THE EFFECT OF LEARNING STYLES AND A TEACHING MODE UPON THE PERFORMANCE IN SCIENCE OF PUPILS IN A SCOTTISH SECONDARY SCHOOL.

by

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ABSTRACT

This study represents an attempt to examine the effect of learning styles and a teaching mode (written worksheet approach) upon the performance in science of S4 pupils in a Scottish secondary school.

It postulates that worksheets, with 'cookery book' instructions, would favour and appeal more to the conscientious, field-dependent and convergent type of pupils, because they provide an external structural support which complements their learning styles, thereby aiding their performance. On the contrary, the worksheets may not provide support and, therefore, favour the performance of the curious, field-independent and divergent pupils. Their learning and subsequent achievement may be adversely affected.

The pupils have been divided into different groups having different motivational and cognitive style characteristics according to their individual choices in two motivation tests, their individual scores in the Hidden Figures Test (HFT) and a convergence/divergence test. Their opinion of the written worksheet approach of teaching/learning science has also been asked for in a semantic differential test. The conscientious pupils responded positively to the mode of teaching while the curious pupils were dissatisfied with it.

The performance of the pupils in science was evaluated from their grades in the internal examination and the external Scottish Certificate of Education (SCE) - Standard Grade examination.

In general, the findings from the two examinations did not support the hypothesis. Rather, it was found that the performance of the curious, field-independent and divergent pupils was better than the conscientious, field-dependent and convergent

pupils, even though they were dissatisfied with the mode of instruction.

Field-independence cognitive style was found to be the major factor influencing the efficiency of performance of the pupils in the examinations. A closer look at the content of the worksheets and the examination questions revealed that what was being observed was the effect of examination answering performance overlying learning and the mode of instruction. Thus the performance of the pupils reflected the nature of the examinations and not only the teaching/learning approach. Evaluation or assessment was considered to give an added motivation to the pupils (including the curious who were not happy with the way they were taught).

Suggestions have been made on how this study may be directed in future, and also on how to make the mode of teaching suitable for the curious, field-independent and divergent pupils and to improve the efficiency of performance of the conscientious, field-dependent and convergent in the examinations.

"Some Men by the unalterable Frame of their Constitutions are *Stout*, others *Timorous*, some *Confident*, others *Modest*, *Tractable*, or *Obstinate*, *Curious* or *Careless*, *Quick* or *Slow* . . . Begin therefore betimes nicely to observe your Son's *Temper*; . . . See what are his *Predominant Passions*, and *Prevailing Inclinations*; whether he be Fierce or Mild, Bold or Bashful, Compassionate or Cruel, Open or Reserved, &c. For as these are different in him, so are your Methods to be different . . ."

John Locke, *Some Thoughts Concerning Education* (1693).

INTRODUCTION

Adapting education to the individual has meant many things in educational discussions.

Individual difference became a primary topic in educational theory in the early years of this century. Until that time, there was largely a fixed curriculum starting with the common branch of knowledge, and proceeding through an academic secondary school programme and a university liberal arts programme. Individual differences were taken into account chiefly in eliminating pupils. Pupils who were less successful dropped out all along the way.

When intelligence tests (I.Q. tests) became available they were used by schools to decide which pupils were to be permitted to drop by the wayside or to vegetate in an undemanding 'slow' classroom, and which were to proceed briskly, be indoctrinated with high aspirations and to go on to higher education (Cronbach 1967)[1]. In other words, pupils were selected for various forms of secondary education by the results of I.Q. tests.

The belief that each pupil has an inherent intelligence has been shaken since the mid 1960s. It is now generally recognised that pupil attainment is what can be measured by tests, and that this is less dependent on inbuilt and fixed intelligence than on the learning experiences encountered by the learner.

The Scottish tradition of secondary education has undergone some changes in organisation and ethos since 1965. The introduction of **Standard Grade** ('S' grade) courses over a period of time in the '80s brought in new problems of organisation, methodology and assessment, all of which contributed to a view that, at 'S' grade, teachers were likely to be faced with **mixed ability** classes. Despite the unpopularity of mixed ability grouping and its associated problems, it was thought to be a good social practice, and that if mixed ability classes were to be a feature of the 'S' grade development then every effort was to be made to capitalise on the numerous perceived educational advantages and to minimise the fewer teaching and organisational problems.

The success of any teaching/learning system depends largely on the teacher, but within different systems the teacher has differing roles. The 'S' grade courses emphasise the importance of skills to be developed by the learner, so that teacher-based systems have gradually given way to more pupil-centred ones.

To cater for learners of a wide range of aptitude, learning needs, career targets, cognitive and affective characteristics a variety in instructional procedures becomes a necessity.

Of the various strategies employed for teaching 'S' grade science in mixed ability classes the most commonly used in Scottish schools is **Individualised Learning**. The highest form in which individualised learning is practised is offering the pupils many modes of learning through the use of books, computers, audio-visual aids, worksheets, etc.. Unfortunately, due to limited resources, the most commonly used mode of teaching/learning in many schools is the written worksheets, to be followed by all pupils year after year. The questions that arise are: Are the learner characteristics such as the diverse cognitive styles and certain affective characteristics like motivation and interests of individual pupils catered for by the worksheet approach? Do all pupils with their individual characteristics respond equally to written worksheets, or does this method of learning appeal to individual learners equally?

The value of worksheets to science teaching is widely known, but their effect on motivation and other drawbacks must not be overlooked. George (1974)[2] takes up the point that lack of variety induces boredom. He writes:

> "the written worksheet or text is an inefficient means of communicating concepts, comparisons, broader implications, and the purpose of the work in hand,especially for many children who find reading a chore, even though they may be quite capable in other directions".

He continues:

> "perhaps the most commonly overlooked objection to the worksheet is the lack of variety which may result. In some schools, equipped with modern reprographic facilities to cope with unstreamed classes, a pupil can be continually faced with worksheets in one subject after another, lesson after lesson, week after week. Some pupils, of course, will thrive on such a diet, but most soon become resistant to the approach. Over-reliance on any one method of teaching is likely to result in eventual breakdown".

The Scottish Education Department (SED 1983)[3] reiterates that point:

> "Because the prevailing approaches are used on such a scale, the damage done to other effective teaching practices is serious. Dullness, from which boredom ensues, is implicit in routine methods. The absence of imaginativeness or originality calls for unusual qualities of patience and stamina in pupils and teachers alike. Motivation and enthusiasm for a subject can be permanently affected."

Woolnough (1981)[4], although acknowledging the benefits of mixed ability teaching, has this to say about individualised worksheet schemes:

> "Underlying some of my unease about certain mixed ability teaching strategies, is my concern for flexibility and for an opportunity for divergence in teaching style.Ironically, in trying to cater for the individual in a mixed ability situation by producing 'individualised' work schemes, we have at times produced highly convergent programmes of work which carry every pupil along a predetermined path to a predetermined goal. I would want to urge that opportunity exists for divergent work to be done in which pupils are encouraged to think and work creatively."

Even if the current practice in Scottish schools constitutes a real pedagogical advance, it must be acknowledged that some problems still exist and some questions like those raised above are still unanswered.

This research work sets out to investigate the effect of learning styles and the worksheet approach of teaching/learning science on the performance of learners of different **motivational patterns**, particularly, the **conscientious** and the **curious**, of different degrees of **field-dependence/independence** and exhibiting differences in **convergent/divergent thinking styles**. It postulates that worksheets (with the

recipe-type instructions and convergent nature) would favour and appeal more to the conscientious, field-dependent and convergent pupils, because the worksheets provide them with all or most of the learning instructions; they are led by the sheets to the goal, and would not have much difficulty separating the relevant from the irrelevant. The worksheets thus provide an external structural support complementing their approach to learning or learning styles, thereby aiding their performance. On the contrary, the worksheets may not provide support and therefore favour the performance, or meet the needs of the curious, field-independent and divergent pupils. Their learning and subsequent achievement may be adversely affected.

The hypothesis is based on information processing theory. Information processing is one model for describing cognition, and it refers to the processes by which incoming information is transformed, reduced, elaborated, encoded, stored, retrieved, and used. The pupils' perception of science, and how they store information received, are affected by the way they are taught, how motivated they are, how easily they can separate an item from its context, and the way they think.

The nature of each of the motivational traits and the cognitive factors and how they were measured will be discussed later. In the meantime, a brief exposition will be given of the curriculum and assessment in the Scottish secondary school, the 'S' grade and its consequences for teaching and learning.

CHAPTER ONE

THE CURRICULUM AND ASSESSMENT IN THE SCOTTISH SECONDARY SCHOOL, THE STANDARD GRADE AND ITS CONSEQUENCES FOR TEACHING AND LEARNING.

1.1 Curriculum and Assessment in the Scottish Secondary School (Kirk 1982)[5].

1.1.1 The Senior and Junior Secondary Tradition

The Scottish tradition of secondary education was a selective one. At the age of 12 the majority of pupils were allocated either to a Senior secondary or a Junior secondary school. The justification for this two-tier form of secondary education derived from a number of related assumptions: that there were manifest intellectual and other differences amongst pupils; that in order to take some account of such differences alternative forms of secondary education should be available; and that a battery of intelligence and attainment tests provided a reasonable basis for the allocation of pupils to one or other type of secondary course. On these assumptions, the traditional system was one in which about one-third of the pupils were selected for a course in the conventional academic subjects that led to a national school-leaving certificate in fifth or sixth year, while the remaining two-thirds embarked on a three-year course with a more vocational and practical orientation. The Junior secondary course differed from the Senior secondary course but was intended to constitute an equally valid educational experience. It was a shorter programme and diverted pupils from the path to academic qualification and higher education.

1.1.2 Reorganisation of Secondary Education and its Effects

In 1965 there was a move towards more democratization and less stratification. It was decided to reorganise secondary education on comprehensive lines and this reflected

a conviction that in at least two major respects the selective system was unsatisfactory. First, the segregation of children into separate schools at the age of 12 denied them the social and personal benefits to be derived from 'spending the formative years of early adolescence in schools where the pupils represented a fuller cross section of the community' (SED 1965)[6]. Secondly, the practice of categorising pupils at the age of 12 in a way that decisively affected their subsequent educational and other opportunities was judged to be fundamentally unfair.

The introduction of comprehensive schools was to postpone, not to abolish, the need for differentiation of courses. The first two years of secondary education was a period of observation and orientation. All pupils took a "common course". The pupils' perceptions of their performance in a range of secondary school activities, together with the teachers' appraisals of their pupils' progress after the two years provided the basis for judgements about the most appropriate pattern of subsequent studies for individual pupils. With regard to the curriculum beyond the common course, the most widely adopted solution relied heavily on the legacy of the senior secondary and junior secondary courses: some pupils embarked on a certificate course, others on a non-certificate course, while a third group undertook a 'bridging' course which might be largely non-certificate but which included one or two Ordinary ('O') grade subjects.

The decision in 1964 to raise the school-leaving age to 16 six years later provided a considerable impetus to the search for an educationally valid alternative to the academic certificate course.

In 1972 the Scottish Certificate of Education Examination Board (SCEEB) suggested a system of banded awards on an A-E scale to replace the familiar pass/fail categorization provided by the 'O' grade examination. That change led to considerable increase in the number of pupils taking SCE courses. This increase in presentation rate was paralleled by an increase in the number who were successful in the examination. On the other hand, there was also evidence of many pupils failing to gain awards in the A to

C bands. The numbers failing provided clear evidence of over-presentation - very many pupils were undertaking courses that were proving to be beyond their abilities.

There was a general concern that the varying aptitudes and abilities of pupils, their different levels of aspiration and degrees of motivation were not adequately accommodated within the three categories of certificate, 'bridging' and non-certificate courses. By the mid-'70s, a widely acceptable curriculum framework which reflected the different rates at which pupils learn had still to be found.

1.1.3 The Curriculum: Its Social Relevance

The extent to which the curriculum adequately prepared pupils for life in a rapidly changing society was questioned. It was repeatedly claimed that many pupils were released from school with an insufficient grasp of the basic literacy and numeracy skills upon which subsequent specialised training depended. The social relevance of the curriculum was questioned on other grounds. A persistent line of criticism maintained that the curriculum was insufficiently related to the social realities of the pupils' experience, that it frequently involved the pursuit of activities which did not illuminate the problems of growing up and living in a complex society, and that, in consequence, it failed to promote the pupils' personal and social well-being.

Other pressures on the curriculum too began to exert themselves. New subjects were incorporated into the curriculum, and claims were advanced for the inclusion of others such as sociology, psychology and geology. At the same time curricular space was demanded for a range of thematic studies - safety education, health education, social education etc..

1.1.4 The Munn and Dunning Committees

In late 1974, two committees were appointed, one by the Consultative Committee on the Curriculum (CCC) to examine the structure of the curriculum in S3 and S4 of the secondary school, and the other by the Secretary of State to inquire into the assessment

and certification arrangements - the Munn and Dunning Committees respectively. Attempts were made to ensure close collaboration between the two committees.

1.1.4.1 The Munn Committee

The remit of the committee was: "To consider how the curriculum at S3 and S4 should be structured in order to ensure that all pupils received a balanced education suitable to their needs and abilities; to consider the implications of its findings for the earlier and later stages of secondary education; and to make recommendations to the Consultative Committee on the Curriculum" (SED 1977)[7].

The Munn Committee adopted four sets of aims for the secondary school. The first set of aims related to the development of pupils' knowledge and understanding. The second was concerned with the development of skills. Thirdly, schools were considered to have a responsibility to promote pupils' affective development. The fourth related to the cultivation of social competence.

One of the problems that taxed the committee seriously concerned the relative weight that should be given to choice and compulsion in the curriculum. The activities which the committee considered to merit a compulsory place in the curriculum were based on a particular conception of 'educatedness'. It preferred to express what were regarded to be essential elements of education as 'modes of activity'. Eight such modes were postulated: literary/linguistic,

mathematics,

social,

scientific,

religious,

moral,

physical, and

creative/aesthetic.

It was maintained that each mode constituted a distinctive way of analysing, reflecting upon, and interpreting human experience. The modes (core curriculum) were each considered to have a distinctive contribution to make to every pupil's development and, thus, should feature in the education of all pupils.

On the question of which mode of curriculum organisation would provide the most effective means of intiating pupils into the various modes of activity, the committee decided in favour of a subject-based approach instead of integrated or multi-disciplinary studies.

The Munn committee's terms of reference very clearly implied that consideration should be given to the ways in which the curriculum could be differentiated to take account of the varying needs and abilities of pupils. It was accepted that pupils differ in their aptitudes, in their level of motivation, and in their interest. It was also acknowledged that pupils also differ in the rate at which they learn. The creation of 'up to three different but overlapping syllabus levels within the courses which are offered in the various subjects' was one means of overcoming this difficulty. By insisting that syllabuses should differ in 'pace, complexity and difficulty', it was hoped that pupils could embark on courses that were appropriate for them; and by stipulating that there should be 'common elements in courses at adjacent levels', provision would be made to ease the transfer of pupils fron one syllabus level to another, depending on their progress.

1.1.4.2 The Dunning Committee

The remit of the committee was: "To identify the aims and purposes of assessment and certification in the fourth year of secondary education in the light of educational and social changes since the introduction of Ordinary Grade of the Scottish Certificate of Education; to consider what form or forms of examination and assessment would be most likely to meet the needs of fourth year pupils of varying academic ability; to make recommendations for any changes in present arrangements that might seem desirable and

to consider the effect of such changes on the Higher Grade of the Scottish Certificate of Education and on the Certificate of Sixth Year Studies" (SED 1977)[8].

On the system of assessment and certification, the committee recommended that national guidelines, prepared by a central agency, should be issued for every subject that was to be assessed for certification at the end of S4. The guidelines would take the form of a combined syllabus/assessment document which set out the aims and content of the syllabus and the means by which the syllabus would be assessed. All syllabuses leading to certification would have internally and externally devised components, the internal component being subject to external moderation by inspection. In each subject there would be three overlapping syllabus levels (Foundation, General and Credit), so that the whole ability range would be covered. Provision would be made for able pupils to work at a level higher than the existing 'O' grade examination, while there would be syllabus elements which ensure that nearly all pupils presented in a subject reached at least a prescribed minimum level of competence. At all levels in a subject the proportion of the syllabus which was internally devised would be the same.

It was also proposed that the assessment which provided the basis for certification would be partly internal and partly external. The internal component of assessment would have the same weighting in all subjects, and at all syllabus levels. The external assessment, which would be of shorter duration would cover the externally devised syllabus. The internal assessment would cover the whole syllabus and would seek to provide a cumulative picture of the pupils' work through S3 and S4. That assessment would be standardized by being scaled against the external assessment. The pupils' final mark would be a combination of the score on the external examination and the scaled internal score, with the external assessment having a weighting of 75%.

A single national certificate, to be called the 'Certificate of Education - Scotland', would be introduced and would be available for all, or virtually all, pupils completing S4. The certificate would encompass three main levels of award at Foundation, General and Credit levels.

The reports of the Munn and Dunning committees form the basis of the 'S' grade courses as they are practised in Scottish secondary schools today.

1.2 The Standard Grade and the Consequences for Teaching

Problems of organisation, methodology and assessment came with the introduction of 'S' grade courses. Class sizes, timetabling problems, opportunities for pupils to succeed at a higher grade, uncertainty about selection of pupils for, say, a General rather than a Credit level presentation of a course were all factors which contributed to an emerging view that at 'S' grade, teachers are likely to be faced with mixed ability classes (SCDS)[9]. These were administrative problems. More importantly, it was thought in some schools that adopting mixed ability teaching would be a good practice in 'S' grade if the move towards less stratification or less selection was to succeed. At the same time it was recognised that to cater for pupils of a wide range of ability, learning need, motivation, interest, career targets, etc., a variety in teaching approaches and resources was a necessity.

1.2.1 Mixed Ability Teaching

Within many Scottish schools, the move to less selection led to a move towards mixed ability teaching in different subjects.

1.2.1.1 Advantages of Mixed Ability Teaching

Newbold (1977)[10] and Postlethwaite and Denton (1978)[11] reporting on a research carried out at Banbury School in England give some direct evidence for the relative advantages of mixed ability grouping (teaching). Woolnough (1981)[12], aware of the danger of oversimplifying the results, draws out what he considers to be the most significant finding of that research: "Pupils starting from a mixed ability base were found to have attained by the first and second years (1) better social attitude to school; and (2) no worse academic achievement. Also (3) they were found to be more likely to choose to

study science in fourth and fifth form (especially the middle-ability girls); and (4) they did no worse, and in some cases significantly better, at their academic examinations at the age of 16. On the whole there was some evidence of a better overall performance on the part of the less able pupils from the mixed-ability situation, without any lowering of the overall levels of attainment achieved by the more able."

Wragg (1984)[13], reporting teacher opinion, lists the following advantages for mixed ability teaching:

1) Children are not labelled: no pupil feels superior or inferior.
2) There is improved class atmosphere.
3) Discipline problems are fewer.
4) Pupils learn to work cooperatively.
5) There are more opportunities for teacher-pupil contact.
6) There are more, and more meaningful, pupil-pupil contacts.
7) Late developers are catered for.
8) Pupils can work at their own level.
9) A levelling up of attainment occurs (slower pupils improve their performance).
10) There is improved language development.
11) Brighter pupils help less able ones.
12) Pupils can delay decisions about specialism.
13) More time is given to individual pupils.
14) More time is available before pupils' abilities need to be assessed.
15) All pupils appear more confident.
16) There is less stress or emotional tension than in a streamed situation.

1.2.1.2 Disadvantages of Mixed Ability Teaching

Wragg[13] also identified disadvantages of mixed ability teaching as perceived by teachers. These were:

1) Appropriate teaching materials are sometimes lacking.

2) Whole class lessons are difficult to pitch at the correct level.

3) Cliques develop among pupils.

