mannion 1983). However, Bruner (1972) claims wider application for discovery methods.

Criticism of discovery learning has not been limited to its narrow scope and imprecise definition. David Ausubel has made a particularly scathing indictment:

> ... learning by discovery ... has its own elaborate mystique. Its legitimate uses and advantages have been unwarrantedly extrapolated to included educational goals, levels of intellectual maturity, levels of subject-matter sophistication, and levels of cognitive functioning for which it is ill-adapted - and for reasons which derive from sheer dogmatic assertion; from pseudonaturalistic conceptions about the nature and conditions of intellectual development; from outmoded ideas about the relationship between language and thought; from sentimental fantasies about the nature of the child and the aims of education; and from uncritical interpretation of the research evidence (Ausubel 1968, p. 467).

He goes on to expose what he calls the 12 untenable arguments of discovery theorists. These are as follows:

1. All real knowledge is self-discovered.
2. Meaning is the product of creative, non-verbal discovery.
3. Subverbal awareness is the key to transfer.
4. Discovery is the main method for transmitting subject matter content.
5. The primary goal of education is problem-solving.
6. It is more important to teach discovery heuristics than subject matter.
7. Every child should be a creative and critical thinker.
8. Expository teaching is authoritarian.
9. Discovery organises learning effectively for later use.
10. Discovery alone generates self-confidence.
11. Discovery is the prime source of intrinsic motivation.
12. Discovery ensures memory conservation.

It would be a mistake to view Ausubel as a reactionary defender of 'chalk and talk' methods who denies discovery learning any value whatsoever. In the first place, as shall be seen in section 2.3 below, Ausubel's concept of expository teaching is *not* 'chalk and talk'. Furthermore, he believes discovery methods *have* a role to play in education, for "certain

designated purposes and for certain carefully specified learning situations" (Ausubel 1968, p. 467). Such situations include the early stages of learning any abstract matter and the teaching of scientific method and problem-solving. Thus, even the critics of discovery learning do not entirely rubbish its value.

2.3 Expository teaching

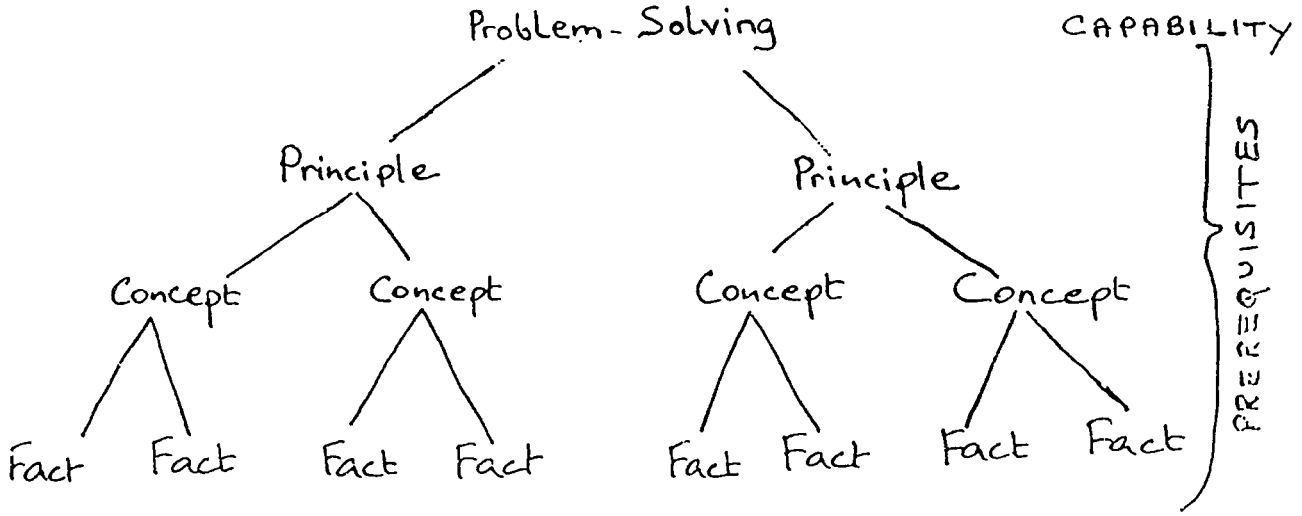
It is customary to talk of discovery *learning* but expository*teaching*. The terminology indicates the substantive distinction. Speaking in generalisations, if *"the student is always right"* in discovery (Keller 1968, p. 88) then the teacher is always right in expository; the teacher, not the child, is the source of learning. Under an expository method, "the teacher presents the student with the entire content of what is to be learned in final form" (De Cecco and Crawford 1974, p. 356). Proponents of such methods claim that expository teaching is more efficient and less time-consuming than discovery learning.

D.P. Ausubel has already been mentioned as an expository theorist. Unlike Bruner, Ausubel takes a *product* view of knowledge. This does *not* mean that he advocates rote memorisation but, rather, 'meaningful verbal learning'. Robert Gagne accords with Bruner by emphasising *process* as an educational objective but agrees with Ausubel on the tactics or instructional methods required. This is because, unlike Bruner, Gagne is an empiricist: he emphasises experience as the source of understanding and can therefore be placed in the Aristotelian or neobehaviourist tradition. Consequently, Gagne is usually associated with Ausubel as a supporter of expository teaching (Shulman 1970; Heywood 1982).

Gagne and Ausubel stress the importance of systematic guidance and the clear sequencing of instructional experiences. For Bruner, discovery or problem-solving is the starting-point of education; for Gagne and Ausubel it is "the final step in a sequence of learning that extends back through the many prerequisite learnings that must have preceded it" (Gagne 1977, p.164)(figure 1 overleaf).

Ausubel is not as strictly bound by the hierarchy as Gagne: his use of advanced organizers for 'ideational scaffolding' involves beginning at a higher point in the sequence. However, their views on instruction are relatively similar when set against those of Bruner, which essentially invert the hierarchy in figure 1.

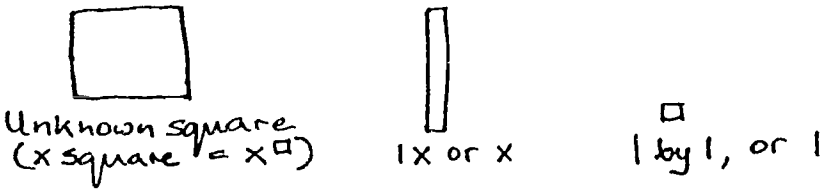
Figure 1: Expository teaching as an instructional hierarchy (after Shulman 1970)



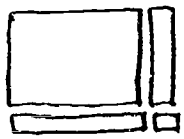
2.4 Examples

Discussion of the discovery-expository controversy has been theoretical so far. Now it is apposite to present some practical examples of the different methods.

Shulman (1970) gives a detailed example of discovery learning in a mathematics class of eight-year olds. The children are given three types of wooden shape:



After playing with these shapes, the children are asked whether they can make larger squares with x by using any number of the other shapes. The children should come up with this solution:



The teacher suggests that they note this as $x^2 + 2x + 1$. He/she also suggests that this can be expressed as $(x+1)(x+1)$. This children then continue making squares such as:

A pattern emerges

$x^2+2x+1 = (x+1)(x+1)$

$x^2+4x+4 = (x+2)(x+2)$

$x^2+6x+9 = (x+3)(x+3)$

From their experience of playing with the shapes, the children themselves should appreciate this pattern and thereby learn something about quadratic equations and mathematical regularities.

Expository techniques in mathematics include the time-honoured memorisation of multiplication tables (rote learning) and doing problems or 'sums' in order to paractise any procedure (e.g. long division) which the teacher has initially demonstrated (meaningful learning).

Boffy (1985) presents an example from the realm of technical training. It concerns the construction of a toolbox. Trainee A is told exactly what tools to use and how to use tem, what assembly parts are needed and how to assemble them, and is closely checked and corrected by the tutor during the assembly stage. Trainee B considers designs for a toolbox, chooses one, selects the appropriate tools and materials, and assembles the toolbox with advice and guidance from the tutor where necessary. Boffy calls the technique used in the case of trainee B 'participative learning', but oviously it could also be described as guided discovery. Trainee A, by contrast, obviously learns by an expository method.

Bruner (1972) himself presents an example of a discovery lesson in geography. A sixth-grade class was taught about the socio-economic geography of the south-eastern U.S. in a conventional manner. The class was then introduced to the north-central region by being asked to locate major cities on a map of physical features and natural resources but with no place names. The ensuing discussion generated a number of theories regarding the locational requirements of a city.

Student-teacher responses in Heywood (1982) contain further examples:

1. In an English poetry lesson the teacher may give an analysis of the poem (expository) or the students may try to 'solve' the poem unseen (discovery).

2. History generally requires expository teaching but drama and projects are discovery methods that can be used, albeit with some necessary guidance.
3. The use of worksheets in science is an example of guided discovery learning.

Worksheets can be used in other subjects. I often give them to the first year history and geography classes I teach but they generally require recourse to a textbook- does this make them more expository than discovery? The dividing line between the two methods is not always easily determined. Guided discovery is often less a variant of one method (discovery) than a combination of both.

2.5 Research

As Heywood (1982) notes, there is relatively little research on different learning strategies. Furthermore, the research that has been done is equivocal.[2] De Cecco and Crawford (1974) claim that most experiments show that discovery learning is better than expository teaching whereas Ausubel (1968) asserts otherwise, at least with regard to pure discovery. He goes on to say that further research is needed to determine whether guided discovery is better than simple didactic exposition.

Ausubel is right: further research is necessary. But some tentative conclusions can be drawn in the meantime. In the late 1950s B.Y. Kersh taught problems involving arithmetical and geometrical relationships to three groups which he termed 'no-help', 'direct reference' and 'rule-given', i.e. pure discovery, guided discovery and expository respectively. The direct-reference group performed best, followed by the no-help group. Thus, "transfer of learning to new situations was facilitated by independent discovery" (McDonald 1965, p. 207). A few years later, Kersh conducted a similar project although this time there wasn't any 'no-help' group. Again, the guided discovery group did better than the 'directed-learning' group in the recall and application of generalisations. However, the control group of 'rotelearning'students performed best of all! At about the same time, Suchman did research into 'inquiry-training' but the results were inconclusive. In experiments in the mid-1960s, Donald Johnson and Paul Stratton found a mixture of expository and discovery methods to be better than either one or the other (McDonald 1965; De Cecco and Crawford 1974).

Taking all these studies into consideration, we may agree with Heywood (1982) that "such evidence as there is suggests that some kind of guidance is likely to be more effective than no guidance at all" (p. 111). Guided discovery seems to be better than the extremes of pure discovery and expository teaching.

2.6 Conclusion

In attempting to evaluate learning strategies, I think one must take into consideration other factors as well as the direct effect on the intellectual performance of students. One such factor is pupil interest or motivation which can, of course, influence achievement. "Learning by discovery," wrote R.F. Dearden in 1976, "characteristically aims to engender intrinsic interest" (quoted in Cohen and Mannion 1983, p. 127). This clearly echoes Bruner's position: "I think that the reward that comes from using materials, discovering regularities, extrapolating, and so forth, is intrinsic to the activity" (Bruner 1972, p. 77). As one would expect, however, Ausubel (1968) disagrees strongly. Not only does he claim that there is no association between discovery and intrinsic motivation and between reception learning and extrinsic motivation, but he postulates exactly the opposite kind of relationship. Who is right?