4) Pupils still choose friends from their own social class and intelligence level.

5) It is difficult to keep track of all pupils' progress.

6) Teachers need to be committed to the philosophy of mixed ability teaching.

7) Teachers need to spend vast amounts of time in preparation and resource-making.

8) Bright pupils waste a lot of time.

9) Teachers spend time disproportionately on the slow learners.

10) Slow learners learn that they always fail.

It is not easy to interpret all the research on mixed ability . In spite of of all the references available, some of which were rather lukewarm, the SCDS[9] found it reasonable to claim that mixed ability grouping:

1) avoids the disadvantages associated with the early labelling of pupils

2) fosters personal and social development

3) does not impair academic achievement.

Although such grouping brought its own set of problems, practitioners tended to weigh the numerous perceived educational advantages against fewer teaching and organisational difficulties.

To end this on a more optimistic note, Phillips (1992)[14], after completing a teaching practice for the Combined Science PGCE in a school of totally mixed ability classes, made the following observation: "... the advantages of teaching science to mixed ability groups is not all idealistic; it can be done. However, I do believe that it is only successful under certain circumstances, where teachers can adapt and prepare lessons specifically and have that discipline which enables those lessons to be executed effectively - and this requires a whole new lesson methodology."

1.2.2 Strategies for Mixed Ability Teaching in 'S' Grade

Various strategies are employed for teaching 'S' grade science in mixed ability classes. Brief descriptions of five strategies will be given here. Detailed description of the various strategies for teaching science in mixed ability classes are found in the works of Sturges (1976)[15], Wragg (1976)[16], and Kerry (1979)[17].

1.2.2.1 Whole-Class Teaching

Woolnough (1981)[12] points out that by whole-class teaching one does not mean that every lesson throughout the year is spent with the teacher conducting 'chalk-and-talk' sessions. But there is considerable value in whole-class teaching done at certain times throughout the topic: it has a place when introducing a topic, setting the problems and giving instructions, and also when drawing together conclusions at the end of a topic. Stimulus materials and illustrative presentations, for example in the form of demonstrations, films, etc., are usually used most effectively with the whole-class together.

1.2.2.2 Small-Group Work

Studies done on the talk that goes on in small groups provide evidence of the educative value of such talk, regardless of whether it is tightly structured or not. Pupils can learn a lot from each other than from the teacher, even if what they learn is not exactly what the teacher thought they should learn (Woolnough 1981)[12]. *The Nuffield A-Level Physics, Teachers Handbook* (1971)[18] speaks of 'talking about ideas, thinking them through by oneself, trying them out on others ... are important ingredients in learning.'

1.2.2.3 Individualised Learning

The SCDS (memo 64)[19] present a practical description of 'individualised'

courses. In these courses, recognition is given to the needs of each pupil in terms of his particular abilities, background and interests. The course is planned by the teacher with these needs in mind rather than for a whole class working as a single unit. This does not necessarily mean that a pupil must work alone throughout the whole course as is often inferred. What it means is more freedom of pace and choice of activity for the pupil. He may work alone at times, but mostly he will work with another pupil or with small groups of pupils who, at some time, are at the same point in course work. The composition and size of these groups will change with individual pupil's progress through the course. Thus he has the stimulus of interaction with his peers, but much of his interaction with his teacher will be on a 1:1 basis, that is, he is treated as an individual.

Bangert, Kulik and Kulik (1983)[20] from their analysis of the findings of studies of individualised systems used in secondary schools give as their **criteria** for including a study in their set of individualised system the following:

1) the use of an individualised teaching system;
2) division of course content into chapter-length units;
3) use of class time for individualised work by students;
4) emphasis on formative testing.

Two other features commonly associated with the individualised systems were:

5) students freedom to move at different rates through course material;
6) the need to demonstrate mastery in order to move from one unit to another.

Gibson and Leckenby (1983)[21] assert that "a completely individualised system would :

a) involve each pupil in working at his own pace
b) take account of the different ways pupils learn
c) incorporate a wide variety of material, providing suitable activities for a range of pupils."

To take account of the pupils' different abilities and rates of progress, various models have evolved. Woolnough (1981)[12] gives three examples. The **linear** model is one in which everyone starts together, but finishes at different stages along the line. In the **branching** model everyone covers the core of the material, but some may branch into extension material, either of a more demanding nature or as supplementary material for reinforcement for the weaker pupil. The **parallel** model introduces different schemes of work for different ability pupils, effectively producing separate streams within the same class.

1.2.2.4 Independent Learning

This term, by definition, infers that the pupil is responsible for planning his own course of study and consequently is not relying on his teacher (SCDS memo. 64)[19]. This situation is quite distinct from individualised learning where the whole class structure has been planned by the teacher and although the pupil may follow his own route through the course, he is dependent on his teacher for the provision of learning materials and for guidance. The nearest approach to independent learning in a school course is probably project work, but even then the teacher is in the background as guide and supervisor.

1.2.2.5 Resource-Based Learning

In its literal sense, science teaching using practical apparatus, has always been resource-based. Every teacher uses resources no matter what teaching strategy is adopted. The resources vary in form from worksheet to video to computer software to the world outside the laboratory. It is the way in which the resources are deployed which distinguishes whole-class, lock-step teaching from pupil-centred learning. The resources are placed at the disposal of the pupils as and when they need them to give them some freedom of pace and choice of activity. As the term implies, the learning is based on the

resources. They are there for the pupils to make as much use of as their individual ability and interest dictate.

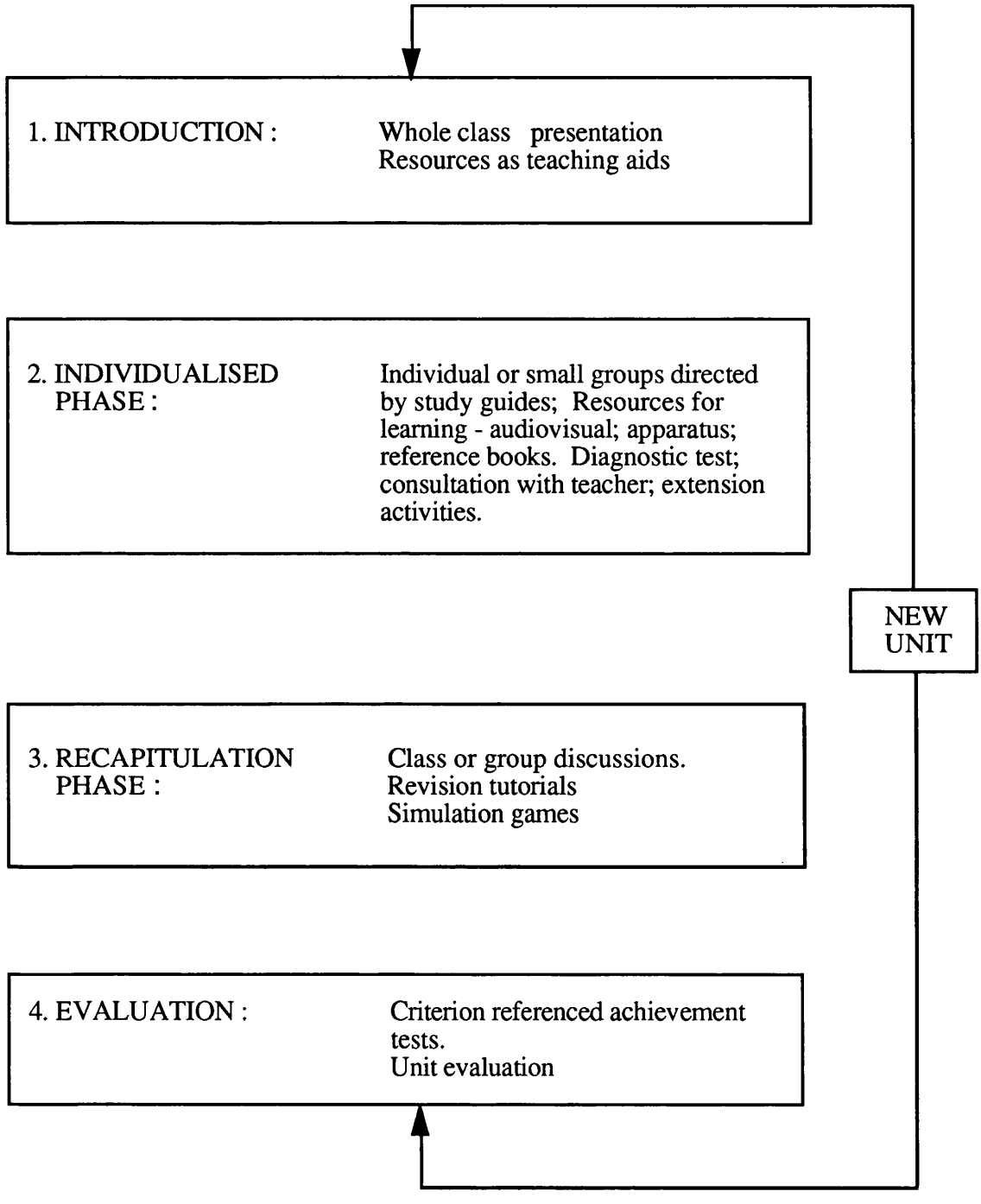


Fig. 1.1 Overall Teaching Strategy - Generalised model (Gibson & Leckenby)[21].

Resourced-based learning and individualised learning are closely interconnected, as pointed out by the SCDS (memo. 64)[19]. In both there is some degree of self-pacing and choice of activity for the pupil. In a resourced-based learning course, however, a variety of methods may be employed ranging from individualised units to whole-class teaching where this may be considered more appropriate. The essence of such a course is variety and flexibility.

Of the strategies mentioned above, what is generally observed in most Scottish schools is a mix of individualised learning and whole-class approaches predominantly done through the use of worksheets (known in some schools as work-booklets or activity sheets). Gibson and Leckenby (1983)[21], based on classroom observation of individualised practice, have presented a generalised model which is reproduced above (Fig. 1.1).

CHAPTER TWO
AN OVERVIEW OF THE LITERATURE

2.1 Introduction

Learning behaviour and preferences for instructional procedures are significantly influenced by a number of factors, for example, cognitive styles and motivational patterns, all of which reside within the learner (Kempa 1992)[22]. It is, therefore, not surprising that over the years it has been increasingly emphasised that instructional procedures in science education and other areas of education should be matched to learner characteristics in order to maximise the effectiveness of the teaching/learning process (Cronbach 1967)[1].

A lot can be found in the literature about learner characteristics that have received attention by researchers. Among these are the cognitive styles, such as field-dependence/independence dimension (Witkin et al. 1977; Davis and Frank 1979)[23, 24] and convergent/divergent thinking (Getzels and Jackson 1962; Hudson 1966; Joyce and Hudson 1968)[25, 26, 27]; and a range of affective characteristics, for example, students' attitudes, interest and motivation (Good and Power 1976; Hofstein and Kempa 1985; Kempa and Martin Diaz 1990)[28, 29, 30].

As already stated, this research is to examine the effect upon the performance in science of learners of different motivational patterns, particularly the conscientious and the curious, and with different cognitive style orientations by their learning styles and the written worksheet approach of teaching/learning science.

In this chapter, an overview of the extensive literature on some of the learner characteristics will be dealt with.

2.2 Motivation

Under this section, the definition, types of motivation and an analysis of the types of motivational patterns will be considered.

2.2.1 Motivation - Attempt at a Definition

Motivation has traditionally been seen as important in education (and in psychology) because it is a significant factor contributing to achievement. Ausubel et al. (1978)[31] have noted that "motivational (and other) characteristics are sufficiently important in school learning to engage our most serious consideration if we wish to maximise...classroom learning." Although it is important, scholars have found it difficult to formulate a definition of motivation that will satisfy all schools of educational and psychological thought. Most scholars prefer to explain the term rather than define it. Orbach (1979)[32] has observed that when writing about motivation, they first deal with the variety of motives and their nature and then attempt to explain how motives originate within the individual and how they determine the "force" and "direction" of human behaviour.

The difficulties of formulating a definition are exemplified in the following attempts. Waejten (1965)[33] proposed this definition: "Motivation is the process of arousing action, sustaining activity in progress and regulating the pattern of activity." Frymier (1970)[34] described motivation as giving "both direction and intensity to behaviour.... Motivation to learn is that which gives direction and intensity to human behaviour in an educational context." Goodwin and Klausmeier (1975)[35] suggested the following definition: "A motive is any condition within the organism that affects its readiness to initiate or continue any activity or sequence of activities. Experiencing a need may serve as a motive. Motivation is a general term, applying either to the strength or the duration of a motivational state...or to the regulation of other motives."

The difficulty of arriving at a definition is also exemplified by Bigge (1971)[36] who distinguished between a definition that will appeal to Stimulus-Response psychologists and one that will appeal to Gestalt field theorists. He writes that motivation according to the former is "the urge to act that results from a stimulus," whereas motivation according to the latter is "the tendency to release tension by proceeding toward a goal, including the overcoming of whatever barriers are on the way."

For the purpose of this research, it is not necessary to have one definition of motivation agreed upon by all schools of thought. Whatever the definitions, as Orbach (1979)[32] has rightly pointed out, two important elements can be found in all of them. These elements are need and readiness: every person, when in a situation defined or explained as motivational, feels a physiological and/or psychological need for something and is ready to take immediate action towards the reduction of this need. In other words, a motivated behaviour, according to all theories of motivation, is goal-directed and lasts until the goal is reached.

2.2.2 Types of Motivation

Motivation can be broadly divided into two types - *Extrinsic* and *Intrinsic*. The basic distinction between the two kinds can be made on the grounds of the source of motivation, whether it is considered to be external to the person or whether it emanates from within the person. Intrinsic motivation refers to behaviour that is functioning without external control (Corno and Rohrkemper 1985; Ryan et al. 1985)[37, 38]. An extrinsically motivated activity will be one in which some external reward is expected as outcome of performance of such activity. Such activity could be considered as a means to an end. On the other hand, an activity is intrinsically motivated if there is no apparent reward except the activity itself. In this case, an intrinsically motivated activity is an end in itself.

These two types of motivation are evident in education. Martin Diaz (1989)[39] states that extrinsically motivated students respond strongly to praise from parents or teachers, whilst those with strong internal motivation are not driven primarily by external rewards, but by their own curiosity and desire to learn. Externally and internally motivated behaviours are not static. One can easily change into the other with time depending on the individual and the prevailing circumstances. For example, an activity which was intially motivated by some external reward or pressure can become so interesting and engaging to the learner that it is pursued and sustained without further external rewards. Some school children start to study with the motives of gaining good marks or earning teachers' or parents' praise, but then become so absorbed by the subject studied that marks and praise are no longer required to sustain their interest and commitment.

2.2.3 Analysis of Types of Motivational Patterns

Adar's (1975)[40] suggested classification of students into four major groups will be used in this research. Since Adar's work is in Hebrew most of the material here has come from Orbach (1979)[32], with some references made to the sources on which Adar based her analysis.

Adar's notion of motivational pattern implies that learners differ with respect to their preference for and responsiveness to different instructional features. It also implies, irrespective of the actual context of learning, that this preference and responsiveness are relatively stable in an individual learner, so that they can be aggregated into clusters of 'preferred' instructional characteristics which, taken together, form his/her motivational pattern (Hofstein and Kempa 1985)[29].

Adar identified four major patterns according to the learners' preference for and responsiveness to different kinds of motivating action. She referred to the learners as:

- the achiever students
- the conscientious students
- the curious students and
- the sociable students.

According to her analysis, there are at least four major types of needs which can provide a basis for their motivation to learn, which are:

- the need to achieve
- the need to discharge a duty
- the need to satisfy one's curiousity (or the intrinsic curiousity for new knowledge)
- the need to interact socially with other people

It should be noted, as rightly pointed out by Martin Diaz (1989)[39], that these labels refer solely to students' motivational patterns, and not to any other characteristics, such as their actual appearance or personality.

2.2.3.1 The Achiever Student

There are two needs which generally stimulate the achieving person:

1) a need to succeed in competition with some standard of excellence (Atkinson and Feather 1966; McClelland 1976)[41, 42] and,
2) a need to gain status and esteem following the achievement of such success (Sears and Hilgard 1964; Maslow 1970)[43, 44].

Most people with a strong need of achievement avoid low-risk tasks, because these provide little chance for excellence. They tend to identify with tasks characterised by medium and, less frequently, high levels of risk (McClelland 1961)[45]. Moreover, these people perform their tasks better when they operate in competitive situations (McKeachie 1973)[46]. They like action and tend to feel short on time or psychologically pressed to finish their task in order to move on to other things that have to be done, and they want to show initiative whenever possible (Atkinson and Feather 1966)[41].

All these characteristics apply to the achiever student. Adar (1975)[40] in her survey of learning motivation, as well as Orbach (1979)[32], therefore, arrive at the conclusion that an ideal situation for the stimulation of the motivation to learn in an achiever student is one in which the student is faced with a set of well-defined tasks and competes with others for the best performance of these tasks. Such an achievement-oriented situation should contain clear criteria of measurement and provide a proper set-up for an objective and immediate evaluation of the student's performance.

However, as noted by Adar, there exists a subtype of the achiever student which includes a student whose fear of failure is greater than his hope for success. He has developed a negative affect towards achievement following experiences of failure in the past. Contrary to the normal achiever, he recoils from achievement-oriented situations. He tends to resist activities in which his competence might be evaluated against some standard or against the competence of others, and feels quite uncomfortable if compelled to engage in them at school.

2.2.3.2 The Conscientious Student

Acccording to Adar (1975)[40], the conscientious student is dominated largely by the need to fulfill what he considers to be his educational duties. A conscientious student has a genuine desire to do only the right thing, failure of which brings him feelings of fear and guilt. Therefore, he takes his studies seriously, because he regards learning as a duty. Unlike other students who also work hard at learning, the conscientious student enjoys learning and finds much satisfaction in performing the various duties associated with it. He is intrinsically motivated to do his duty - the nature of his personality - and does not need any kind of external stimulation to do it.

Linked to the feeling of fear and guilt, the conscientious student is characterised by compulsiveness of mind and a need for external, supportive control. As Adar suggests, compulsiveness of mind comes from the inability of the student to know for

sure if his class work is a good or perfect performance. Since he has doubts about the perfection of his performance, the conscientious student tries to insure himself against failure by attending minutely to each and every detail of his work. The same doubts are also responsible for the need for external, supportive control. Since he is not sure how well his work has been done, he seeks affirmation from the teacher by way of constant evaluation and feedback.

The conscientious student, therefore, prefers the organisation of learning inside the classroom to be well-structured, well-ordered and well-focussed in the teacher. He wants to know exactly what his task is, and this is usually better afforded under well-structured, familiar conditions (Adar 1975)[40].

Additional properties which characterise the conscientious student are: a compliant nature and a tendency toward disciplinary asceticism. With respect to the former, there is evidence of a positive correlation existing between the degree of pressure exerted by the person's conscience and the degree of his conformity. The more conscientious a student is, the more dogmatic, opinionated and conformist he is (Berkowitz 1964; Adar 1975)[47, 40]. As regard his inclination towards asceticism, the conscientious student attaches great importance not only to his success at performing a duty but also, and significantly, to his very effort at achieving such success.

Resulting from the student's inclination to attach great importance to ascetic behaviour and from his compliant nature, Adar suggests that the well-structured tasks that require real effort, such as learning a passage by heart, summarizing material, routine problem-solving, or extracting of information from given texts, will motivate a conscientious student more than tasks that have to be personally structured or tasks requiring no real effort at their completion.

2.2.3.3 The Curious Student

Adar's curious student is, as she suggests, curious about intellectual objects. Comparing curiousity with creativity, she holds that some of the major components of

creativity can be equated with "curiosity in action". This view is supported by evidence concerning creativity from Getzels and Jackson (1962)[25]. According to Adar then, the curious student is a person with a pronounced tendency to reexamine what is known, and to explore what is yet unknown. Such a student usually chooses to react to those stimuli appearing in his environment which are novel and complex.