In my opinion, the level of pupil interest or intrinsic motivation is related to innovation and originality. Children like a change, as long as it is not too radical or permanent.[3] Given that expository teaching still holds sway in most schools, it is not surprising that the level of interest may increase during a discovery lesson. But if discovery learning was predominant, I do not doubt for one moment that children would welcome an occasional dose of didactic exposition. The key to motivation in this regard seems to be *variation*.

Other factors that must be considered are the time taken to teach a discovery lesson as against an expository lesson with the same objectives, and the amount of preparatory work involved. These are not theoretical considerations but they may explain why, in reality, expository is more widely practised than discovery. The fact is that teachers generally have a limited amount

of time to get through a set syllabus. According to McDonald (1965), "learning through inductive processes appears to take longer than learning the applications of a given rule or generalization" (p. 210).[4] Ausubel (1968) explains why:

> In reception learning (rote or meaningful) the entire content of what is to be learned is presented to the learner in final form.... The essential feature of discovery learning ... is that the principal content of what is to be learned is not given but must be discovered by the learner *before* he can incorporate it meaningfully into his cognitive structure (p. 22).

Also, in my opinion discovery learning demands more preparation from teachers, especially in terms of imagination and creativity, thereby imposing a time constraint out of the classroom as well as in it. Thus, many more teachers might use discovery methods if they simply had less subject matter to teach or more time to do it in.

Finally, I want to introduce a note of concord into the debate between discovery and expository methods. The discovery-expository dichotomy is actually an illusion; it is not a dichotomy at all but a continuum.[5] Rather than staking claims to polar extremes, it seems to me that Bruner and Gagne/Ausubel have been fighting for the middleground. This is not to say that there are no differences between them, but perhaps the differences are not as pronounced as we have been led to believe. Advocates of discovery learning admit the need for considerable teacher involvement. As Cohen and Mannion (1983) have noted, discovery learning doesn't just happen. Boffy's (1985) distinction between trainee A and trainee B is not quite as clearcut as it seems to be at first.[6] In the case of trainee B, the tutor encourages him "to think of solutions to the problems and to come up with alternative strategies for solving them". The next sentence is significant: "Only then, if necessary, does he provide the answer" (p. 21). Thus, exposition may have to support discovery methods. Similarly, expository teaching is not entirely devoid of elements of discovery learning. Ausubel (1968) defines guided discovery as follows:

> It demands the learner's active participation and requires him to formulate his own generalizations and integrate his knowledge in response to carefully programmed leading questions; and it is obviously much more highly structured than most discovery methods (p. 504).

Using this definition, he goes on to claim that guided discovery "is actually a variant of expository teaching that is very similar to Socratic questioning" (p. 504). Cohen and Mannion (1983) prefer to classify guided discovery as a variant of discovery learning in which "a teacher supports a child's self-chosen activity with questions, commentary and suggestions" (p. 126).[7] The terminology or classification doesn't matter; what does matter is that Ausubel and Cohen and Mannion are talking about the same thing. Thus, the differences between 'discovery' and 'expository' are often more apparent than real.

3 Approaching the Lessons

3.1 Choice of hypothesis

It was stated in section 1 that IT and IM are classes of approximately equal ability, while section 2.5 concluded that guided discovery is probably more effective than either pure discovery or expository teaching. These two propositions were combined to produce the following hypothesis for the project:

IT geography class, taught using guided discovery methods, will develop and retain a higher level of knowledge and understanding of the water cycle than IM geography class, taught using expository methods.

This was the principal hypothesis but a secondary hypothesis was also envisaged. There is evidence to suggest that discovery methods are particularly suitable for high ability students and particularly unsuitable for low ability students (McDonald 1965; Heywood 1982). Consequently, one might expect there to be greater intra-class variation in knowledge and understanding among the pupils of IT than among the pupils of I M. In summary, I expected a higher mean test score in IT class but also a higher standard deviation of test scores.

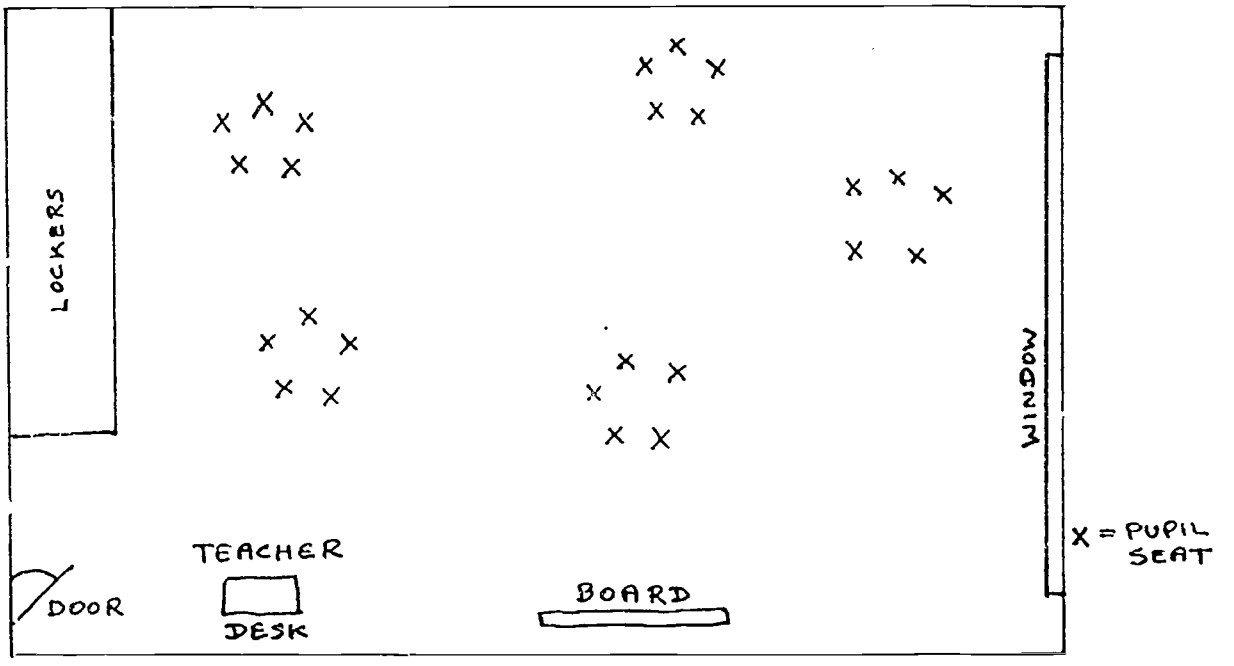
3.2 Planning the lessons

The aims and objectives of the water cycle lessons were the same for IT and IM and may be seen in figure 5.[8] The learning strategies and actual content of each lesson were obviously different. Figures 5 and 6 are the relevant lessons plans; in this section I intend to expand upon and explain what is in the lesson plans.

IT (guided discovery)

Upon entering the classroom the pupils are divided into five groups with approximately five pupils in each group. Clusters of seats are arranged around the classroom in a roughly circular pattern and each group has its own cluster of seats (figure 2).

Figure 2: Classroom layout for IT (guided discoverY) lesson



Each group is told to take out one blank sheet of paper and to appoint one of their number to be in charge of writing. Then I ask each group, in turn, the first question in the content column of figure 5. This practice is repeated with the other questions. The groups write down each answer on the piece of paper, beginning at the bottom of the sheet and working their way up. If a group cannot think of an answer or writes down a wrong answer, then before I give them the next question I help them to come up with the right answer to the last question. The final question invites pupils to find a connection between all the words, the connection being the concept of a cycle.

Heywood (1982) is right to point out that "a basic weakness of discovery learning is that pupils are not only often allowed to discover them without teacher evaluation, but that the correctly discovered is often not reinforced" (p. 111). The second half of the lesson has three elements to reinforce pupil learning:

1. Each group is labelled a part of the water cycle and I am 'the water'. I stand beside the group named 'precipitation' and ask the class as a whole which group I should go to next. This procedure is repeated until I am back at the 'precipitation' group.

2. Each pupil is told to draw a diagram of the cycle in their geography notebook.

3. At the end of the lesson I show a standardised diagram of the water cycle on the overhead projector (see figure 3 below). New terms such as 'run-off' (surface water such as rivers) are explained.

1 M (expository)

The lesson begins with the writing of the title, 'the water cycle', on the board. The cycle is then explained to the pupils and, as each element of the cycle is mentioned, it is written on the board. A circular pattern of words emerges. Once it is complete, the words are linked with arrows. Questions are invited from pupils. Reinforcement of learning is provided by displaying the diagram of the cycle (figure 3) on the overhead projector; pupils are told to copy the diagram into their geography notebook.

3.3 Devising a test

The same test was given to 1T and 1M. The test paper has two questions (see figure 4 below). Question 1 was designed to examine pupil *retention* of the information presented in the water cycle lesson. It relates to the first behavioural objective in figure 5. Question 2 relates to the second and third behavioural objectives and was intended to assess pupil *understanding* of the lesson. The marking scheme for the test is shown in table 2 below (total marks: 25).

Table 2 Marking scheme for the water cycle test

Q.	Marks
1	'Precipitation' - 2 marks (1 for 'Rainfall') 'Run-off' or 'Rivers' - 2 marks 'Groundwater' - 2 marks [1 for 'Underground Stream' or variants] 'Evaporation' or 'Water vapour' - 2 marks 'Condensation' or'Clouds'- 2 marks *Total- 10 marks*
2	Description and explanation of 'Precipitation' - 2 marks- Description and explanation of 'Run-off' and 'Groundwater'- 3 marks Description of 'Sea/Lake' - 1 mark Description and explanation of 'Evaporation' - 2 marks Description and explanation of 'Condensation' - 2 marks Explicit mention of the cyclical relationship of the above elements - 2 marks [1 for implicit mention] Extra information, general expression, etc. - 3marks *Total- 15 marks*

The water cycle lesson was taught to 1T on 2 April and to 1M on 3 April. I intended to give each class the test, without forewarning, on 9 and 10 April respectively. The test was indeed given to 1T on 9 April but the school closed for the Easter vacation earlier than scheduled on 10 April. As a result, I could not give the test to 1M until 30 April, almost four weeks after the lesson. This unavoidable change of plan affected the principal hypothesis of the project.[9] If the hypothesis was 'proven', then the result might actually be attributable to the variation in the gap between the lesson and the test, i.e. 1T might have done better than 1 M because they were tested nearer to the date of the lesson. Obviously, if the hypothesis was disproven, then the result would be especially significant since 1M would have performed better than 1T *despite* being tested at a time more distant from the lesson.