Novel situations may be considered as situations dominated by change and surprise (Rethlingshafer 1963)[48]. In the teaching/learning context, i.e classroom, this change and surprise can be brought about by the teaching material, the teaching method and the teacher. On the other hand, complex situations are dominated mainly by incongruity and conflict of information (Maw and Maw 1965; Adar 1975)[49, 40]. In the classroom, incongruity and conflict relate mainly to the information contained in the learning material. Parts of the information may be contradictory or a relationship/connection between information parts may be missing.

Novelty and complexity are, then, the two major properties of stimulus for learning to which a curious student will react most strongly (Orbach 1979)[32]. When a curious student encounters novel and complex situations, dissonant conditions and changes in arousal level are produced in him leading to the experience of feelings of doubt and confusion. He finds it difficult to live with these feelings and is, therefore, stirred into exploratory and manipulative actions that aim at clearing his doubts and resolving his confusion. Thus, exploratory behaviour and manipulation are the most important products of curiousity.

However, the motivational value of novel and complex situations depend on the fulfilment of two conditions (Adar 1975)[40]:

1) the conflict or problem must be seen as realistic and concrete rather than imaginary or contrived.
2) the problem must also be raised, defined or delineated not by the teacher, but rather by the student himself.

These observations, taken together, point to the curious student as having the following characteristics (Adar 1975; Orbach 1979)[32, 40]:

- a liking of novel and complex situations;
- an inclination to examine, to investigate and to manipulate;
- a liking of tasks whose results cannot be foreseen with ease;
- a liking for decision making; and
- a liking of teaching/learning atmosphere encouraging non-conformity and originality.

2.2.3.4 The Sociable Student

This student is the fourth major type proposed by Adar in her theoretical classification. The sociable student is dominated by a strong need for affiliation. This need for affiliation may result in two opposing patterns of behaviour, depending on the student's past experience. The first behaviour is characterised by approach - a desire to find and maintain positive, friendly, and gratifying personal relationships; the second has a withdrawal characteristic - fear and rejection of such relationships (Orbach 1979)[32]. Adar (1975)[40] named the two kinds of sociable student, the *positive* and the *anxious* respectively. The positive experiences an increasing motivation to learn when personal relationships are incorporated into the teaching/learning situation, while the anxious experiences the contrary.

The most important properties which describe both subtypes of the sociable student are self-confidence and personal pace. The positive subtype has a considerable measure of self-confidence which is both a condition for and a result of success in the social world; the anxious lacks it. As suggested by Adar, self-confidence influences other properties, such as spontaneity, optimism, nonauthoritativeness, and freedom from fear of failure in achievement-oriented situations. Thus, the positive social student usually has a larger measure of these properties than does his anxious colleague.

Personal pace refers to the amount of energy spent by an individual in performing various tasks. The positive student is very active in his learning. The term "active" is not only confined to physical activity, but also includes the process of making decisions (Orbach 1979)[32].

The positive social student prefers a friendly and informal classroom atmosphere, and likes to have the chance to take initiative and to pursue his own enquiry.

The above classification and description of students as pure types - whether Achiever or Conscientious or Curious or Sociable - is vital for research and essential for the purposes of analysis and explanation (Orbach 1979)[32]. As Orbach has pointed out, pure types of students who are motivated to learn by only one need or another exist mostly in theory, but such classification and description must be accepted with an understanding that in real life there may be a few students who belong clearly and solely to one pure type or another. In real life there are many students whose motivation to learn originates from more than one source, and many who are hardly motivated at all by any of the sources discussed above.

2.2.4 Interactions Between Students' Motivational Patterns and their Preferences for Different Modes of Instruction

The primary purpose of this study is not to establish a relationship between students' motivational patterns and their preferences for different modes of instruction in science. However, the presentation above and the general direction of the research make it reasonable to give a brief overview of the relationship between these two quantities.

It has been proposed that students' motivational orientations have a significant influence on their preferences for, or dislike of, different instructional approaches used in science education. Adar (1975)[40] originally postulated in general terms the existence

of such a link. This was later elaborated by Hofstein and Kempa (1985)[29] for instructional activities in science. In the theoretical preditions made by Hofstein and Kempa, they took the position that the motivating quality of an instructional procedure

Table 2.1 Summary of the relationships between students' motivational patterns and preferences for instructional procedures (Kempa & Diaz 1990)[30].

	Motivational Pattern			
Instructional procedure	*Ach.*	*Cons.*	*Cur.*	*Soc.*
Knowledge acquisition mode				
- Formal teaching	-	+	-	- -
- Use of reference books for finding information		-	+ +	
- Use of discovery learning	+		+ +	(+)
Working arrangements				
- Individual work				- -
- Involvement in group work		(+)		+ +
Practical work				
- Doing practical work			+ +	(+)
- Experimental work with instructions		+ +	- -	
Organisation of teaching				
- Opportunity to pursue one's own enquiry	+		+	+ +
Evaluation				
- Evaluation by teacher		+ +		
- General dislike for being tested				+ +
- Risk-taking			+	

+ + denotes strong preference; - - denotes strong dislike
+ denotes moderate preference; - denotes moderate dislike
(+) indicates a moderate preference trend due to an indirect, rather than a direct relationship between preference and motivational pattern.

arises from its interaction with the motivational pattern of the learner. This notion is supported in a study by Ames and Ames (1984)[50] on systems of student motivation. If the instructional procedures are to generate or sustain motivation on the part of the learner, they must be broadly matched to his motivational characteristics. Hofstein and Kempa stress that motivation in this context arises from, or is influenced by, the nature of the teachers' pedagogical interventions and teaching strategies. It is different from 'interest-arousal' which is associated with the nature and orientation of the subject

matter that is taught or learned. An empirical examination of the links predicted above has been done by Kempa and Martin Diaz (1990)[30]. The general view is that students of different motivational orientations respond differently to different instructional procedures. A summary of the main findings of Kempa and Martin Diaz is presented in Table 2 above.

2.3 Cognitive Styles

There have been studies to investigate the practical implication of cognitive styles for teaching/learning, memory and education in general.

Cognitive styles have been defined as dimensions of individual differences involving the form of cognitive functioning, with expression in a wide array of content areas including perceptual, intellectual, social-interpersonal, and personality-defensive processes (Goodenough 1976)[51]. They represent relatively stable and characteristic ways in which people select, perceive and process information with which they are confronted (Kempa 1992)[22]. Examples of well-known cognitive styles are ***Field-dependence/Field-independence*** and ***Convergent/Divergent thinking***.

2.3.1 Field-dependent and Field-independent Cognitive Styles

In theory, field-dependence (FD) or field-independence (FI) is considered to be an expression of a more general individual-difference dimension, defined at one extreme by a global mode of field approach and at the other extreme by an articulated mode of field approach (Witkin et al. 1974)[52]. Experiences of people with a relatively global cognitive style are governed by the organisation of the field. By contrast, experiences of people with a relatively articulated cognitive style can be analysed and structured in new ways, depending on the task at hand (Goodenough 1976)[51].

It is postulated that field-dependent individuals rely more on external frames of reference while field-independent individuals rely more on internal frames of reference. Cognitive restructuring and interpersonal competence are seen as two domains on

which these styles have a particular profound impact. Particular attention will be given here to cognitive restructuring.

2.3.1.1 Field-dependence/independence and Cognitive Restructuring

According to Witkin et al. (1977)[23] the common denominator underlying individual differences in performance in various task is the extent to which the learner perceives part of a field as discrete from the surrounding field as a whole, rather than embedded in the field; or the extent to which the organisation of the prevailing field determines perception of its components; or simply, the extent to which the learner perceives analytically. At one extreme of the performance range perception is strongly dominated by the prevailing field (global). This mode of perception is designated "Field-dependent". At the other extreme, where the learner experiences items as more or less separate from the surrounding field (articulated), the designation used is "Field-independent". In other words, field-dependence/independence express the extent to which a person tends to extract information from an otherwise distracting background. It should be noted, as Witkin et al. point out, that these labels reflect a tendency, in varying degrees of strength, toward one mode of perception or the other. It does not imply that there are two distinct types of human beings.

The styles identified in perception manifest themselves as well when the learner is dealing with symbolic representations, as thinking and problem-solving. The individual who, in perception, cannot keep an item separate from the surrounding field - i.e the field-dependent - is likely to have difficulty with that class of problems where the solution depends on taking some critical element out of the context in which it is presented and restructuring the problem material so that the item is now used in a different context. Johnstone and El-Banna (1988)[53] offer, in this situation, an interesting description of field-dependence/independence as a measure of the capacity to separate 'signal' from 'noise'. They argue in their study of students' ability to solve

chemistry problems (as a function of the complexity of the problem to be solved and students' working memory) that generally field-independent students are better at extracting the 'signals' from the problem-related information than their field-dependent colleagues, even if both show identical working memory capacity.

It is the internal referents available to field-independent people which provide them with a reservoir of mediating mechanisms for use in restructuring a field on their own, when that is demanded by the task at hand (Witkin 1978)[54]. Restructuring may involve organising a field which lacks inherent structure, imposing a different organisation on the field than the one it contains, or breaking up an organised field so that its parts are rendered discrete from ground. All these acts involve making changes in the field, or going beyond the information given, rather than following the field as it is given. That field-independent people are more likely to follow a restructuring approach than field-dependent people has been demonstrated in numerous studies which have examined a wide range of perceptual and problem-solving dimensions which, while discrete in particular characteristics, all require skill in cognitive restructuring. Examples of restructuring dimensions linked to field-independence (Witkin 1978)[54] are:

- Disembedding (known as Flexibility of Closure in factor-analytic literature). One of the tests of this dimension is the embedded-figure test. The task here is to locate a previously seen simple figure within a larger organised geometric figure which has been organised to obscure it.
- Speed of Closure is another restructuring dimension on which the field-independent do better. On tests of this dimension the subject is shown an impoverished representation of an object which he is required to identify. He must provide an organisation to the stimulus array to succeed.

2.3.1.2 Field-dependence/independence and the Social Dimension

In the social domain, field-dependence expresses itself in interpersonal competencies due to the individuals' reliance more on external frames of reference; field-independent individuals show less competence in interpersonal relations. There is evidence that field-dependent individuals have in effect what amounts to a sensitive radar system, selectively attuned to social components of the environment (Witkin et al. 1977)[23]. This tendency shows itself in many social modalities. For example, it has been demonstrated that field-dependent individuals more than field-independent individuals literally: - look more at others, the primary source of information, about what others are feeling or thinking;

- attend more to verbal messages with social content, even when the messages occur in the periphery of attention;
- take greater account of external social referents in defining their attitude and feelings; and
- are drawn to people, in the sense of liking to be with them - "with people" stance.

Because of these social orientations, it is not surprising that field-dependent individuals have been perceived as warm, tactful, considerate, socially outgoing and affectionate by others; they know and are known to many (Witkin et al. 1977)[23]. In contrast, relatively field-independent people tend to have a more impersonal orientation. They are described as individualistic, aloof and concerned with ideas and principles rather than people.

2.3.1.3 Educational Implications of Field-dependence/ independence Cognitive Styles

Studies of the role of cognitive style in student learning have used both the cognitive and social characteristics constituents in the field-dependence/independence dimensions to conceptualize relations between learning behaviour and cognitive style.

Learning Social Material

It is suggested by Fitzgibbons et al. (1965)[55] that relatively field-dependent and field-independent students do not seem to differ to any large extent in sheer learning ability and memory. However, reflecting differences between them in what is relevant, attended to, and salient, field-dependent students tend to be better at learning and remembering social material than their relatively field-independent colleagues. This view is also supported in a study by Ruble and Nakamura (1972)[56]. It must be pointed that the inferiority of the field-independent students in this regard is a lack of attention, rather than lack of ability. Their performance can be easily made equivalent to that of the field-dependent by bringing the learning of social material to focal attention (Adcock and Webberley 1971)[57].

Effect of Reinforcement

A second way in which students' cognitive styles may influence their learning is found in effects of different kinds of reinforcement. As already mentioned, field-independent individuals are likely to have internalized referents to which they adhere as guides for self-definition and which they maintain as distinctly separate from external social referents, while the tendency is for field-dependent individuals to rely more on external referents for self-definition. There is evidence to suggest, as expected, that field-independent students tend to learn more than the field-dependent under conditions of intrinsic motivation (Fitz 1971; Steinfeld 1973)[58, 59]. Field-dependent students would be more likely to require externally defined goals and reinforcements. Steinfeld

maintains, however, that the difference disappears when external rewards for learning are introduced.

The Use of Mediators in Learning

It is demonstrated by studies of organisational factors in learning that field-independent students more often make use of mediators or mediating concepts - actively abstracted from their experiences - in many situations. In learning, the material to be learned frequently lacks clear inherent structure, creating the requirement that the student himself provides organisation as an aid to the learning. Their lesser use of structuring as a mediator may handicap field-dependent students in unstructured learning situations. They may need more explicit instruction in problem-solving strategies or more exact definition of performance outcomes than field-independent students, who may even perform better when allowed to develop their own strategies.

If the use of mediators is indeed more typical of field-independent than field-dependent people, then as pointed out by Nebelkopf and Dreyer (1973)[60], field-independent students would attempt to use an hypothesis testing approach and field-dependent students a spectator approach to concept attainment. Effective learning may take place by either an hypothesis testing or a spectator approach - no significant difference is observed between the field-independent and field-dependent. Here field-dependence/ independence appears to be more related to the "how" than to the "how much of", or the effectiveness of, cognitive functioning.

Cue Salience

In the formation of hypotheses about the nature of the concepts to be learned, noticeable cues are, in general, more likely to be used than cues that are not very noticeable. Similarly, concepts defined in terms of more salient cues are generally easier to learn than concepts defined in terms of less salient cues. It is suggested that the effects of cue salience may be more pronounced for field-dependent than field-independent concept learners, because the field-dependents, as seen above, are

particularly responsive to the dominant arrangement of the field as given and are not very likely to depart from that arrangement (Witkin et al. 1977)[23].

It would appear from the above consideration on the field-dependent/ independent cognitive styles that relatively field-dependent and field-independent learners tend to favour different learning approaches. The approaches favoured by one kind of learner do not necessarily make for better achievement than the approaches favoured by the other kind. Whether one approach will lead to a better learning outcome than others seems to depend rather on the specific characteristics of the learning tasks and the particular circumstances under which learning takes place. However, other studies, as will be seen in the next section, seem to indicate otherwise.

2.3.1.4 The Role of Field-dependence/independence in Learning and Memory

Research concerning the role of field-dependence/independence in learning and memory clearly indicate that field-dependence/independence is an individual difference variable which influences many different aspects of learning and memory.

Goodenough (1976)[51], in a review of literature relating to this subject, concluded that a lot of the findings were consistent with field-dependence theory and that the data suggested that field-dependent and field-independent learners differed more in the processes they used than in the effectiveness of their learning or retention. However, Davis and Frank (1979)[24], in their review on concept learning, short-term memory and free recall, discussed alternative explanations which emphasised developmental differences, and differences in efficiency of performance, between field-dependent and field-independent learners.

Efficiency of performance between field-dependence and field-independence

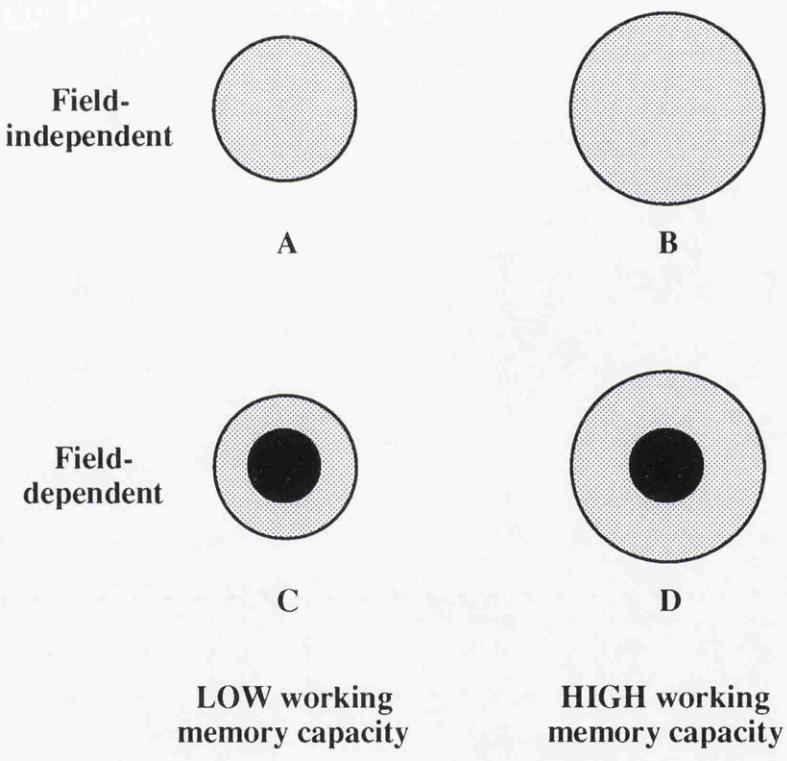
Citing various studies, Davis and Frank (1979)[24] reached a conclusion that, the bulk of *concept learning* research consistently shows that field-independent learners are more effective than field-dependent learners. This does not support Goodenough's (1976)[51] contention that field-dependent and field-independent learners differ in the processes they employ but not in the effectiveness of their performance. Davis and Frank suggested that the greater effectiveness of field-independent learners is related to the ability to conduct combinatorial analysis and to memory processes employed in concept learning. Citing Flavell (1977)[61], they explained combinatorial analysis as referring to the ability to systematically generate all possible combinations and permutations of a set of elements. Efficient concept learning requires the ability to generate and remember the possible combinations of attributes which define the concept, as well as the ability to remember the nature of past cues examined.

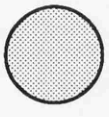
Studies on the role of memory in field-dependence/independence have found that task factors such as information load, interference potential and subjective organisation contribute to differences in memory performance between field-dependent and field-independent learners. Davis and Frank have considered two areas of memory research, short-term memory and free recall, which have contributed to the knowledge regarding memory and field-dependence.

Short-term memory - Whereas Goodenough (1976)[51] found little evidence to suggest that field-dependent and field-independent individuals differed in rote or associative memory, Davis and Frank (1979)[24] unearthed a lot of evidence (eg. Berger 1977; Robinson & Bennink 1978)[62, 63] to demonstrate that efficiency of performance in short-term memory tasks is related to field-independence. This relationship is, however, dependent on task variables. Field-independent learners are more efficient than field-dependent learners in the recall of information stored in short-term memory when there is interference and when the information load is high. However, when

information load is low and no interference is present, field-independent and field-dependent learners do not differ.

This relationship between efficiency of performance in short-term memory tasks and field-independence in the presence of interference and high information load is well illustrated by Johnstone (1992)[64]. Figure 2.1 shows the effect of the same amount of interference/high information load on individuals with different working memory ('M' space or short-term memory) capacities.





Working memory space available for information processing.

Working memory space taken up by 'noise' and therefore not available for information processing.

Fig. 2.1 Effect of interference/high information load ('noise') on working memory capacities.

The figure depicts what could be thought of in terms of *potential* working memory capacity and *usable* working memory capacity (Johnstone and Al-Naeme)[65]. When no irrelevant material is presented a pupil can perform to his full capacity as in **A** and **B**, but in a real problem-solving situation, where 'signal' and 'noise' are both present, he suffers a drop in performance. It could be that 'noise' occupies some of the potential working space, leaving a reduced space for useful processing of the relevant material of the problem (as in **C** and **D**). In problem-solving, the situation of the field-independent, who is capable of separating 'noise' from 'signal', could be described by **A** and **B**. All available working space is used in solving the problem. The situation of the field-dependent would be different - **C** and **D**. Since he is unable to separate the irrelevant from the relevant, part of his working memory is occupied by 'noise' and so he performs below his potential. In such a situation, the field-dependent with a high working memory may perform almost as equally as a field-independent with a low working memory. Considering the working memory capacity of individual pupils, a field-independent pupil with a low working memory capacity will outdo a field-dependent pupil with a low working memory capacity in a problem-solving situation where 'noise' and 'signal' are both present. Similarly, a high capacity field-independent pupil will perform better than a high capacity field-dependent pupil.