FIGURE 3: THE WATER CYCLE

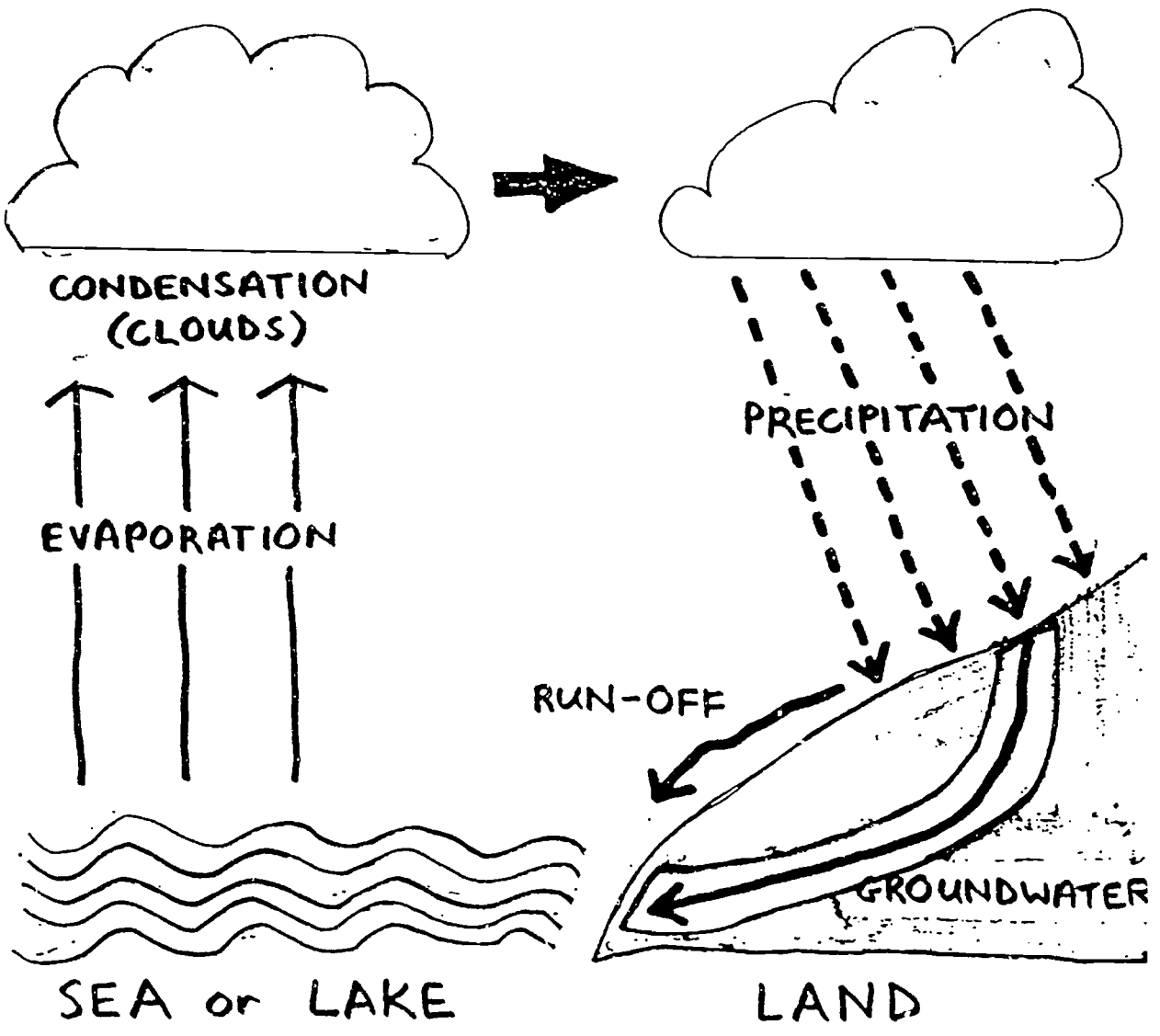
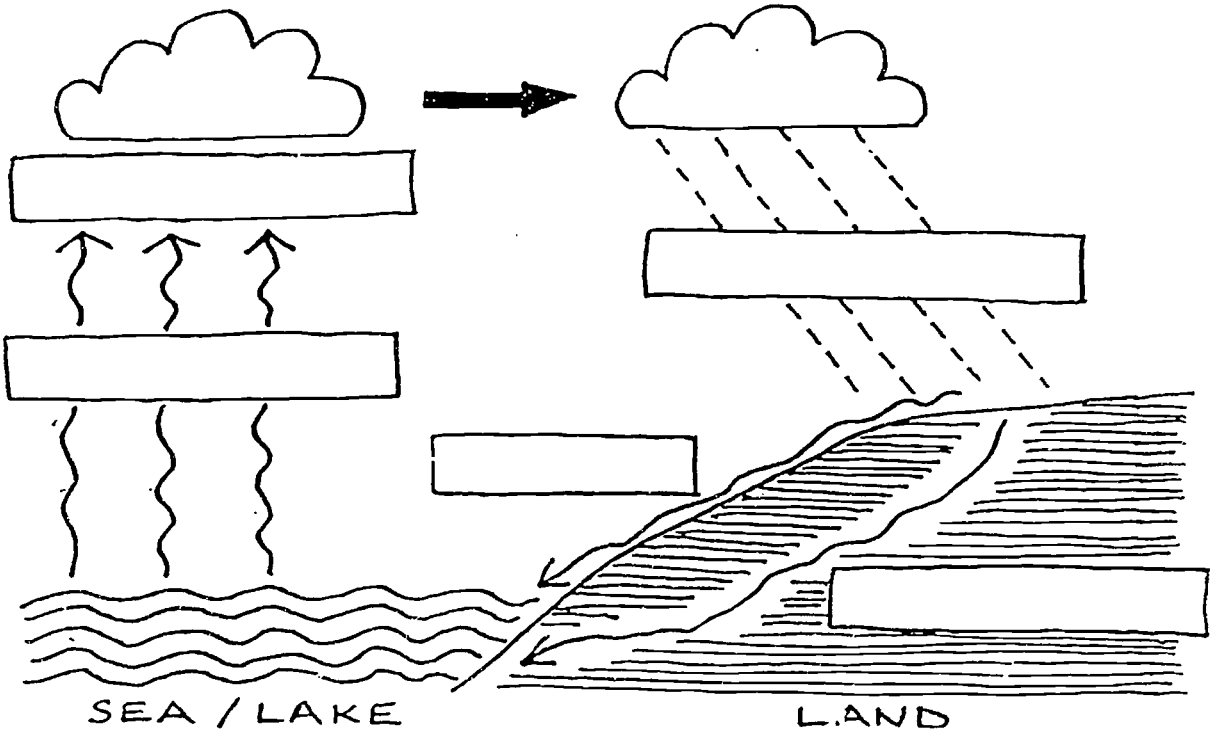


Figure 4 - THE WATER CYCLE: TEST

Name: _____

1. Here is a diagram of the water cycle. Fill in the boxes with suitable words describing each stage of the cycle.



2. In the space provided below, describe what happens in the water cycle. In your description you should include explanations of any words you put in the boxes in the diagram above.

Figure 5: IT (Guided Discovery) Lesson Plan

Subject: Geography Gender:Female Number:Approx. 25 Ability: Mixed

Aims/Objectives	Lesson Phases	Learning Strategies	Content	Questioning
Aim/Non-behavioural objective To develop pupils' knowledge and understanding of the water cycle.	Introduction 2.40 p.m.	Expository	(a) Entry. Arrange seats in 5 groups of 5. (b) Divide pupils into 5 groups of 5 and allocate seats (c) Tell each gropu to take out a sheet of paper and to appoint a "scribe".	
Behavioural Objectives 1. Pupils will be able to draw and/or label a diagram of the water cycle. 2.	Presentation 2.45 p.m.	Guided discovery (Group discussions)	(a) Ask each group, in turn, "where does the water in rivers or the ground come from?" Tell them to write the answer on the bottom of the paper. (b) Check each group's answer ('rain') and ask each grop the next question - (c) Repeat process in (b) - (d) Ask groups to connect each element with arrows (they should perceive a cylcle at this stage).	where does the rain come from? where do clouds come from? where does water vapour (evaporation)come from? where does the water in seas/lakes come from? where do rivers/groundwater come from?
3. Pupils will be able to describe in their own words what happens in the water cycle; in particular, they will be able to explain why it is a cycle.	Application 3.00 p.m.	Guided Discovery (reinforcement by written activity)	(a)Label each group an element from the cycle; I am 'water'. Go from group to group (by asking the class) to illustrate the cycle. (b) Tell pupils to draw the cycle. (c) Show water cycle on overhead projector. Explain terms.	
	Conclusion 3.15 p.m.	Expository	Collect/return any copies	

Figure 6: IM (Expository) Lesson Plan

Subject: Geography. Gender: Female No.: Approx. 25 Ability: Mixed

Aims/Objectives	Lesson Phases	Learning Strategies	Content	Questioning
As for IT (guided discovery) lesson plan (figure 5 above)	Introduction	Expository	(a) Entry (b) Return/collect any copies	
	Presentation	Expository	(a) Introduce 'water cycle' by writing title on board. (b) Explain the cycle; write each element on board and connect them with arrows. (c) Any questions (from pupils)?	
	Application	Expository	(a) Display water cycle diagram on overhead projector (b) Tell class to copy the diagram into their notebooks.	
	Conclusion	Expository	Return to topic begun in lesson No. 25 (pressure/wind/etc.) (if time).	

5. Immediate Evaluation

1T (guided discovery)

At the start of the lesson the pupils were quite lively and talkative. They were not in their usual classroom since I had had to get a room that would allow for a flexible arrangement of seats (figure 2). Perhaps the change of scene contributed to the pupils' excitement. Another contributing factor was their realisation, once I had divided them into groups, that this lesson was going to be a little unusual (I use expository methods most of the time). However, the class soon settled down and the lesson got underway.

The pupils seemed to enjoy answering the questions about each stage of the water cycle, and they usually came up with the right answers. Sometimes they needed some encouragement; rarely did they end up on the wrong track altogether. For me, this phase of the lesson was quite stressful as I was constantly on the move from group to group and while talking to each group I also had to keep an eye on the rest of the class. There was, of course, a constant level of chatter and I am sure that not all of it was related to the task in hand! This unsettled me a little as I usually have a fairly quiet class.

By the end of the presentation phase of the lesson, all groups had arrived at the concept of the water cycle from the words and arrows on their sheets of paper. But there was no unanimity in the diagrammatic representations of the cycle which pupils did by way of reinforcement. Many pupils drew a diagram similar to figure 3 (which they had not seen at this stage), i.e. a single, simple scene containing all the elements of the cycle. Other pupils, however, drew a separate symbol for each element. Figure 3 was only shown to the pupils after they had finished their own diagrams so they could not copy it down.

All in all, 1T seemed to enjoy the guided discovery lesson and managed to grasp the discovery itself without difficulty. I, on the other hand, found it more stressful than a normal lesson. Firstly, it required quite a lot of planning, although this paid off as there were no hitches or time problems. Secondly, during the lesson itself I had to maintain a high level of concentration.

1M (expository)

The expository lesson not only required less activity on the part of the students but, strangely enough, I found that it also involved less preparatory work and actual stress for me. Of course, this may well be because expository is the teaching style I use most often.[10] The pupils of 1M were less lively than 1T, and they paid attention throughout the presentation phase. I felt very much in control and was satisfied that I had explained the water cycle well. The pupils seemed to enjoy copying figure 3 into their notebooks. And there the lesson ended. Little more can be said about it. It only took 20-25 minutes of a 35-minute period; by contrast, the guided discovery lesson with 1T had taken a full period. Consequently, I had time at the end of the 1 M lesson to move on to a different topic. My experience with 1T and 1M thus confirmed the remarks in section 2.6 above to the effect that guided discovery is more time-consuming than expository.