Another study which has found differences in efficiency of performance between field-dependent and field-independent learners is that by Johnstone and El-Banna (1988)[53]. The study suggests that a significant relationship exists between students' attainment (in chemical problem-solving) and their level of field-independence. Their main purpose was to explore students' ability to solve chemical problems as a function of (i) the complexity of the problem to be solved (i.e the number of pieces of information required to be manipulated for its solution) and (ii) students' 'working memory' (defined broadly in terms of the number of pieces of information one can hold in one's conscious memory and operate upon simultaneously). Johnstone and El-Banna found that, when the number of pieces of information [defined as the

number of steps used by the weakest successful student, assuming he does no 'chunking' (i.e. the breaking down of the information into smaller units for storage in short-term memory)] that had to be manipulated for the purpose of solving a problem, exceeded the student's working memory capacity, then the problem could not be solved. Furthermore, they found that students' success in problem-solving tasks could be affected by their level of field-independence: when the information load was close to the limit of the students' working memory capacity, a fairly strong correlation was observed between their attainment score and their field-independence score (r=0.5, significant at the p=0.001 level).

Free recall - As already mentioned, the theory of field-dependence assumes that field-independent subjects are more competent in cognitive restructuring skills (Witkin & Goodenough 1977)[66]. If this is so, then the expectation would be that, field-independent learners would exhibit a greater degree of organisation in free recall tasks. It has been found in several researches that the hypothesised relationship is dependent on the conditions on which the recall is elicited. Davis and Frank (1979)[24] suggested that the evidence reviewed indicated that the chances of field-independent individuals displaying superior recall increase as the inherent organisation of the task material decreases.

2.3.2 Convergent and Divergent Thinking Styles

Among the learner characteristics, students may be classified along a continuum of cognitive style called Convergence/Divergence.

Getzels and Jackson (1962)[25] distinguish between two types of learners: the 'High IQ' and the 'High Creative'. They define the difference between the 'High IQ' and the 'High Creative' in terms of scores on two contrasted types of mental tests. The 'High IQ', as the name suggests, is especially good at intelligence tests, but relatively weak on tests of creativity. The 'High Creative' is the opposite: he is especially good at the creativity tests but scores relatively low marks in IQ tests.

Based on the work of Getzels and Jackson, Hudson (1966, 1968)[26, 67] also distinguished between two categories of learners. Technically, he calls the 'High IQ' learner a Converger and the 'High Creative' learner a Diverger; their styles of reasoning being convergent and divergent respectively.

2.3.2.1 Definition of Convergence/Divergence

The convergent thinker has been defined and distinguished (Child and Smithers 1973)[68] "by his comparatively high scores in problems requiring one conventionally accepted solution clearly obtainable from the information available (as in intelligence tests), whilst at the same time obtaining low scores in problems requiring a generation of several equally acceptable solutions (typified in divergent thinking tests)." The reverse arrangement defines the divergent thinker: he scores high marks in problems requiring several equally acceptable solutions, whilst at the same time performing poorly in problems requiring one conventionally acceptable solution. The convergent/divergent thinking style, therefore, refer to the tendency of some learners to use a mode of thinking or reasoning which leads to logical conclusions and uniquely correct or conventionally accepted solutions, whilst others tend to use an approach leading to a variety of solutions.

In the teaching/learning situation, these kinds of thinking may be found. In science teaching, for example, the teachers habitually teach the science students to focus their thinking onto the answer; they must converge their thought-processes towards the one correct solution. In contrast, teachers would encourage arts students to use versatile thinking, to search for a variety of responses; they must therefore diverge their thought-processes (Hudson 1968)[67].

Convergent thinking then, is characterised by the recall of facts; the facts are manipulated; formulae are applied to them to get to the answer. In other words, the facts are ordered in such a way as to converge towards the answer. On the other hand,

divergent thinking calls for speculation, brainstorming and inventing possibilities. It is characterised by not having enough information to give one acceptable answer. The learner starts with a few facts and branches out to a multitude of reasonable answers (Pavelich 1982)[69].

2.3.2.2 Hudson's Work

Hudson's work (1966)[26] on convergers and divergers emerged from his study of 'Arts/Science specialization' by students. In a comparative study between arts and science-oriented students in an IQ test, he found that the arts specialists usually had verbal biases of ability while the scientists had numerical or diagrammatical biases. The general observation was that the scientists performed better than their arts counterparts in the IQ test. The difference in scores still held good when the same test was given to clever 15-year old schoolboys. And there was similar biases, too, among 13 and 14 year-olds whose academic specialization had not begun. Hudson concluded that biases of intelligence existed prior to academic specialization, and were not merely by-products of it.

The converger, according to Hudson, is the learner who is substantially better at intelligence tests than he is at open-ended tests; the diverger is the reverse. In addition, there are the all-rounders who are more or less equally good or bad on both types of tests. He clearly points out, however, that convergence/divergence dimension is a measure of bias, not of level, of ability.

The central results of Hudson's work is that most arts specialists, weak at the IQ test, were much better at the open-ended ones; most scientists being the opposite. Arts specialists are on the whole divergers and physical scientists are convergers.

Besides differentiating arts from science, the converger/diverger distinction also correlates with a wide network of other variables, some of them intellectual, and some personal.

Some characteristics of the converger are:

- his reaction to controversial issues are often stereotyped, and that he is prone to compartmentalize one topic from another;
- his attitudes tend to be conventional and authoritarian. In other words, he is willing to observe codes of conduct and positively enjoys the security which rigid systems of belief engender;
- his restriction affects his thinking as well as his personality and interest. He is disconcerted with open-ended tests particularly because they offer a task which lacks a single right answer. They seem to dislike ambiguity (as, for example, in Meaning of Words). The converger is thus seen as someone whose restrictions limit the scope of his experience, but permits him,within these limits, great intellectual freedom.

The diverger is in many respects the converger's opposite:

- he flourishes on open-ended tests which convergers dislike;
- he is liberal in his attitude; and seems less prone than the converger to accept beliefs or facts on trust, or to think in conventional terms.

In a nutshell, the convergent pupil's ability consists of a narrowing in focus, a winnowing down of detail and an imaginative austerity. The divergent pupil has the "ability to synthesise and recombine material to form new solutions to problems" (Hill 1976)[70]. It must, however, be pointed out that not all convergers/divergers fall strictly within this interpretation.

2.3.3 Characteristics of Cognitive Styles

To end this overview of cognitive styles, it may be appropriate to enumerate some of their characteristics (Witkin 1978)[54].

1) Cognitive styles are **process variables**. Being process variables, they represent techniques for moving toward a goal, rather than competence in

achieving goals. Whether use of a particular cognitive style will contribute to goal attainment or not depends on the context in which it is used.

2) Cognitive styles are **pervasive** dimensions of individual functioning. They express themselves across domains traditionally considered in isolation from each other. It has been seen above that, for example, field-dependent/independent styles manifest themselves in a wide array of cognitive functions and in many facets of interpersonal behaviour.
3) Cognitive styles tend to be **stable**. They show consistency over time as well as across domain. This does not imply that they are unchangable. Evidence from training studies suggest that development of at least some components of the field-dependent/independent dimension may be influence by specially designed educational efforts. So also teachers may play an important role in shaping the style of thinking of learners.
4) Another characteristic of cognitive style is that they are **bipolar**. For example,the cluster of restructuring skills and that of interpersonal competencies have their high and low levels at opposite poles of the field-dependence/independence cognitive style dimension. It is in this sense that the dimension is bipolar.
5) Finally, the bipolarity of the styles makes them **value-neutral**. Each pole of the field-dependence/independence dimension or the convergence/ divergence dimensions has qualities that may help a person to get along in specified circumstances. Accordingly, whether a given style is "good" or "bad" depends on its adaptive value in a particular situation. In short, value is relative to context for cognitive styles.

CHAPTER THREE

EXPERIMENTAL DETAILS

3.1 Introduction

Several instruments are available for measuring cognitive and affective factors. Some of those employed in this research to measure the motivational patterns, field-dependence/independence dimension and convergent/divergent thinking styles of the sample were developed and modified by researchers at the Centre for Science Education, Glasgow University. Trials of these tests were omitted because they had been tested and found appropriate in previous research work done at the Centre. The semantic differential test for measuring the responses of pupils to the use of worksheets in science lessons was developed by the researcher.

3.2 Sample

Pupils in S4 in a secondary school in the city of Glasgow doing the 'S' grade science were used. A mix of individualised learning and whole-class teaching, predominantly through printed worksheets, is used in 'S' grade science in the school.

The original total of sample was about 350, with about one-third absenting themselves from some or all the tests. Pupils who took all the tests and were used for this research were 219.

3.3 Measurement of the Motivational Patterns

Based upon work done by Adar (1975)[40] and by Hofstein and Kempa (1985)[29], the Centre for Science Education produced a series of tests for measuring the motivational patterns of pupils; two of which were used here.

Adar (1975)[40] placed pupils in one of four motivational patterns: the achiever pupils, the conscientious pupils, the curious, and the social pupils. The characteristics of each of these groups have been discussed in Chapter Two.

3.3.1 Motivation Test I

The test (Al-Naeme 1991)[71] consisted of sixteen statements representing four different categories of activity: i) about class work; ii) about laboratory work; iii) about projects; and iv) about social life. Four different statements, representing the four different motivational patterns, were put in each row representing a different category of activity. Pictorial characters, from original designs for TAPS materials by the Graphics Department of Jordanhill College, were used to narrate the statements. A pupil was asked to read the statements in each row and to write the name of the character whose opinion closely matched his/her own opinion in a space provided at the end of each row. A sample of the test is shown in Appendix 1A. The patterns *Ach* (achiever), *Cons* (conscientious), *Cur* (curious) and *Soc* (social) were omitted on the test sheets given to the pupils. A period of 5 minutes was allowed for the completion of the test.

The **scheme** for the classification of pupils in this test into the motivational patterns was as follows:

A pupil was categorised, for example, as **conscientious** :

- if he/she described him/herself as conscientious in the four different categories (rows) of activity - 4:0.
- he/she was still categorised as conscientious if he/she described him/herself in three different categories of activity as conscientious and as an achiever in the remaining one - 3:1.
- If a pupil described him/herself as conscientious in two different categories, and as an achiever and sociable in each of the remaining two categories, he/she

was regarded as a conscientious pupil - 2:1:1.

- A pupil could not be categorised as belonging to any one motivational pattern if he/she described him/herself as conscientious in two categories and as curious in the remaining two categories - 2:2.
- So also he/she could not be put in any one pattern if he/she described him/herself as an achiever in one category, as conscientious in a second, as curious in a third, and as sociable in the remaining category - 1:1:1:1.

The same scheme was used to categorise pupils as achiever, curious and sociable.

3.3.2 Motivation Test II

The purpose of this test was to help categorise pupils whose description ratio in Test I was 2:2 or 1:1:1:1 or were absent. It was also to confirm or deny the motivational pattern chosen by a pupil, especially in cases where the ratio was 2:1:1.

The test (Al-Naeme 1991)[71] shows four different characters (two males and two females), each one describing him/herself in four different statements concerning the four categories of activity (about class work, lab work, projects and social life). The pupil was asked to select a single character he/she agreed with most. The pupil simply ticked a box against the character selected. It was hoped that the pupil would select the most likely unique motivational pattern which may describe him/her without any overlaps with other patterns. It did not mean that he/she agreed with all the four statements of the character selected. It was expected that there would be, in some cases, at least one statement he/she did not completely agree with. Example of the test is shown in Appendix 1B. The patterns (*Ach.*, *Cons.*, *Cur.*, *Soc.*) were omitted on the test sheets given to the pupils.

The **classification scheme** used was by giving the pupil the motivational pattern of the character he/she selected.

3.3.3 Overall Classification of the Sample

The results from the two motivation tests were put together and the following scheme was used to categorise the pupils into the various motivational patterns. For example, a pupil was classified as **conscientious**:

- if he/she described him/herself as conscientious in the four different categories (rows) of activity - 4:0 in Test I. His/Her choice in Test II did not affect the result. If he/she ticked the conscientious box in Test II, it only confirmed his/her motivational pattern.
- A pupil was still considered as conscientious if he/she described him/herself as such in three different categories of activity - 3:1. The description in Test II did not affect the result.
- If a pupil described him/herself as conscientious, and partially as an achiever and sociable, in the ratio 2:1:1 respectively in Test I, then,
    * if he/she ticked the conscientious box in Test II, he/she was categorised as conscientious.
    * If, on the other hand, he/she ticked the achiever or social box in Test II, he/she was considered an achiever or sociable respectively, even though there was a score of 1 in each case in Test I. The reason was that in Test II the pupil, by the nature of the test, was 'forced' to put himself in one or the other motivational pattern. It was presupposed that he/she would at least agree fully with two of the statements and to some degree with the other two. The fact that this 'forced' pattern appeared in Test I makes it highly probable that the pupil was what he/she described him/herself in Test II.
    * If the pupil ticked in Test II none of the above - i.e conscientious, achiever or sociable - but described him/herself as curious, then the score of 2:1:1 in Test I was superceded by the choice in the former -

i.e curious. The pupil was 'forced' to make a definite choice there, unlike in Test I where there were many options and he/she may not have been committed to the choices made.

- When a pupil described him/herself as conscientious in two categories and as curious in the remaining two in Test I, then in Test II
  * if he/she ticked either of those boxes he/she was categorised according to box ticked;
  * if none of the two patterns above is picked then the pupil was categorised according to whichever of the remaining patterns he/she picked in Test II.
- If a pupil did not take Test I he/she was categorised according to the choice in Test II.

3.3.4 Interrelationships Between the Motivational Patterns

In real life there are a few pupils who may belong clearly and solely to one motivational pattern or another. There are many pupils whose motivation to learn originates from more than one source. For this reason, pupils' choices in both tests for motivational patterns were individually examined to find out where overlaps existed. The following **scheme** was used in deciding what a pupil's dominant pattern is and the less dominant overlapping pattern(s).

- Pupils who showed an overlap between more than two motivational patterns and those who could not be categorised from Test I & II were ignored.
- If a pupil is, for example, **sociable** (dominant) overall:
  + if he/she scored 4:0 in Test I, then the overlapping pattern (less dominant) may show in Test II. If he/she did not take Test II or if he/she did and still described him/herself as sociable, then there is no interaction with other patterns. If he/she chose any other pattern

other than social, then, since he/she was 'forced' into choosing only one pattern and presumably may not have agreed with all the four statements there, this other pattern was considered the less dominant or overlapping pattern.

+ If he/she scored 3:1 in Test I then the less dominant pattern is shown in Test I if he/she did not take Test II. If he/she did Test II and again described him/herself as sociable, the less dominant pattern remained as in I. On the other hand, if he/she ticked another pattern other than sociable in II, then that pattern became the overlapping pattern for the same reason given above.
+ If he scored 2:1:1 in Test I, any pattern chosen in II became the dominant pattern. If the social pattern was confirmed then, since the pupil has more than one less dominant pattern, i.e more than two overlapping patterns, he was ignored. If the social pattern was not confirmed, and the pupil was categorised as having one of the other three patterns in Test II, then the social pattern chosen in I became the less dominant or overlapping pattern.
+ A pupil who scored 2:2 in Test I and still described him/herself as sociable in II has the other pattern in I becoming the overlapping pattern. If he/she chose the other pattern then social became the less dominant. If neither of the two was chosen in II then he was ignored because he/she had more than two patterns overlapping.

3.4 Measurement of the Field-dependence/independence Dimension

The test applied was the **Hidden Figures Test** (HFT). It aimed to measure the relative degree of field-dependence or field-independence of the pupils.

3.4.1 The Hidden Figures Test

The HFT is a group administered, paper and pencil test. The design of the test (El-Banna 1987)[72] is based on the work of Witkin and others (1971)[73]. In their definition of field-dependent/independent cognitive style, they postulate that the field-dependent subjects find it difficult to overcome the influence of a surrounding field, or to separate an item from its context. Field-independent subjects, on the other hand, are able to distinguish an item from its context, or find it easy to break up an organised perceptual field.

The HFT consisted of 18 complex figures plus 2 introductory items as examples. Six simple geometric and non-geometric shapes were embedded in the 18 complex figures (one simple shape in each complex figure). The task here was for the pupil to locate a previously seen simple figure within a larger complex figure which had been designed to obscure it. A sample of the test is shown in Appendix 2A.

With the two examples given at the start, the pupils were then asked to locate the hidden simple shape in each of the 18 complex figures. They were to outline and trace it in pencil or pen against the lines of the complex figure. The following points were to be noted. They were:

1) to use 20 minutes for the test;
2) not to use a ruler or any measuring device in finding the simple shape;
3) to rub out all mistakes;
4) to do problems in order and not to skip any unless they were absolutely stuck;
5) to trace only one simple shape in each problem, although in some cases they could see more than one;
6) to look back at the simple forms as often as necessary.

7) The simple shape was always present in the complex figure in the same size, same proportions, and facing in the same direction, as it appeared alone.

The **marking scheme** was to award one mark for each correct simple figure found and traced by the pupil. The marks were added up to give the total score for each pupil. The maximum mark that could be obtained was 18.

An item was scored right if:

a) A simple shape of the same size, in the same proportion and facing in the same direction (as the given specimen) within the complex figure had been located.

b) There was no extension of this simple shape into another shape.

c) No other wrong shape in the complex figure had been traced.

An item was scored wrong if:

a) There was no simple shape traced.

b) The simple shape outlined was not the same size, proportion and orientation as the specimen.

c) There was an extension of the correct simple shape into another shape.

The scoring key is shown in Appendix 2B.

3.4.2 Classification of the Sample

The criterion used to classify the sample was to consider pupils who scored more than 0.4SD (Standard Deviation) above the mean score as *field-independent*, and pupils who scored less than 0.4SD below the mean score as *field-dependent*. Those scoring between +/-0.4SD were classified as *field-intermediate*. The factor 0.4SD gave a better distribution than 0.5SD or 0.25SD (See Appendix 5). The designations "field-dependent" and "field-independent" reflect a tendency, in varying degrees of strength,

toward one mode of perception or the other. It was, therefore, thought inappropriate to divide the sample into two distinct types along the mean, but to spread them between the two poles. For the most part, the results would be analysed in terms of comparisons between the two extreme groups, the field-dependent and the field-independent. This was not because the field-intermediate were unimportant, but because comparisons between contrasting groups were a convenient way of describing complex results.

3.5 Measurement of Convergence and Divergence

This study is based upon Hudson's original work (1966)[26]. The aim of the test was to measure and classify the sample as either convergent thinkers or divergent thinkers.

Child and Smithers (1973)[68], based upon Hudson's work, distinguished convergent thinkers by their high achievement in problems requiring one conventionally accepted solution which is obtainable from the given information (as in intelligence test). But convergent pupils would be more likely to have a more diminished ability than divergent pupils in providing a variety of answers to problems requiring the generation of several equally acceptable solutions (as in divergent thinking tests). In divergent thinking tests, which were used in this research, the divergent thinkers would be expected to obtain higher scores than their convergent counterparts.

3.5.1 Description of the Test

The test consisted of six mini tests (Al-Naeme 1991)[71], each allotted a limited time for completion. The total amount of time allowed was 25 minutes. The pupils were required to write as many answers as possible for every given question. A sample of the test is shown in Appendix 3.