6. Test Results and Final Evaluation

6.1 General statistics

As mentioned in section 3.3 above, the water cycle test (figure 4) was given to 1T on 9 April and to 1 M on 30 April. In other words, 1T were tested one week after the guided discovery lesson whereas 1 M were tested almost four weeks after the expository lesson. Pupils were given 15 minutes in which to complete the test but many were finished before the time limit expired. Summary statistics for the test results of both classes are given in table 3 below.

Table 3: Summary statistics of test scores

Measure	1T	1M
Mean (μ)	15.6	16.7
Mode	18 (4 cases)	18 (6 cases)
Median	16	17.5
Standard deviation (σ)	4.1	3.3
Number of pupils (N)	24	20

The main statistics from table 3 to focus on are the mean (μ) and standard deviation (σ), since these determine whether the hypotheses in section 3.1 can be accepted. 1M recorded a mean score of 16.7 compared to μ=15.6 for 1T, even though the test was given to 1M three weeks later than 1T. This means that the principal hypothesis must be rejected. In fact, it would appear that expository teaching (used with 1 M) was more effective than guided discovery learning (used with 1T).

With regard to the secondary hypothesis in section 3.1 above, the standard deviation scores suggest acceptance. 1T's test scores *do* exhibit a greater spread than 1M's, as reflected in comparative σ values of 4.1 and 3.3 respectively.

6.2 Frequency distribution

The frequency distribution of test scores for both classes is shown in tabular format in table 4 and graphic format in figures 7 and 8 below.

Table 4: Frequency distribution of test scores

Scores	1T	1M
0-5	1	0
6-9	1	1
10-13	5	2
14-17	8	7
18-21	8	7
22-25	1	2
Total	24	20

Figure 7:
Histogram of 1T test scores

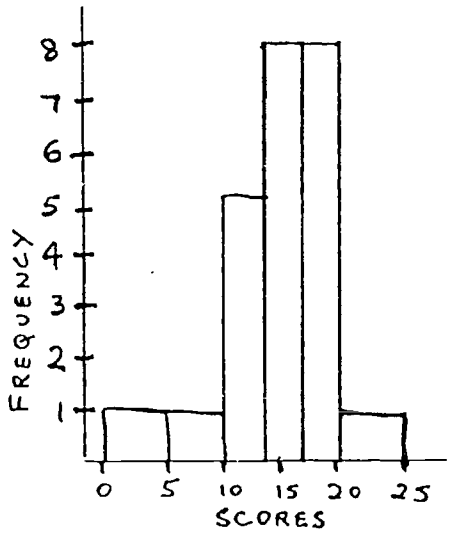


Figure 8:
Histogram of 1M test scores

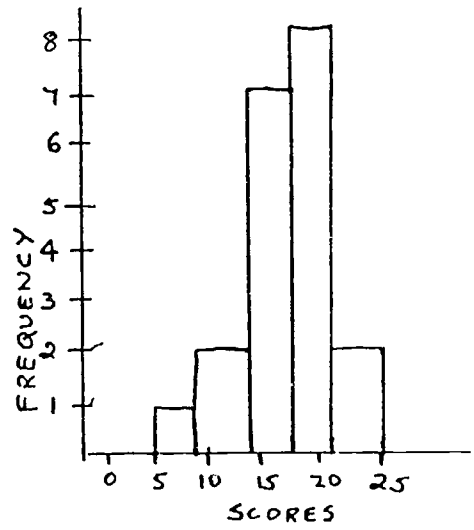


Table 4 confirms that 1T's scores are more widely spread than those of 1M. Three-quarters of the pupils in 1M scored between 14 and 21 inclusive compared with two-thirds of 1T. Various measures of distribution express the same pattern. Standard deviation values are reported in section 6.1 above. The range of scores for 1T is 20 (5 to 24 inclusive) compared with only 14 for 1M (9 to 22 inclusive). Finally, the inter-quartile deviation is 2.5 for the 1T scores and only 1.5 for the 1 M scores.

The scores of both 1M and 1T have a right-skewed distribution (figures 7 and 8). This was suggested by table 3, which showed the mode and median to be higher than the mean in both sets of scores.[11] A right-skewed distribution indicates a dearth of low scores and a predominance of high scores. This may be due to an easy test or exceptionally good student performances. The scores of 1T are nearer to a normal distribution than are 1M's scores and this reiterates the wider variation in intra-class performance among 1T pupils, especially towards the lower end of the scale.

Figure 9 below presents three sample pupil scripts as an illustration of the range from high to mediocre to low scores. Figure 9(a) is the script of a 1M pupil who scored 22 out of 25. Figure 9(b) is from a 1T pupil who recorded a score of 16. Figure 9(c) is the test paper of a 1M pupil who scored a lowly 9 out of 25.

6.3 Discussion of test results

The results outlined in sections 6.1 and 6.2 above both confirm and contradict the findings of previous research.[12] Such research tentatively indicated that guided discovery learning was more effective than both pure discovery and expository teaching. My results clearly contradicted these findings. This may not be significant if any of the following factors were operating:

1. The pupils of 1M are of considerably higher ability than those of 1T.

2. 1M pupils did geography revision which included the water cycle over the Easter break, i.e. before the test. 1T had no such opportunity.

3. 1T pupils told 1M pupils that they had got a test on the water cycle before the holidays. 1M pupils deduced that, since they had also learned about the water cycle, they would get the test at the start of the summer term. Armed with such advance warning, they prepared for the test.

Although I cannot be sure, I do not think any of these three factors applied.