Test 1

The test was designed to find a pupil's ability to think of as many different words as possible having the same or similar meaning to the one given. An example

was given to show the pupil what he/she was asked to do. This test was to be done in 5 minutes.

Test 2

The pupil was asked in the test to write as many different sentences as possible using all the four given words in each sentence. He/She was to use the words in the form they were given (e.g took could not be used in place of the given word take), but not necessarily in the order they appeared on the sheet. An example was given and 5 minutes allowed for the test.

Test 3

This test was pictorial to give pupils with difficulty in language and writing the opportunity to express their ideas and imaginations easily. Most convergent/divergent tests are verbal and can be difficult for such pupils. In this test, the pupil was required to draw up to five symbols for each word or phrase given. An illustrated example was given and 5 minutes set for the test.

Test 4

The test was intended to reflect a pupil's thinking about subjects. The pupil was asked to write down all the things "which are round or which are round more often than any other shape". The time limit was 3 minutes, and an example was given to show what was to be done.

Test 5

The intention here was similar to that of test 4. The pupil was asked to think of and write down as many words as possible which began with the letter 'G' and ended with the letter 'T'. Names of places and people were not allowed. An example was given and the pupil had 4 minutes to finish the test.

Test 6

This was a free-imagination test. The pupil was given a specific topic and asked to write as many ideas as he/she could think of about the topic with no restrictions. The

test made demands on the pupil's ability in composition and imagination. Here, again, an example was given and 4 minutes allowed for the test.

The **scheme** for scoring was to allot one mark for every correct answer.

3.5.2 Classification of the Sample into Convergers and Divergers

Pupils who scored more than 0.4SD above the mean score were classified as *divergers* and those who scored less than 0.4SD below the mean as *convergers*. Pupils in between +/-0.4SD were identified as the all-rounders. Here again, 0.4SD was used because it gave a better distribution than 0.5SD or 0.25SD (See Appendix 6). The results were analysed in terms of comparison between convergers and divergers because it was a convenient way of describing the results.

3.6 Measurement of Pupils' Attitude/Response to the Worksheet Approach of Teaching/Learning

Semantic differential, an attitude measuring technique developed by Osgood, Suci and Tannenbaum (1957)[74] was used to measure the response of pupils to the written worksheet approach of teaching/learning science. A sample is shown in Appendix 4. It contained seven bipolar adjective/phrase scales. The technique was to enable the measurement of the pupils' judgement of the concept: **"Using work-booklets or activity sheets in science lessons"**. Beginning with an example, the respondents were instructed to give their opinion about the concept on each of the bipolar adjective/phrase scales by ticking one of the boxes on each scale.

For convenience, the judgements on the semantic differential were not quantified on the usual one-to-x (x = 3, 5, 7) scale with x representing the most positive opinion. Intervals between responses could not be assumed to be equal, so an ordinal scale was used. The responses of the motivational groups were examined to find out how the responses from each were distributed and in which direction.

CHAPTER FOUR

RESULTS AND ANALYSIS OF DATA FROM THE AFFECTIVE AND COGNITIVE STYLE TESTS.

4.1 Introduction

This chapter deals with the presentation and analysis of data collected from the motivation, the field-dependence/independence and the convergence/divergence tests. Attention will be drawn to any statistically significant relationships which may arise from the factors measured. It is hoped that these may lead to some predictions on the effect of the written worksheets on students' learning and the outcome of their studies.

4.2 Distribution of Pupils in the Motivation Tests

Following the schemes presented in Sections 3.3.1, 3.3.2 and 3.3.3 the distribution of pupils in the two tests and the overall distribution which is a composite of Tests I and II are as follows:

Table 4.1 Distribution of pupils in the motivation tests.

Motivational Patterns	Test I	Test II	Overall@
Achievers	4	7	9 (*4%*)
Conscientious	65	62	87 (*40%*)
Curious	39	36	42 (*19%*)
Sociable	34	63	65 (*30%*)
None*	54	22	16 (*7%*)
Absentees	23	29	-
	219	219	219

* Those who could not be classified as belonging to any one of the four patterns.
@ See section 3.3.3 for how the overall distribution was arrived at.

The results do not suggest that each pupil belongs solely to his/her motivational pattern. In other words, the pupils are not classified as pure types. As pointed out in chapter 2, such classification of pupils as pure types who are motivated to learn by only one need or another exists mostly in theory; and is convenient and meaningful for research and essential for purposes of analysis and explanation (Orbach 1979)[32]. The patterns are, therefore, not fully independent of one another. Hence, some interrelationships between motivational patterns may well be expected. There are, however, a few pupils (8) who described themselves in both tests as belonging solely to one pure pattern or another. The great majority of pupils showed overlaps of motivational patterns. They, therefore, have more than one motivational pattern. In many cases, where a single pattern dominates, there is still the likelihood of an overlap with at least one other pattern.

4.3 Interrelationships Between Motivational Patterns

A pupil's choices in both tests were examined to find out the interacting picture between the motivational patterns. The scheme for determining the overlaps between patterns is presented above (section 3.2.4). The pattern of interaction is shown in Table 4.2.

It is evident, as will be shown, that some patterns overlap often with each other. These are highlighted in Table 4.2. In general, the overlaps are between the conscientious, the curious and the social patterns. There is a relatively strong interaction between the conscientious and the social patterns. Pupils who are classified as being predominantly conscientious more often have an overlapping social pattern. A reverse trend is found with the predominantly social pupils. They very often have an overlapping conscientious pattern. Another observed relationship between patterns is the overlap between the conscientious and the curious patterns. After the social motivational pattern, the curious pattern is the next overlap that conscientious are likely to show. A similar pattern may be expected of the curious pupils. Of this group a

higher proportion are observed to show a second trait which is very often an overlap with the conscientious pattern. Then, there is an overlap between the curious and the social patterns.

Table 4.2 Interactions between pupils' motivational patterns

Patterns	Achievers	Conscien.	Curious	Sociable	No Overlap or Ignored*	Total
Achievers	**0** *0%*	**3** *33%*	**2** *22%*	**0** *0%*	**4** *44%*	**9**
Conscien.	**2** *2%*	**0** *0%*	**26** *30%*	**32** *37%*	**27** *31%*	**87**
Curious	**1** *2%*	**17** *40%*	**0** *0%*	**11** *26%*	**13** *31%*	**42**
Sociable	**0** *0%*	**18** *28%*	**12** *18%*	**0** *0%*	**35** *54%*	**65**
None	-	-	-	-	**16**	**16**
						219

* Pupils who showed an overlap between more than two motivational patterns and those who could not be categorised from Tests I and II were ignored.

Overlap between the conscientious and curious patterns.

Overlap between the conscientious and social patterns.

Overlap between the curious and social patterns.

The charts below show how each pattern interacted with the others. The height of each bar indicates the extent of overlap.

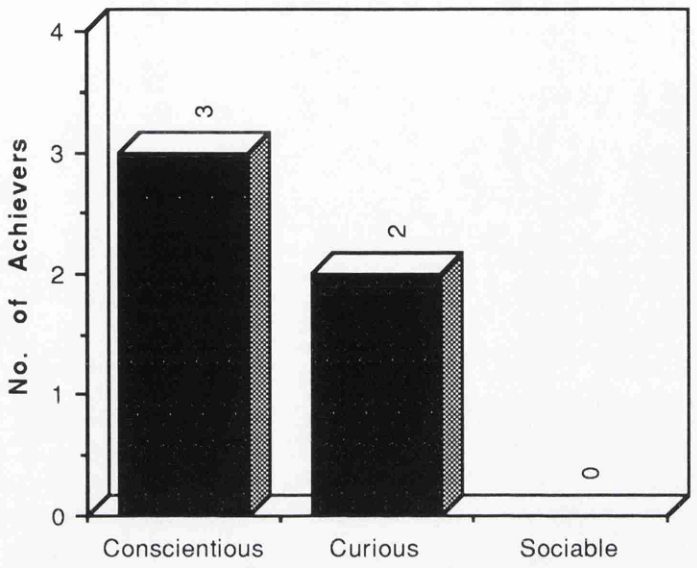


Fig. 4.1 Extent of overlaps with other patterns shown by achiever pupils.

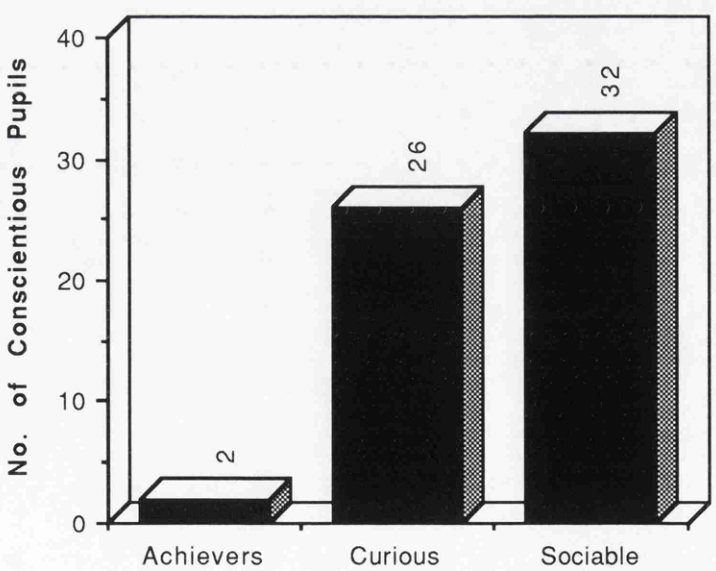


Fig. 4.2 Extent of overlaps with other patterns shown by conscientious pupils.

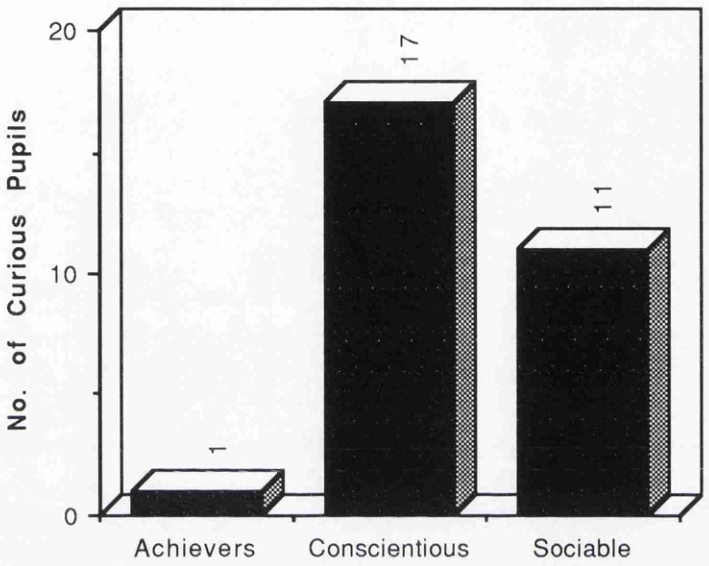


Fig. 4.3 Extent of overlaps with other patterns shown by curious pupils.

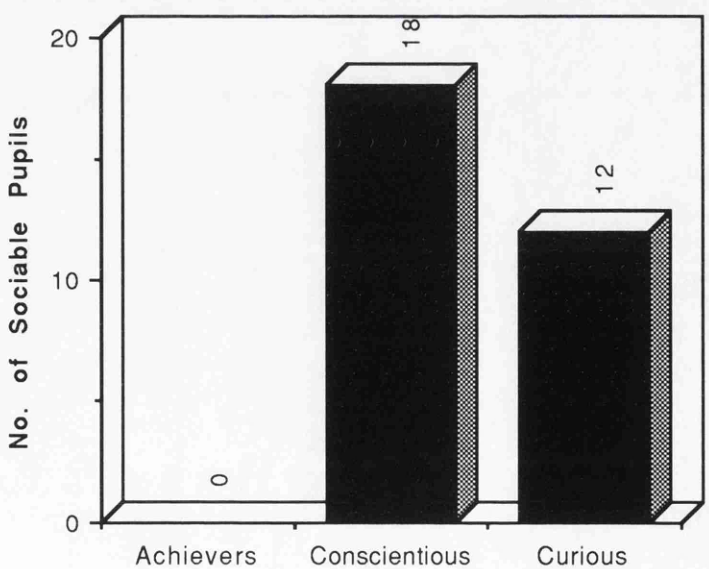


Fig. 4.4 Extent of overlap with other patterns shown by sociable pupils.

As already indicated, pupils who exhibited more than two overlapping patterns were disregarded in the examination of the interactions between patterns. It must be mentioned, however, that most of those ignored belonged to one of three motivational patterns - the conscientious or the curious or the social pattern - with the remaining two as the overlapping traits. It may also be of interest to mention that about 80% of the absentees in either of the two motivation tests described themselves as social pupils in whichever test they did.

The overlapping patterns may influence each other resulting in the observation of a mix of characteristics found in a particular pupil. This may show in the pupil's needs and preferences for particular instructional modes. For example, a conscientious pupil with an overlapping social pattern will be expected to show, in addition to his preferences for formal modes of teaching, practical work with instructions, and his attitude of seeing his work as a duty, a need to affiliate with others through, say, involvement in group work, and a preference to study in a non-competitive atmosphere (characteristics very typical of social pupils).

4.4 Classification and Distribution of the Sample in the Hidden Figures Test

For the reasons given in Section 3.3.2, the sample was divided into three groups, the **field-dependent (FD)**, the **field-independent (FI)** and the **field-intermediate (FInt)** who are given less attention here in order to accentuate the differences between the two extremes. Pupils who scored more than 0.4SD above the mean score are classified as FI, those with scores less than 0.4SD below the mean are classified as FD, and those who scored in between +/-0.4SD around the mean as FInt. The factor +/-0.4SD gives a better distribution of the sample than +/-0.5SD and +/-0.25SD which were also tried (see Appendix 5). Many pupils were lost to the FInt group when 0.5SD was used reducing the other two cells. A quarter of the standard deviation, on the other hand, made the FInt cell too small for any statistical considerations. Fig. 4.5 and Table

4.3 show the frequency distribution of the scores and the number of pupils in each classification respectively. The mean score is 7.2 (Standard deviation = 3.5).

Fig. 4.5 Frequency distribution of scores in the Hidden Figures Test.

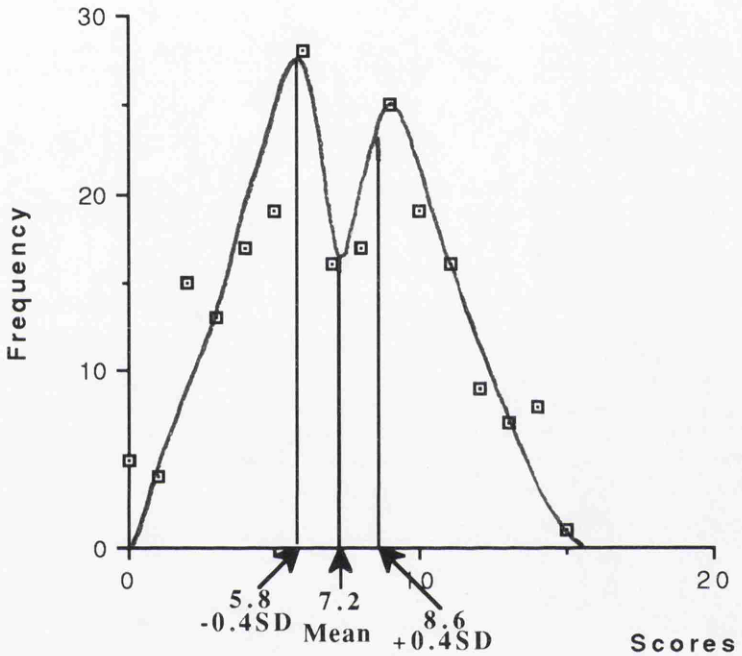


Table 4.3 Distribution of the sample in the field-dependence/independence test.

Groups	FD	FInt	FI	Total
Pupils(n)	**101**	**33**	**85**	**219**
%	*46*	*15*	*39*	*100*

4.5 Classification and Distribution of the Sample in the Convergence/Divergence Tests

Here too, the sample was divided into three groups - **convergent thinkers (Conv.)**, **divergent thinkers (Div.)** and the **all-rounders (AR)** - for the reason given in Section 3.4.2. Again, to accentuate the differences between the extremes, the all-rounders were given no attention Pupils who scored more than 0.4SD above the mean score are considered as divergent thinkers and those who scored less than 0.4SD below the mean are considered as convergent thinkers. Pupils with scores in between +/- 0.4SD are classified as all-rounders. The mean score is 41.7 (Standard deviation = 14.7) The frequency distribution of the scores and the distribution of the sample in the three groups are shown in Fig. 4.6 and Table 4.4 respectively. See Appendix 6 for the distributions of sample using +/-0.5SD and +/-0.25SD.

Fig. 4.6 Frequency distribution of scores in the convergence/divergence test.

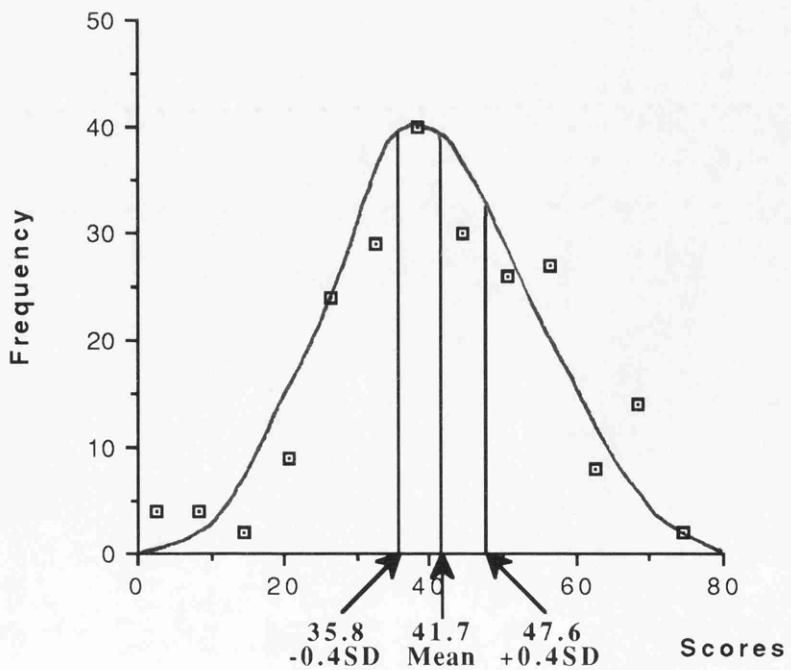


Table 4.4 Distribution of the sample in the convergence/divergence test.

Groups	Conv.	AR	Div.	Total
Pupils(n)	**77**	**65**	**77**	**219**
%	*35*	*30*	*35*	*100*

4.6 Correlation Between the Field-dependence/independence and the Convergence/Divergence Cognitive Styles

For descriptive purposes, a scatterplot of the scores of the field-dependence/independence test and the convergence/divergence test was done and the correlation coefficient (r) which shows the relationship between both tests computed.

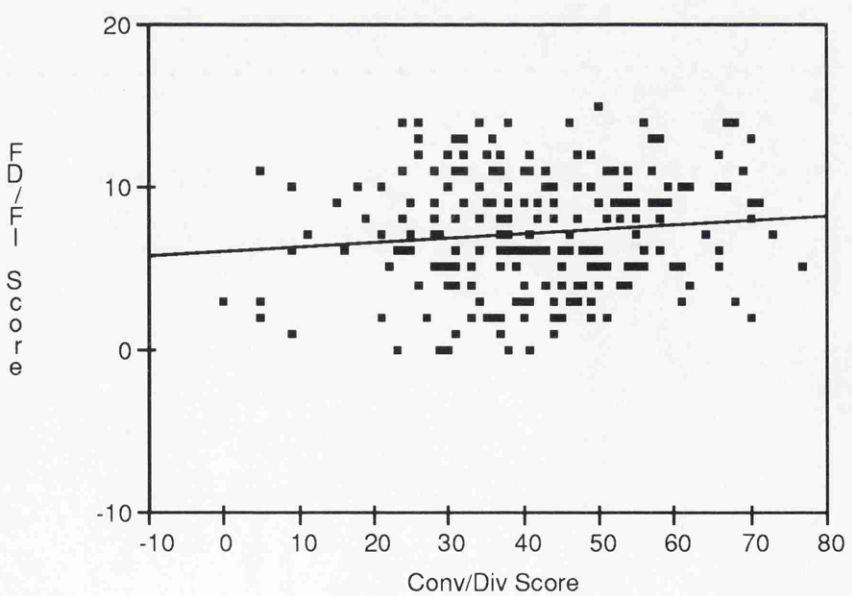


Fig. 4.7 Scattergram of scores of the field-dependence/independence and the convergence/divergence tests.

If the factors measured are independent factors, then a low correlation would be expected. The value obtained is +0.11, which was not significant. The very low correlation indicates that the field-dependence/independence dimension and the convergent/ divergent thinking styles are probably independent factors and could be treated separately.

The general tendency from the scores in both tests is that more FI pupils performed well in the convergence/divergence test than the FD pupils. Thus, the FI pupils tend to be divergent thinkers. The FDs did not do well in the test and would, therefore, appear to be more convergent than divergent thinkers. A similar outcome may be expected in the field-dependence/independence test. Divergers, who are more likely to be FI, performed better than the convergers who are more likely to be FD.

4.7 Distribution of the Motivational Patterns in the Field-dependence/independence Test

A study of how the achiever, the conscientious, the curious and the sociable pupils were distributed in the field-dependence/independence test was done to see if any relationships could be observed. Table 4.6 shows the distribution.

Table 4.6 Distribution of the motivational patterns in the field-dependence/ independence test.

Groups	FD		FInt		FI		Total
	n	%	n	%	n	%	
Achievers	**3**	*33*	**0**	*0*	**6**	*67*	**9**
Conscien.	**45**	*52*	**10**	*11*	**32**	*37*	**87**
Curious	**12**	*29*	**9**	*21*	**21**	*50*	**42**
Sociable	**32**	*49*	**12**	*19*	**21**	*32*	**65**
None	**9**	*56*	**2**	*13*	**5**	*31*	**16**
Total	**101**		**33**		**85**		**219**

In line with the hypothesis (see Introduction pp 3-4), the numbers falling into the conscientious and the curious patterns were of particular interest and were given more attention.

It is observed that the conscientious and the social pupils are more likely to be field-dependent, while the the curious and the achievers are more likely to be field-independent. A similar result was obtained in a study by Al-Naeme (1991)[71], except that in his case he found the social pupils to be more likely field-independent. That conscientious pupils are more likely to be field-dependent and curious pupils field-independent is not unexpected. As it has already been pointed out (see Section 2.2.3.2), conscientious pupils are less motivated by unstructured tasks (lacking clear instructions)

or tasks that have to be personally structured. This may be due to their difficulty in keeping an item separate from its surrounding field, a feature very characteristic of field-dependent pupils. So in the Hidden Figures Test the conscientious pupils may have found it difficult restructuring the complex figures by breaking them up so that their parts were disembedded from the field in order to locate the hidden simple shapes in them. Most curious pupils, on the other hand, had little difficulty breaking up the complex figures to locate the simple figures hidden in them. Curious pupils like complex situations; they are not afraid to take risks, and they prefer doing experimental and theoretical tasks with no clear instructions. Thus, they will enjoy problems of the HFT type.

4.8 Distribution of the Motivational Patterns in the Convergence/Divergence Test

A study similar to Section 4.7 was done here. Again, attention was given to the conscientious and the curious pupils. The distribution is shown in Table 4.7.

Table 4.7 Distribution of motivational patterns in the convergence/ divergence test.

Groups	Conv.		AR		Div.		Total
	n	%	n	%	n	%	
Achievers	3	*33*	4	*44*	2	*22*	9
Conscien.	26	*30*	25	*29*	36	*41*	87
Curious	14	*33*	8	*19*	20	*48*	42
Sociable	25	*38*	23	*35*	17	*27*	65
None	9	*56*	5	*31*	2	*13*	16
Total	77		65		77		219

The general observation is that the achievers and the social pupils are more likely to be convergent thinkers, while the conscientious and the curious pupils are more likely to be divergent thinkers. That the curious pupils are divergent is expected. Divergent thinking calls for speculation, brainstorming and inventing possibilities, the kind of engagement that will interest a curious pupil. A conscientious pupil seems to dislike ambiguity which is also the characteristic of the converger. He likes his tasks with clearly defined instructions and outcome. He will, therefore, show a dislike for divergent thinking tests (eg. open-ended problems) in which he may be uncertain about what constitutes a perfect answer or performance. The performance of the conscientious pupils then, which makes them more likely to be divergers, is surprising. There is a possibility, however, that this may have resulted from conscientious pupils with an overlapping curious pattern - 30% of them. The overlapping curious pattern may have boosted their performance in the divergent thinking test. It could be that the overlap between the conscientious and curious is a matter of conformity. The instructional procedure that is on offer is one that suits the conscientious, so some of the

curious pupils are inclined to adjust to it. They, therefore, showed more conscientious than curious characteristics.

4.9 Relationship Between the Motivational Patterns and the Cognitive Styles.

Table 4.8 which is a composite of Tables 4.6 and 4.7 summarises the observations made in Sections 4.7 and 4.8. The field-intermediate and all-rounders have been omitted in the consideration for reasons given above (see Sections 4.4 and 4.5). The patterns observed in those sections repeat themselves here. The conscientious

Table 4.8 Distribution of the motivational patterns in the cognitive style tests.

Groups	FD/Conv.		FD/Div.		FI/Conv.		FI/Div.	
	n	%	n	%	n	%	n	%
Achievers	2	*22*	1	*11*	1	*11*	1	*11*
Conscien.	15	*17*	16	*18*	9	*10*	16	*18*
Curious	4	*10*	5	*12*	6	*14*	12	*29*
Sociable	9	*14*	8	*12*	11	*17*	5	*8*
None	-	-	-	-	-	-	-	-

pupils are generally field-dependent [i.e. (17% + 18%) > (10% + 18%)] and, contrary to expectation, divergent [i.e. (18% + 18%) > (17% + 10%)]. As mentioned above, the overlapping curious pattern shown by about a third of the conscientious group may explain this outcome. Curious pupils, however, are more likely to be field-independent [i.e. (14% + 29%) > (10% + 12%)] and divergent [i.e (12% + 29%) > (10% + 14%)].

4.10 "Predictions" About Pupils' Learning and Attainment

It had been anticipated that the conscientious pupils would more likely be field-dependent and convergent than field-independent and divergent, but the observations made from the results make that assumption questionable. It was also anticipated that the curious pupils would more likely be field-independent and divergent than field-dependent and convergent. This assumption is supported by the results.

While it was easy to describe or to distinguish pupils as being either field-dependent or field-independent and as being either convergent or divergent, the description and classification of pupils in the various motivational patterns was not so clear-cut. It was observed from the results that there were interrelationships between the motivational patterns. Pupils were largely motivated to learn by more than one need, and there were a few who were hardly motivated by any of the sources.

How would the assumptions enable any "predictions" to be made about the pupils' learning and learning outcomes?

Regarding the motivational patterns, the effectiveness of the pupils' learning and learning outcomes will, among other factors, depend on the satisfaction of their individual needs and preferences for particular modes of instruction. It has been mentioned that the conscientious pupil is dominated by the need to fulfil what he considers to be his educational duties. He sees his work as a duty, and is intrinsically motivated to do it. He is more teacher-dependent and has a strong preference for formal modes of teaching, with precise and clear instruction to be followed. The curious pupil, as the name suggests, is curious about intellectual objects. He has a pronounced tendency to re-examine what is known, and to explore the unknown; and reacts to stimuli in his environment which are novel and complex. He has a distinctive preference for discovery learning; enjoys practical work or problem-solving activities with no precise/detailed instructions, and has a general dislike for formal modes of teaching.

Written worksheets in general, with the 'recipe-type' instructions and the lack of variety which sometimes results, will appeal more to the conscientious pupil. Every instruction he needs for the task in hand is provided; he is led by the sheet to the learning goals; and the teacher is there to help in case of any difficulty. The worksheet generates or sustains his motivation to learn. The curious pupil, on the other hand, may find this approach of teaching/learning science boring. There is little on offer to satisfy his curiousity, and little or no opportunity to pursue his own enquiry or for discovery learning. This absence of imagination or originality may affect the curious pupil's motivation for a subject or for learning in general.

The convergent or divergent thinking style, as pointed out by Hudson (1966)[26], is more a measure of bias, than of level, of ability. But as Woolnough (1981)[4] noted, *some* worksheets are "highly convergent programmes of work which carry pupils along a predetermined path to a predetermined goal." Opportunity does not exist for divergent work to be done in which pupils are encouraged to think and work creatively. This will certainly not favour a curious and/or divergent pupil. A conscientious and/or convergent pupil will thrive on this.

The role of the field-dependence/independence dimension in students' learning has been widely researched. While some findings of the literature suggest that "field-dependent and field-independent learners differ more consistently in how the learning processes occur than in how effective the process is" (Goodenough 1976)[51], there are reasons from other findings to suggest that, because of their greater effectiveness in the use of various cognitive processes, field-independent learners will be more effective in their performance than field-dependent learners, at least under some conditions. With the nature of the worksheets in mind, it may be reasonable to speculate that while they may not influence the performance or learning outcome of the field-independent, they may improve the efficiency of performance of the field-dependent learners. The great difficulty of field-dependent learners is their inability to filter relevant incoming teaching/learning material from the irrelevant in order to allow them to use their

'potential' working memory fully for useful processing. The exact and detailed instructions of the worksheets may help them to overcome this to some extent.

To summarise, this research postulates that the written worksheet approach of teaching/learning science will be favourable to and encourage the conscientious, convergent and field-dependent pupils in their learning and attainment in Standard grade science relative to the curious, divergent and field-independent. Whereas the learning and attainment of the curious, divergent and field-independent may not be favoured and even hampered by this mode of teaching/learning science, the effect of the worksheets on motivation and other drawbacks may affect their performance.

In the next chapter, it would be seen from the science results of the internal and the external Scottish Certificate of Education (SCE) - Standard grade examinations whether this hypothesis is supported.

CHAPTER FIVE

THE RELATIONSHIP BETWEEN PUPILS' ATTAINMENT AND THEIR LEARNING STYLES.

5.1 Introduction

It has been postulated that the worksheet approach of teaching/learning science favours the conscientious, field-dependent and convergent pupil, but may not encourage or favour the curious, field-independent and divergent pupil. From the sample's internal examination and the external Scottish Certificate of Education (SCE) - Standard Grade results, an attempt is made in this chapter to support or reject the hypothesis. A look at the pupils' attainment in the examinations may give us new ideas and more understanding of the relationship between their learning styles, the mode of instruction and their learning outcomes. The attitude/response of the pupils to the instructional procedure i.e. the worksheet approach of teaching/learning science is also considered here.

5.2 ASSESSMENT

The science subjects in the SCE - Standard Grade are assessed under three categories: Knowledge and Understanding (K&U), Problem-Solving (PS) and Practical Abilities (PA). Grades are awarded from 1 to 7, the highest grade being 1. Technically, 7 is fail but it is designated "course completed". The weighting carried by each category in chemistry, biology, physics and general science are as follows:

	K&U	PS	PA	Total
Chemistry	2	2	1	5
Biology	1	1	1	3
Physics	1	1	1	3
General Science	1	1	1	3

A pupil's grade in each category is multiplied by the respective weighting and the sum of the categories divided by the total weighting to give the pupils' overall grade (to the nearest whole number) in a subject. For example, the chemistry grade of a pupil who scored K&U=3, PS=2 and PA=1 will be: (3x2) + (2x2) + (1x1)/5 = 2.4. So his overall grade in chemistry is 2.

5.3 Internal Examination

The mean grade of pupils in each group, i.e. each motivational group and/or cognitive style has been determined, and a comparison done of their performance in the internal science examinations. Where possible, correlations of pupils' individual grades and their scores in the cognitive tests have been done to look for any relationships.

5.3.1 Performance in Science of Pupils of Different Motivational Patterns

The mean grade of pupils in each motivational group was determined. Table 5.1 shows the grade of each group. The curious pupils performed relatively better than the conscientious (and the achievers and sociable) pupils.

Table 5.1 Mean grades of the motivational groups in the internal science exam.

Motivational Patterns		Mean Grade
Achievers	(n=9)	**2.7**
Conscientious	(n=87)	**2.8**
Curious	(n=42)	**2.2**
Sociable	(n=65)	**3.2**
None	(n=16)	**2.8**

This outcome is contrary to what was expected. It was anticipated that the benefits of the worksheets to the conscientious pupils would show in their performance; at least, make them do equally as well as the curious pupils.

The performance of each motivational group was re-examined separately, this time taking into account their overlapping patterns. The results of this are shown in the tables below.

Table 5.2 Mean grades of the conscientious pupils in the internal science exam.

Overlapping Patterns		Mean Grade
Pure*	(n=13)	**2.8**
Achievers	(n=2)	**3.0**
Curious	(n=26)	**2.7**
Sociable	(n=32)	**2.8**

* Showed no overlap overall.

Table 5.3 Mean grades of the curious pupils in the internal science exam.

Overlapping Patterns		Mean Grade
Pure*	(n=2)	**2.5**
Achievers	(n=1)	**1.0**
Conscientious	(n=17)	**2.4**
Sociable	(n=11)	**1.9**

* Showed no overlap overall.

Table 5.4 Mean grades of the sociable pupils in the internal science exam.

Overlapping Patterns		Mean Grade
Pure*	(n=17)	**3.4**
Achievers	(n=0)	**-**
Conscientious	(n=18)	**3.2**
Curious	(n=12)	**2.8**

* Showed no overlap overall.

Table 5.5 Mean grades of the achiever pupils in the internal science exam.

OverlappingPatterns		Mean Grade
Pure*	(n=1)	**4.0**
Conscientious	(n=3)	**1.7**
Curious	(n=2)	**1.5**
Sociable	(n=0)	**-**

* Showed no overlap overall.

It is noticed from Tables 5.2, 5.4 and 5.5 that pupils in a motivational group with an overlapping curious pattern performed relatively better than their colleagues in the group. The performance of the conscientious pupils with an overlapping curious pattern (Table 5.2) is not as significant as the sociable and the achievers with the same overlapping pattern (Tables 5.4 & 5.5). However, it could be said of all the groups that the overlapping curious pattern may the contributing factor to the better performance of

that subgroup compared to the subgroups with different or no overlapping pattern. Table 5.5 was included purely for academic interest. The only pure achiever scored poorly in the internal examination, uncharacteristic of an achiever pupil. It is likely he/she was not interested in the motivation test and may have chosen any pattern.

On the whole, the curious pupils seem to perform best of all the motivational types.

5.3.2 Performance in Science of Field-dependent and Field-independent Pupils

The mean grades of the field-dependent, the field-intermediate and the field-independent pupils in the internal SCE examinations are shown in Table 5.6.

Table 5.6 Mean grades of pupils of different degrees of field-dependence/ independence in the internal science exam.

Groups		Mean Grade
FD	(n=101)	**3.3**
FInt	(n=33)	**3.1**
FI	(n=85)	**2.1**

The difference in mean grades between the field-dependent and field-independent pupils is 1.2. Since the worksheets are thought to meet to a greater extent the needs and preferences for instructional procedures of the field-dependent pupils, it had been assumed that their performance or learning outcome would be favoured. The results do not support the assumption. The attainment of the field-independent pupils is higher than the field-dependent. The field-intermediate scored less than the field-independent, but more than the field-dependent pupils as would be expected.

A scatterplot of the pupils' scores in the field-dependence/independence test versus their individual grades in the internal examination gave a significant negative correlation. The coefficient of correlation (r) was -0.40, significant at $p < 0.01$. **NOTE**: Grade '1' is excellent; '7' is "course completed" (technically, failed). The relationship here is: the higher a pupil's score in the field-dependence/independence test the higher his/her chance of obtaining a higher mark in the science exam. In other words, the field-independent are more likely to obtain better grades than the field-dependent pupils. This relationship supports the observation made earlier (see Table 5.6) that the field-independent pupils performed better than the field-dependent; but it does not support the hypothesis. Could it be that the examination was favouring the field-independent while the instructional procedure was not?

5.3.3 Performance in Science of Convergent Thinkers and Divergent Thinkers

Contrary to the hypothesis, divergers obtained a higher mean grade than convergers. Table 5.7 shows the mean grade of each group. The difference between the mean grades of convergers and divergers is 0.7. The grade of the all-rounders falls between the two extremes.

Table 5.7 Mean grades of the convergers and divergers in the internal science exam.

Groups		Mean Grade
Convergers	(n=77)	**3.1**
All-rounders	(n=65)	**2.9**
Divergers	(n=77)	**2.4**

A scatterplot of the scores of the convergence/divergence test versus the individual examination grades gave a negative correlation of -0.27, significant at $p < 0.01$. The divergent thinkers are more likely to score higher marks than the convergent thinkers, and therefore get better grades.

5.3.4 Performance in Science of Pupils of Different Cognitive Styles

From a comparison of the correlation coefficients (see Sections 5.3.2 and 5.3.3), the field-dependence/independence dimension seems to be the major contributing factor to the differences observed between groups of pupils of different cognitive styles. An examination of combinations of cognitive styles and their effects on pupils' performance in the internal examination shows this. The mean grades of groups are presented in Table 5.8. The divergent field-independent pupils scored the best grade, followed by the convergent field-independent pupils, then the divergent field-dependent, and lastly the convergent field-dependent pupils.

Table 5.8 Mean grades of pupils of different cognitive styles in the internal exam.

Groups		Mean Grade
FD/Conv.	(n=35)	**3.8**
FD/Div.	(n=31)	**2.9**
FI/Conv.	(n=30)	**2.3**
FI/Div.	(n=35)	**1.9**

Of the divergers, the difference between the mean grades of the field-independent and the field-dependent is 1.0; and the difference between the convergent field-independent and the convergent field-dependent pupils is 1.5. Of the field-independent,

the difference between divergers and convergers in 0.4; and of the field-dependent, the difference between the divergers and the convergers is 0.9. Thus, when convergence or field-dependence is the common characteristic, the difference between the field-independent and field-dependent pupils or the divergers and convergers respectively is relatively larger (1.5 and 0.9) than when divergence or field-independence is the common characteristic (1.0 and 0.4). There seems to be an indication that the efficiency of performance of pupils in the examination is related to field-independence and, to a lesser degree, divergence.

5.3.5 Performance of Differently Motivated Pupils of Different Degrees of Field-dependence/independence

Generally, the performance of the field-independent pupils is better in all three motivational groups (Table 5.9). A comparison of their mean grades (mg) in their respective motivational groups with their counterparts who are field-dependent shows wide differences, especially for the conscientious and the curious pupils. The differences

Table 5.9 Mean grades of differently motivated pupils of different degrees of field-dependence/independence.

Groups	FD		FI		*Difference
	n	mg	n	mg	
Conscien.	45	**3.4**	32	**1.9**	**1.5**
Curious	12	**2.7**	21	**1.7**	**1.0**
Sociable	32	**3.3**	21	**2.9**	**0.4**

* Difference between the mean grades of the FD and FI in each motivational group.