Another possible explanation is that 1M pupils scored particularly well in question 1 of the exam, which tested recall, rather than question 2, which tested understanding. This effect might have been reinforced by the fact that the diagram used in question 1 was similar to the diagram copied down by 1M pupils (figure 3). Comparison of the average score of each class in each question should resolve the issue (table 5 below).

Table 5: Mean test scores by question

	1T	1M
Question 1 (out of 10)	6.5	7.4
Question 2 (out of 15)	9.1	9.3
Total (out of 25)	15.6	16.7

Table 5 shows that most of the difference in mean total score between 1M and 1T was indeed accounted for by inter-class variation in question 1 scores. Nevertheless, the average 1M pupil still scored slightly higher in question 2 than the average 1T pupil, despite a wider gap between lesson and test. Thus, 1M displayed a greater knowledge *and* understanding of the water cycle than did 1T. In the last analysis, the most likely explanation seems to be the difference in learning strategy.

The results of the lesson plan project also *confirmed* previous research in some respects. In section 3.1 it was noted that discovery methods are often ill-suited for less able students who may want and need guidance from the teacher. My results echoed this finding. The scores of 1T were spread out more than those of 1M,[13] indicating that the guided discovery lesson was successful for high ability pupils and unsuccessful for weaker students. An examination of individual pupils' performance confirms this general pattern. Two of the lowest ability pupils in 1T scored only 5 and 7 respectively in the test. By contrast, even the weakest students in 1M managed to record a score in double figures. However, the other side of the coin is that some of the highest achievers in 1M recorded only an average or slightly above average score. In summary, low ability pupils benefited

most from the expository lesson whereas, to a less significant degree, high ability pupils benefited most from the guided discovery lesson.

6.4 Conclusion

"An all-or-none position regarding use of the discovery method is warranted by neither logic nor evidence" (Ausubel 1968, p. 471). The same might be said of expository methods, in spite of the results of this lesson plan project. The guided discovery lesson conducted with IT did have some worth. It was academically successful for some pupils; it was probably emotionally successful for all pupils. They seemed to *enjoy* it and surely enjoyment of school is a valuable experience for children.

Nevertheless, I feel that the lesson plan exercise has vindicated my teaching practices in the eyes of my *alter ego*, my critical self. Those practices consist of expository teaching most but not all of the time, with occasional and even frequent recourse to other methods in order to provide an essential infusion of variation and innovation. But there is no room for complacency. Teaching and learning methods are not about rigid formulae, much less dogma. They require flexibility and a willingness to adapt and change depending on the circumstances, which are the school, the subject aims and content, the pupils and even oneself, the teacher. One cannot go far wrong if one continually asks the question: "For what purposes and for which students and under what learning conditions should I employ any one method or combination of methods of instruction?" (De Cecco and Crawford 1974, p. 364).

Notes

1. As will be seen in section 2.6 below, guided discovery contains elements of both extremes and, indeed, is claimed by both sides in the debate; hence, its separate treatment will arise in the context of a concluding synthesis.
2. This is especially true with regard to long-term retention. Immediate learning may be best facilitated by expository teaching (Shulman 1970).
3. The guided imagery exercise (lesson plan 4) brought this home to me. Most of my pupils liked the exercise but quite a few remarked that they would not want such lessons frequently.
4. Discovery learning is similare to inductive learning, while expository teaching is sometimes called deductive (McDonald 1965: De Cecco and Crawford 1974). This should not be confused with Wittrock's use of 'deductive' and 'inductive' in table 1 (see section 2.1 above).
5. This is tacitly acknowledged by De Cecco and Crawford (1974) when they observe that it is difficult to find pure expository and pure discovery examples.
6. See section 2.4 above.
7. Similarly, in his description of a discovery learning lesson in mathematics, Shulman (1970) notes that "Provocative or leading questions are often used Socratically to elicit this discovery" (p.27).
8. See section 4 below.
9. See section 3.1 above.
10. In this regard, it may be of interest to record that I am an assimilator according to the Kolb Learning Style Inventory.
11. In a normal distribution, the three measures of central tendency are the same. In a left-skewed distribution, the mean is higher than the mode and the median.
12. See section 2.5 above for a brief report on the research.
13. See sections 6.1 and 6.2 above.

Bibliography

Ausubel, D.P. (1968), *Educational Psychology: A Cognitive View*, New York: Holt, Rinehart and Winston.

Boffy, R. (1985), 'YTS Core Skills and Participative Learning', *NATFHE Journal*, November, pp. 20-22.

Bruner, J.S. (1960), *The Process of Education*, Cambridge, Mass.: Harvard University Press.

Bruner, J.S. (1972), *The Relevance of Education*, London: George Allen & Unwin.

Cohen, L. and Mannion, L. (1983), *A guide to teaching practice*, 2nd edn., London: Methuen.

De Cecco, J.P. and Crawford, W.R. (1974), *The Psychology of Learning and Instruction*, 2nd edn., Englewood Cliffs, N.J.: Prentice-Hall.

Gagne, R.M. (1977), *The Conditions of Learning*, 3rd edn., New York: Holt, Rinehart and Winston.

Heywood, J. (1982), *Pitfalls and Planning in Student Teaching*, London: Kogan Page.

Heywood, J. (1984), *Considering the Curriculum During Student Teaching*, London: Kogan Page.

Keller, F.S. (1968), 'Good-Bye, Teacher ...', *Journal of Applied Behavior Analysis*, vol. 1, no. 1, pp. 79-89.

McDonald, F.J. (1965), *Educational Psychology*, 2nd edn., Belmont, Cal.: Wadsworth.

Shulman, L.S. (1970), 'Psychology and Mathematics Education', in Begle, E.G., *Mathematics Education*, Chicago: National Society for the Study of Education, pp. 23-71.