NOTE: Achievers have been omitted here and in subsequent sections because their small number prevent any appreciable comparison with the other groups.

are 1.5 and 1.0 respectively. The difference between the sociable field-independent and the sociable field-dependent is 0.4. Here again, the curious pupils have the edge on the conscientious (and the sociable) pupils. In both the field-dependent and field-independent groups, they come out with the higher grades. It is, however, noticed that the performance of the conscientious is greatly improved under field-independence, coming close to the mean grade of the curious field-independent group (the difference between them is 0.2). This supports evidence from other research work that efficiency of performance in conventional science examinations is related to field-independence (depending on task variables).

Between the conscientious and the curious pupils, it had been assumed that the conscientious field-dependent ones would show some efficiency of performance in their learning and learning outcomes, being the beneficiaries of the worksheet approach of teaching/learning science, while the curious field-independent learners may even be hampered. From the results, this assumption has not been supported.

5.3.6 Performance of Differently Motivated Pupils of Different Degrees of Convergence/Divergence

Similar to an observation made earlier, the divergers generally have higher grades. The differences between the mean grades of divergers and convergers in their respective motivational groups are not as much as observed between the field-independent and the field-dependent (Table 5.10). Generally, the curious pupils have the best grades. The results, however, do not support the assumption that the conscientious convergent pupils would be favoured by the worksheets.

Table 5.10 Mean grades of differently motivated pupils of different degrees of convergence/divergence.

Groups	Convergers		Divergers		Difference
	n	mg	n	mg	
Conscien.	26	**3.2**	36	**2.4**	**0.8**
Curious	14	**2.4**	20	**1.9**	**0.5**
Sociable	25	**3.4**	17	**2.9**	**0.5**

5.3.7 Performance of Pupils of Different Motivational Patterns and Cognitive Styles

This section attempts to find the overall picture of the relationship between pupils' learning styles and their attainment in the internal examination. It has been speculated initially that the conscientious, field-dependent and convergent pupils would be favoured by the worksheets, while the curious, field-independent and divergent pupils may be unfavourably affected. Table 5.11 shows the mean grades of the groups.

Table 5.11 Mean grades of pupils of different motivational patterns and cognitive styles.

Groups	Conscien.		Curious		Sociable	
	n	mg	n	mg	n	mg
FD/Conv.	15	**4.1**	4	**3.2**	9	**3.6**
FD/Div.	16	**3.1**	5	**2.2**	8	**3.2**
FI/Conv.	9	**1.6**	6	**1.5**	11	**3.2**
FI/Div.	16	**1.8**	12	**1.7**	5	**2.6**

Overall, there is a sharp distinction between individuals in the conscientious and the curious motivational groups who are field-independent and those in the same groups who are field-dependent. The field-independent groups have higher mean grades than the field-dependent groups. The convergence characteristic of the field-independent pupils does appear to influence slightly their efficiency of performance in the examination, contrary to what has been observed already i.e. that divergers perform better than convergers. It is seen among both the conscientious and the curious pupils that, the convergent field-independent seem to do marginally better than the divergent field-independent. A plausible explanation may be that the convergent field-independent seem to be able to get to the meaning of a question despite 'noise', and then converge to an unique answer. So what is being observed may be the effects of exam answering performance overlying learning. In that case, the hypothesis appears to be partially supported: that convergent pupils may be favoured by the written worksheet approach of teaching/learning science (and/or the nature of the examination). This is only observed of the convergent field-independent but not of the convergent field-dependent who may not get over the first part of answering the question - separating the 'noise' (if there is any) from the signals. This, again, emphasises the relationship between performance and field-independence. There is no apparent difference in the performance of the convergent field-independent who are either conscientious or curious, and also between the divergent field-independent who are either conscientious or curious. The lack of a clear difference between these groups may be due to the interrelationships observed earlier on between the motivational patterns (see Section 4.3). There are, however, differences in performance between the convergent field-dependent in the conscientious and curious groups, and between the conscientious, field-dependent and divergent and the curious, field-dependent and divergent pupils. These findings, however, do not completely support the hypothesis. Overall, it seems that efficiency of performance is related more to field-independence than to the other factors considered.

5.3.8 Comparison of Mean Grades From Knowledge & Understanding and Problem-Solving

Because of their liking for practical activities, it was thought that the grades of the curious, field-independent and divergent pupils in Practical Abilities (PA) may have boosted their overall grades, giving rise to the above results. The comparative study was repeated of the mean grades of the various groups, but this time only in the theoretical part of the internal examination, i.e. Knowledge & Understanding (K&U) and Problem-Solving (PS). The mean grades increased - i.e. decreased performance - in all the groups, but the patterns were not different from the patterns already observed. The curious, field-independent and divergent still performed better in the internal examination than the conscientious, field-dependent and convergent (see Appendix 7 for the results).

5.4 External Examination

As was done with the results of the internal examination, the mean grade in science of each group, i.e motivational and/or cognitive style, has been determined and a comparison done of their performance in the external Scottish Certificate of Education - Standard Grade examination. It would be found in the tables that the pattern or the order of performance of the groups, largely, does not change. Furthermore, the performance of the pupils in the external examination is generally below what was achieved in the internal examination.

The presentation will be very brief here as there are few differences to be pointed out that have not been observed in the internal examination. Some comparisons will be done of the mean grades in both examinations.

5.4.1 Performance of Pupils of Different Motivational Patterns

While the mean grades of all groups increased i.e lowering in performance, the achiever pupils improved their performance. Once again, the curious pupils have the edge over the other groups, although their grade went up by a tenth. The mean grades are presented in Table 5.12.

Table 5.12 Mean grades in science of the motivational groups in the external exam.

Motivational Patterns		Mean Grade
Achievers	(n=9)	**2.4**
Conscientious	(n=87)	**3.0**
Curious	(n=42)	**2.3**
Sociable	(n=65)	**3.6**
None	(n=16)	**3.1**

On considering the overlapping patterns of the pupils, those with a curious overlapping pattern in each motivational group came out the best. The results are shown in tables below.

Table 5.13 Mean grades in science of the conscientious pupils in the external exam.

Overlapping Patterns		Mean Grade
Pure*	(n=13)	**3.2**
Achievers	(n=2)	**3.5**
Curious	(n=26)	**2.8**
Sociable	(n=32)	**3.0**

* Showed no overlap overall.

Table 5.14 Mean grades in science of the curious pupils in the external exam.

Overlapping Patterns		Mean Grade
Pure*	(n=2)	**3.0**
Achievers	(n=1)	**1.0**
Conscientious	(n=17)	**2.5**
Sociable	(n=11)	**2.3**

* Showed no overlap overall.

Table 5.15 Mean grades in science of the sociable pupils in the external exam.

Overlapping Patterns		Mean Grade
Pure*	(n=17)	**4.1**
Achievers	(n=0)	**-**
Conscientious	(n=18)	**3.5**
Curious	(n=12)	**3.0**

* Showed no overlap overall.

Table 5.16 Mean grades in science of the achiever pupils in the external exam.

OverlappingPatterns		Mean Grade
Pure*	(n=1)	**4.0**
Conscientious	(n=3)	**1.7**
Curious	(n=2)	**1.0**
Sociable	(n=0)	**-**

* Showed no overlap overall.

5.4.2 Performance of the Field-dependent and Field-independent Pupils

Table 5.17 shows the performance of the field-dependent and field-independent pupils. The grades go up by 0.3 for the field-dependent and 0.2 for the field-independent. The field-independent, as observed in the internal examination, are on average the best performers. The difference between the two groups is 1.3; and the field-intermediates, as would be expected, fall between the two extremes.

Table 5.17 Mean grades in science of pupils of different degrees of field-dependence/independence in the external exam.

Groups		Mean Grade
FD	(n=101)	**3.6**
FInt	(n=33)	**3.3**
FI	(n=85)	**2.3**

A scattergram of the scores in the Hidden Figures Test against individual grades in the examination gave a significant correlation. The correlation coefficient was -0.41 ($p < 0.01$). The more field-independent a pupil is, the more likely he is to perform well in the external examination.

5.4.3 Performance of Convergent and Divergent Thinkers

The mean grades of convergers and divergers (Table 5.18) go up by the same margins as were noticed for the field-dependent and field-independent pupils respectively. Between the convergers and the divergers, there is a difference of 0.8. The all-rounderes scored more than the convergers but less than the divergers. A scattergram of the scores in the convergence/divergence test against individual examination grades gave a negative correlation of 0.26 ($p < 0.01$).

Table 5.18 Mean grades in science of convergers and divergers in the external exam.

Groups		Mean Grade
Convergers	(n=77)	**3.4**
All-rounders	(n=65)	**3.1**
Divergers	(n=77)	**2.6**

5.4.4 Performance of Pupils of Different Cognitive Styles

The order of performance here is similar to that in the internal examination and, as identified in the cases above, there are increases in the mean grades. The grades are presented in Table 5.19.

Table 5.19 Mean grades of pupils of different cognitive styles in the external exam.

Groups		Mean Grade
FD/Conv.	(n=35)	**4.1**
FD/Div.	(n=31)	**3.2**
FI/Conv.	(n=30)	**2.6**
FI/Div.	(n=35)	**2.1**

An earlier remark that the efficiency of performance of pupils in the internal examination is related more to field-independence than to divergence is reflected in the external examination as well. When field-independence is the common factor, the difference in mean grades between convergent and divergent thinkers is 0.5. With divergence as the common factor, the difference between mean grades of the field-independent and field-dependent pupils is 1.1. When field-dependence is the common factor the difference in mean grades is 0.9, and 1.5 for convergence, between divergers and convergers and between field-independent and field-dependent pupils respectively.

5.4.5 Performance of Differently Motivated Pupils of Different Degrees of Field-dependence/independence

Again, achievers have been left out here and in the sections that follow because no fair comparison between them and the other groups could be done due to their small number. The performance of the field-dependent and field-independent pupils in the remaining motivational groups are shown in Table 5.20.

Table 5.20 Mean grades of differently motivated pupils of different degrees of field-dependence/independence.

Groups	FD		FI		*Difference
	n	mg	n	mg	
Conscien.	45	**3.6**	32	**2.0**	**1.6**
Curious	12	**3.0**	21	**1.8**	**1.2**
Sociable	32	**3.8**	21	**3.0**	**0.8**

* Difference between the mean grades of the FD and FI in each motivational group.

The field-independent pupils in the three groups have better grades than the field-dependent pupils. The curious have the edge on the conscientious and sociable pupils overall. There is a dramatic difference in grades between the conscientious field-independent and the conscientious field-dependent. A similar observation was made in the internal examination. Being field-independent is an advantage in the examination for the conscientious pupils who have that characteristic.

5.4.6 Performance of Differently Motivated Pupils of Different Degrees of Convergence/Divergence

Divergent thinkers, once more, did better than convergent thinkers in the conscientious, the curious and the sociable groups. Except for the sociable pupils, differences between convergers and divergers in the motivational groups are a half of the differences observed between the field-dependent and the field-independent. This emphasises the idea that performance in science is more dependent on field-independence than on divergence. The mean grades are shown in Table 5.21.

Table 5.21 Mean grades of differently motivated pupils of different degrees of convergence/divergence.

Groups	Convergers		Divergers		Difference
	n	mg	n	mg	
Conscien.	26	3.4	36	2.6	0.8
Curious	14	2.6	20	2.0	0.6
Sociable	25	3.9	17	3.1	0.8

5.4.7 Performance of Pupils of Different Motivational Patterns and Cognitive Styles

In Table 5.22, all the learner characteristics have been put together. The overall picture is similar to what obtained in the internal examination, except that in addition to the lowering in performance in the external examination, the conscientious,field-independent and convergent are observed to have performed better than the curious, field-independent and convergent pupils. This is due to the fact that one curious pupil dropped from grade 2 to 4, and another from grade 1 to 2 in their science subject.

Table 5.22 Mean grades of pupils of different motivational patterns and cognitive styles.

Groups	Conscien.		Curious		Sociable	
	n	mg	n	mg	n	mg
FD/Conv.	15	4.2	4	3.5	9	4.6
FD/Div.	16	3.4	5	2.6	8	3.1
FI/Conv.	9	1.7	6	2.0	11	3.4
FI/Div.	16	2.0	12	1.7	5	3.0

The field-independent in both the conscientious and curious groups performed better than their field-dependent counterparts. Considering the numbers in the conscientious or curious group who are field-independent and convergent and those who are field-independent and divergent, it would seem that efficiency of performance in science examination is related to field-independence (and, to some degree, convergence). As already mentioned, what is being observed may be the effect of exam answering performance overlying teaching/learning. The convergent field-independent pupils can get to the meaning of a question despite the 'noise' and then converge to an unique answer. This is, however, not the case for the convergent field-dependent because they are unable, for the highly 'noisy' questions, to overcome the initial part of the exam answering 'technique' - separating signals from noise - before converging to the answer.

In general, the results of the external examination do not lend support to the hypothesis, that the conscientious, field-dependent and convergent pupils will perform better in science because of the favour they receive from the written worksheet approach of teaching/learning science, and that the performance of the curious, field-independent and divergent pupils may be adversely affected because the instructional mode does not meet their needs and preferences for instructional procedures.

What could be said from all these results? Could it be that the curious, field-independent and divergent pupils are being favoured equally or are rather benefitting from the worksheet approach of teaching/learning science, instead of the conscientious, field-dependent and convergent pupils? Are the worksheets meeting the needs and preferences for instructional procedures of the conscientious, field-dependent and convergent pupils? Do worksheets or the examination questions present too much 'noise' for the conscientious, field-dependent and convergent learners, preventing them from using their potential working memory to the full? Are other factors, apart from the above, responsible for these findings? These will all be examined in some detail in the next

chapter. In the meantime, the response of the pupils to the use of worksheets in their science lessons will be considered.

5.5 Attitude/Response of the Pupils to Science Worksheets

Several researchers have suggested a link between students' learning styles and their preferences for different instructional modes in science education. The relationship between students' motivational orientations and their preferences for, or dislike of, the different approaches of instruction is the most studied. The semantic differential test was done to find out the attitude or response of the sample to the use of worksheets in their science lessons, and how that may influence their performance in science. A hundred and thirty-four pupils out of the total sample (219) took part in the test. The achievers were left out because of their small number. Tables 5.23, 5.24 and 5.25 show the percentage distribution of judgement of the motivational groups in the seven bipolar adjective/phrase scales.

Table 5.23 Percentage distribution of the judgement of conscientious pupils (n=56) in the semantic differential test.

Interesting	**21**	**65**	**14**	**Boring**	**<---**
Enjoyable	**16**	**66**	**18**	**Unenjoyable**	**<-->**
Easy to read	**71**	**18**	**11**	**Difficult to read**	**<---**
Easy to understand	**55**	**36**	**9**	**Difficult to understand**	**<---**
Good	**36**	**55**	**9**	**Bad**	**<---**
Like them	**21**	**59**	**20**	**Don't like them**	**<-->**
Allow me to follow my own ideas	**14**	**70**	**16**	**Prevent me from following my own ideas**	**<-->**

KEY: <--- represents a "positive response".

---> represents a "negative response".

<--> represents "neither positive nor negative response".

More of the conscientious pupils find the worksheets to be interesting and good than boring and bad. A greater proportion of them find them easy to read, and understand the lessons in the worksheets. Their judgements on whether it is enjoyable using the worksheets or not; their likes and dislikes of the worksheets; and whether the mode of instruction allows or prevents them from using their own ideas were normally distributed. As already mentioned, the strategy for teaching science to the sample (mixed ability group) is a mix of Individualised Learning and Whole-Class approaches, predominantly done through worksheets. It is formal, expository teaching with emphasis on the inputs from the worksheets and the teacher. Experimental work is based on clear and precise instructions from the worksheets and the teacher. It is not surprising, therefore, that the conscientious pupils generally sound positive in their response to the approach of teaching/learning. It has been mentioned already that conscientious pupils have a preference for formal teaching, experimental work with clear and precise instructions and evaluation by teacher.

Table 5.24 Percentage distribution of the judgement of curious pupils (n=27) in the semantic differential test.

Interesting	**7**	**81**	**12**	**Boring**	**--->**
Enjoyable	**16**	**66**	**18**	**Unenjoyable**	**<-->**
Easy to read	**78**	**22**	**0**	**Difficult to read**	**<---**
Easy to understand	**63**	**37**	**0**	**Difficult to understand**	**<---**
Good	**33**	**63**	**4**	**Bad**	**<---**
Like them	**14**	**66**	**20**	**Don't like them**	**--->**
Allow me to follow my own ideas	**11**	**70**	**19**	**Prevent me from following my own ideas**	**--->**

KEY: - as above.

The curious pupils, on the other hand, responded slightly negatively to the approach of teaching/learning. They appeared less interested in the worksheets; they tend not to like them and they think the worksheets prevent them from following their own ideas in science lessons, i.e. no opportunity is provided for pursuing one's own interests. Most of them find the worksheets easy to read and understand. The negative response of the curious pupils is not unexpected. They have a preference for discovery learning; doing practical work (without clear and precise instructions) and they like to be given the opportunity to pursue their own enquiry. As mentioned already in chapter two, novelty and complexity are the two major properties of stimulus for learning to which a curious pupil is strongly attracted. The motivational value of novel and complex situations depend on the problem being raised and defined by the pupil himself, and also conceived to be concrete and realistic. The worksheet approach of teaching/learning science does not present this situation. It offers little challenge to the curious learners, so they are likely to respond negatively to it. Despite the dislike, more of the curious pupils find the use of the worksheets in science lessons good. This may appear conflicting, but the reason may be their ability to easily work through the sheets; their higher grades in the internal examination is an indication of that. Thus, for the curious pupils, using worksheets in science lessons is boring and disliked because they do not present enough challenge, but they are good as long as it is easy to work through them and they enhance their chances of success.

The attitude of the sociable pupils is examined out of interest. They show even a greater dislike of the worksheet approach of teaching/learning science than the curious pupils. They find it boring and unenjoyable. They do not like the use of the worksheets in science lessons and are of the opinion that they are prevented from following their own ideas. They find the sheets easy to read and understand, and are normally distributed in their response to whether it is good or bad to use worksheets in science lessons. Table 5.25 show the response of the sociable pupils to the use of worksheets in science lessons.

Table 5.25 Percentage distribution of the judgement of the sociable pupils (n=47) in the semantic differential test.

Interesting	**15**	**55**	**30**	**Boring**	**--->**
Enjoyable	**9**	**47**	**45**	**Unenjoyable**	**--->**
Easy to read	**53**	**38**	**9**	**Difficult to read**	**<---**
Easy to understand	**34**	**57**	**9**	**Difficult to understand**	**<---**
Good	**21**	**59**	**19**	**Bad**	**<-->**
Like them	**15**	**57**	**28**	**Don't like them**	**--->**
Allow me to follow my own ideas	**9**	**60**	**32**	**Prevent me from following my own ideas**	**--->**

KEY: -as above

On the whole then, conscientious pupils seem to favour the use of worksheets in science lessons while the curious and sociable pupils dislike them.

The distribution of responses to the test confirm some of the findings of Kempa and Martin Diaz (1990)[30] on the relationship between students' motivational patterns and preferences for instructional procedures (see Table 2.1, pg 29). Conscientious pupils show a preference for formal teaching and experimental work with instruction. Curious pupils show a dislike for both. They have a preference for discovery learning and the opportunity to pursue one's own enquiry. Sociable pupils show a stronger dislike of formal teaching and a strong preference for pursuing one's own enquiry.

How do the above results help understand the outcome of the internal and external examinations?

CHAPTER SIX

DISCUSSION AND CONCLUSION

6.1 Review of Results of the Affective and Cognitive Style Tests

It has been possible, with the motivation and cognitive style tests, to classify the pupils according to their learning styles. The conscientious pupils formed the largest percentage of the sample, followed by the sociable, the curious and achievers in that order. The trend from the scores of the Hidden Figures Test and the convergence/ divergence test was that, field-dependent pupils were more likely to be convergent thinkers than divergent thinkers, and the field-independent more likely to be divergent than convergent thinkers. Conversely, convergers were more likely to be field-dependent and divergers more likely to be field-independent.

Altogether, the general tendency from the motivation and cognitive tests was for the conscientious pupils to be field-dependent and convergent, and the curious pupils to be field-independent and divergent. More conscientious pupils were found to be divergent, a situation more likely to have resulted from the fact that about a third of them had an overlapping curious pattern which they may have adopted as a matter of conformity and this may have helped their performance in the convergence/divergence test, thus increasing the number who were divergent. The curious pupils, as expected, were more field-independent and divergent than field-dependent and convergent.

6.2 Learning Styles, Instructional Mode and Pupils' Performance in Science

This study represents an attempt to examine the effect of learning styles and the written worksheet approach of teaching/learning on the performance of the sample in science. It was proposed that some worksheets, by their very nature, would favour and

appeal more to the conscientious, field-dependent and convergent pupils, because they provide an external structural support which complements their approach to learning or their learning styles and thereby aid their performance in science. The needs of the curious, field-independent and divergent pupils are, on the other hand, not met by these worksheets. They may, therefore, not find such worksheets appealing and their performance may be affected unfavourably. The results, so far, do not support this contention.

6.2.1 The Science Worksheets

On perusing the programmes in the worksheets used by the pupils, it is not difficult to conclude that such programmes are highly convergent. There is more or less no opportunity for divergence in learning. The worksheets, in general, do not foster creative thinking and work. The pupils are led through the course 'by the hand' along a predetermined path to the learning or attainment targets. The programmes are, however, clearly presented to reduce the amount of 'noise', enabling the field-dependent to cope with the course (see Appendix 8A & 8B for examples).

In general then, the worksheet approach of teaching/learning caters for the needs and preferences of the conscientious, field-dependent and convergent pupils in this particular situation. They enjoy the formal teaching aspect of the approach; they are given the instructions needed for class and practical work; they are directed to the goal of learning and 'noise' is kept at a low level which helps them to use their working memory efficiently. In short, their need for external, supportive control is provided by the worksheets and the teacher. It is no wonder then, that more of the conscientious pupils, who have been found to be field-dependent and convergent, responded positively in the semantic differential test to the written worksheet approach of learning science. Since this approach is not flexible, offers no opportunity for divergence in learning style, and does not encourage the pupils to think and work creatively, the curious pupils who tend to be field-independent and divergent would be least attracted to it. This is evident from the

negative response of many of them to the use of worksheets in science lessons. However, it may not be right to suggest from their response that the worksheet approach of teaching/learning science puts a complete damper on the motivation of the curious pupils to learn. Although, generally, they tend to dislike the approach, they quite like to use the worksheets in their science lessons, probably due to the ease of working through them. They may be conforming because nothing else is on offer. Their rejection of the approach is not as outright as in the case of the sociable pupils.

6.2.2 Field-independence - an Advantage in Examination

If the conscientious, field-dependent and convergent pupils are happy with the method of instruction, why is their performance in the examinations not superior; and if the curious pupils are dissatisfied with the worksheet approach of instruction, why are they performing better on average than the conscientious pupils?

It was noticed from the analysis of the relationship between the pupils' learning styles and their attainment in the examinations that efficiency of performance is related more to field-independence than to field-dependence, convergence/divergence and the conscientious or curious motivational pattern.

What is being observed here may be the effect of exam answering performance overlying learning and the response to mode of instruction. While the worksheets or the instructional procedures in general may be complementing the approach of learning of the conscientious, field-dependent and convergent, a look at the examination papers suggests that the demand for processing capacity of some questions is high (see Appendix 9A & 9B for examples), which from the point of view of their field-dependence style will be a disadvantage. The examination papers are not "noise-free". The extraneous and distracting information may lead to a lowering in the performance of the field-dependent who are less capable of separating irrelevant (noise) from relevant (signal) information. Part of their working memory is taken up by the 'noise', thus they are likely to perform below their potential. The competence of the field-independent in cognitive restructuring

or their ability actively to abstract and organise information presented to them may be an advantage for them in examinations. It has been suggested that efficient concept learning requires the ability to generate and remember the possible combinations of attributes which define a concept, as well as the ability to remember the nature of past cues examined. The nature of the examination questions demands and makes these same qualities an advantage in the examination situation. These qualities are related to field-independence. The field-independent pupils are, therefore, more able than the field-dependent at answering the examination questions efficiently. They have greater processing resources to employ in answering the questions.

If the conjecture is true, that, what is being observed is the effect of examination answering performance overlying learning and the mode of instruction, then the examinations are not necessarily a reflection of the teaching. The performance of the pupils is reflecting the nature of the examination and not necessarily the teaching/learning approach.

Field-independence, it would seem, is related to scientific aptitude or intelligence. For social reasons, measurement of intelligence is no longer permitted in schools. It would be interesting if future research could study the relationship between field-independence and intelligence to find out whether the efficient performance of the field-independent pupils in the examinations has anything to do with their being more intelligent than the field-dependent.

6.3 Factors Other Than Field-independence

The response of the curious pupils in the semantic differential test showed their dissatisfaction with the written worksheet approach of learning science. It may be suggested that the motivation of the curious is not enhanced by the teaching technique because it does not interact with or match their motivational pattern. One may expect that their performance in science would be adversely affected due to lack of interest or boredom. This is shown not to be the case from their performance in the examinations.

Apart from their greater likelihood of being field-independent, which has been seen to be contributing to their better performance in science than the conscientious, field-dependent and convergent , there may be other factors responsible for this.

It would be generally agreed that the effectiveness of pupils' learning and learning outcomes (attainment) does not depend solely on the satisfaction of their individual needs and preferences for particular modes of instruction. Educators agree too that, in addition to cognitive ability like field-independence, motivation explains a significant part of the variation in attainment. Motivation may be engendered by the fact that the teaching method interacts with the pupil's motivational pattern or learning styles. Evaluation or assessment in school, usually taking the form of grades in examinations, class work etc. has, among other factors, been also found to affect pupil motivation.

The motivational significance of evaluation depends on its implications for the whole gamut of values at work in the learning situation. Nisan (1981)[75] categorises the values at work in the learning situation into four groups: a) values intrinsic to learning, linked to the need for mastery and control of the environment; b) values connected with self-image, based on the striving of the individual to enhance and defend his self-esteem; c) social values, associated with the approval or censure of significant persons in the learner's life - parents, teachers, friends; d) material values outside the learning situation - reward and punishment.

The individual, regardless of his motivational pattern, harbours a basic need for evaluation of his ability and knowledge, and students have generally been found to be very interested in having their performance evaluated. Nisan states that the existence of a need for self-evaluation implies that when the individual believes his performance will be accompanied by evaluation containing new information about himself, his motivation for this performance will be stronger. The greater the significance attributed to the expected evaluation, the higher the motivation. The presence of evaluation, then, affords the learner the *added* motivation derived from being assessed, but the existing motivation, insofar as it is based on other sources, remain as is.

Alongside the need for cognitive clarity, is the need for self-enhancement (Epstein 1973)[76]. For youngsters, success in school is central for their self-image, and school grades are regarded as an authoritative index of this success. The influence of evaluation depends largely on the centrality of success in the pupil's self-image, which in this case will be a more powerful motive for the achiever pupil than for the conscientious, the curious or the socially-motivated pupil.

Apart from the implications of evaluation for cognitive clarity and the level of self-esteem, evaluation also has instrumental implications (Nisan 1981)[75]. Grades may have results which are in themselves positive or negative, one of the most outstanding being approval or censure by significant persons in the pupil's life. It may be reasonably expected that success in school will lead to the approval of the pupil's parents, teachers and friends, and failure lead to their censure, although it need not do so. To the extent that this approval or censure is important to him, the pupil will strive to succeed and avoid failure. These are conscientious characteristics which may be a streak in all learners. Evaluation, in the form of grades as in Standard grade examination, provide a salient and readily available index of scholastic success, thereby reinforcing the motivation linked to social approval or censure. The motivational effect may vary according to age, sex, personal traits and situation. In the fourth year of secondary school (15 and 16 year olds) the esteem of friends may have great influence.

Material values may also be associated with evaluation. A low grade is often associated with punishment and a high grade with direct or indirect material reward. For example, a high grade means the "liberation" of the pupil who is now free to pursue his own affairs. However, more important are the long-term implications of grades in terms of future opportunity and employment prospects after secondary education. The pupils are well aware that high grades are a guarantee of acceptance to further education, interesting and highly paid jobs etc.. The material rewards associated with evaluation supposedly give it much of its motivating power and are known to have a great effect on pupils' behaviour (Nisan)[75].

The various types of pupils considered in this study are all likely to be motivated to some extent by some of the implications of evaluation considered above. Assuming this to be so, it is my view that the curious pupils, although not favoured by the mode of instruction, would still be motivated to learn by the value(s) above. With their field-independent characteristic which has been found to be very important in exam answering performance, and some of the extraneous, distracting questions in the Standard grade examinations, the performance in science of the curious, field-independent and divergent pupils will, not surprisingly, be better than the conscientious, field-dependent and convergent pupils, even though they are not the ones favoured by the written worksheet approach of teaching/learning.

6.4 Conclusion

The classification of the pupils into the four motivational patterns was not so straightforward. This was partly due to the short time in which the study had to be completed and the inability of the school to offer too much of their valuable time for testing. If future research is done over a longer period and each of the motivational tests repeated, a more reliable classification may be obtained. It must, however, be pointed out that the patterns are not absolutely independent of each other, thus, the observed interrelationships between the motivational patterns were to be expected. Almost every pupil was motivated to learn by more than one need, thus a mix of characteristics were likely to show in a particular pupil.

There was a clear-cut division between the field-dependent and the field-independent pupils from their individual scores in the Hidden Figures Test (HFT). Similarly, the pupils divided into convergent and divergent thinkers from their scores in the convergence/divergence test. The two factors, field-dependent/independent and convergent/divergent cognitive styles, were considered to be independent of each other because they showed a very low correlation.

The overall result of the research has been contrary to the proposition. The findings, as evident from the internal and external examination results, is not due to the effect of the pupils' learning styles and the teaching mode, but to the effect of the learning styles and exam answering efficiency. The performance of the pupils, then, is a reflection of the nature of the examinations and the efficiency of the pupils in answering the examination questions than of the mode of teaching.

It is evident from the study that, pupils appear to divide themselves into different groups having different motivational and cognitive characteristics which, ideally, call for the employment of different teaching procedures if pupils' characteristics, learning and attainment are to be balanced and maximised.

Although the curious, field-independent and divergent pupils are performing better than the conscientious, field-dependent and convergent pupils, there is more that can be done to make the teaching/learning approach appealing to them by developing and introducing instructional strategies and teaching/learning materials that reflect their learning styles. This may not only enhance their already better performance but may also increase their interest and appreciation of science. Likewise, more needs to be done to enhance the efficiency of performance of the conscientious, field-dependent and convergent pupils in examinations by controlling the amount of relevant and useful information which the pupils have to process and also limit or eliminate the extraneous, distracting information.

Science teaching has very often taken place in mixed ability classes and thus the task of having to cater for a variety of pupils of different needs, different motivations and different cognitive styles towards the learning of science cannot be easily ruled out. This, inevitably, demands the use of a variety of teaching strategies on the part of the teachers and, if possible, differentiated examinations, if the unique needs, motivational and cognitive aspirations of as many different types of pupils are to be met. Unfortunately, circumstances have more or less compelled teachers and curriculum developers to adopt particular teaching methods without considering their suitability for all pupils.

Added to this problem, teachers are often faced with the problem of having to cover so much work in the syllabuses in a short space of time. The syllabuses need to be trimmed down to make room for the teaching to be spread over a period of time to allow time for practice and so gradually establish what is being taught.

This study was restricted to only one school. It would, therefore, not be appropriate to consider the finding as prevailing in all Scottish schools where the same or a similar mode of teaching is practised. I would suggest that future study in this area covers many schools where the written worksheet approach of teaching/learning science is used in order to establish more generalisable findings. A comparative study may also be done by incorporating schools where approaches other than the written worksheet are in use to find a better way forward. I would also suggest that in future research the sociable pupils should be given more attention. Their response to the use of worksheets in science in the semantic differential test and their general performance in the examinations leave much to be desired. There is more that needs to be done to enhance their performance in examinations and their learning by way of providing instructional strategies that suit their needs and preferences.

I would recommend that pupils are introduced to a variety of teaching methods and the opportunity be given them at some stage in the Standard grade course (at the end of S2) to choose between at least two of the methods on offer. That would be streaming by the pupils themselves according to their individual needs and preferences. This may require a lot more funding for schools. The benefits to the pupils and all concerned with their education would be worth the expense.

I hope that observations from this study would stimulate teachers and educators in general to give further consideration to the way examination questions are formulated and the kinds of instructional methods that would adequately meet the needs, preferences, and abilities of learners and enhance or promote their individual learning and attainment, so that all pupils could be helped to become the best that they can be.

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APPENDIX 1

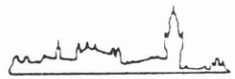
A. MOTIVATION TEST I

NAME : .....

INSTRUCTIONS : Please look at <u>each</u> row of pictures and decide which <u>ONE</u> of the pupils has an opinion most like your own. Enter the name of that pupil in the blank space in the last column.

					Blank space
About class work		Cur. In class, I enjoy hearing about the applications of science to everyday life, whether they are examined or not. — David	Soc. The support of my friends is very important to me during exam times. — Ian	Ach. It is very important to me to be in the top few of the class. — Maria	Cons. I don't like to offer suggestions in class discussions unless I'm sure I'm right. — Bina	
About lab work		Cons. I like practical work when the instructions are clear and you know just where you are and what is expected. — Bina	Soc. I enjoy discussing and doing practical problems with my friends. — Lee	Cur. Practicals with very rigid instructions bore me. I prefer to follow my own ideas such as in a project. — David	Ach. I hate doing practical work with others since they keep you back. — Maria	
About projects		Cons. I don't like planning and investigating new science projects unless I can follow clear instructions. — David	Cur. I'm keen to learn about latest discoveries and inventions rather than stick to set materials. — Bina	Ach. In school, I would rather study science facts and laws than waste my time in planning and carrying out investigations. — Ian	Soc. I don't like to work alone when I'm learning new ideas in science. — Maria	
About social life		Soc. I'm normally so busy enjoying life that I tend to put off my study till the last minute. — Lee	Ach. I like social activities in which I can compete with others and win. — Maria	Cur. I like to be involved in new and unusual hobbies and games rather than stick to the normal ones. — Bina	Cons. When exam times come round I cut out other activities to concentrate on study. — Ian	

UNIVERSITY OF GLASGOW
CENTRE FOR SCIENCE EDUCATION



NAME: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ **CLASS:** _____

INSTRUCTIONS: These four pupils are talking about their science work in school. Which one of these pupils is saying the kind of things with which you agree most. Put a tick (in the box) against the pupil with whom you agree most.

1. In class, I enjoy hearing about the applications of science to everyday life.
2. Practicals with very rigid instructions bore me. I prefer to follow my own ideas.
3. I'm keen to learn about the latest discoveries and inventions.
4. I like to be involved in new and unusual hobbies and games rather than stick to the normal ones.

☐ Cur.

1. It is very important to me to be in the top few of the class.
2. I hate doing practical work with others since they can keep you back.
3. In school, I would rather study science facts and laws than waste my time in practical investigations.
4. I like activities in which I can compete with others and win.

☐ Ach.

1. I don't like to offer suggestions in class discussion unless I'm sure I'm right.
2. I like practical work when the instructions are clear and you know just where you are and what is expected.
3. I don't like doing new science projects in the lab unless I can follow clear instructions.
4. When exam times come round I cut out other activities to concentrate on study.

☐ Cons.

1. The support of my friends is very important to me during exam times.
2. I enjoy discussing and doing practical problems with my friends.
3. I don't like to work alone when I'm learning new ideas in science.
4. I'm so busy enjoying life that I tend to put off my study till the last minute.

☐ Soc.

APPENDIX 2

FIELD-DEPENDENT/INDEPENDENT DIMENSION

A. THE HIDDEN FIGURES TEST(HFT)

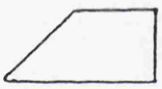
NAME : **SEX :**

SCHOOL : **DATE OF BIRTH :**

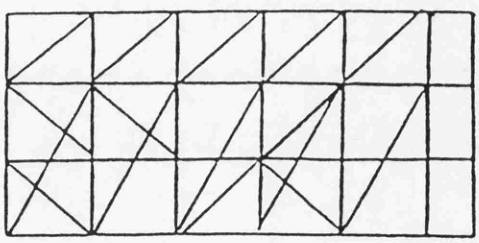
This is a test of your ability to find a simple shape when it is hidden within a complex pattern. The results will not affect your school work in any way.

Example 1

Here is a simple shape which we have labelled (X):

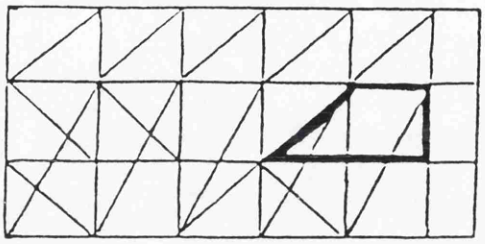
(X) 

This simple shape is hidden within the more complex figure below:



Try to find the simple shape in the complex figure and trace it in pen directly over the lines of the complex figure. It is the same size, in the same proportions, and faces the same direction within the complex figure as when it appeared alone.

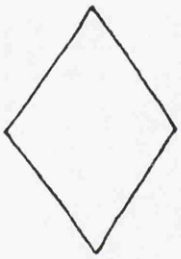
(When you finish, turn the page to check your answer.)

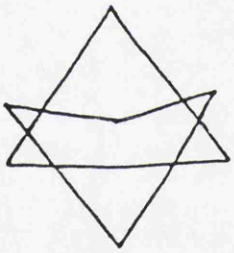


Example 2

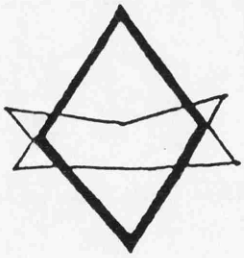
Find and trace the simple shape (Y) in the complex figure beside it.

(Y)





The answer is:



In the following pages, problems like the ones above will appear. On each page you will see a complex figure, and beside it will be an indication of the simple shape which is hidden in it. For each problem, find and trace the simple shape in pen over the lines of the complex figure.

Note these points:

(1) Do not use a ruler or any measuring device in finding the simple shape.

(2) Rub out all mistakes.

(3) Do the problems in order. Don't skip a problem unless you are absolutely stuck to it.

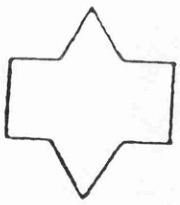
(4) Trace only one simple shape in each problem. You may see more than one, but just trace one of them.

(5) The simple shape is always present in the complex figure in the
same size,
same proportions,
and facing in the same direction, as it appears alone.

(6) LOOK BACK AT THE SIMPLE FORMS AS OFTEN AS NECESSARY.

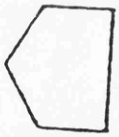
Now: Attempt each of the items on the following sheets.

SIMPLE FORMS



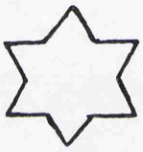
A

B



C

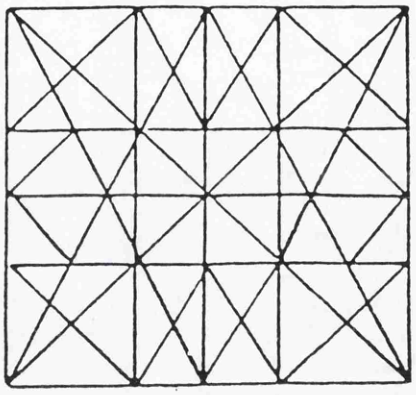
D



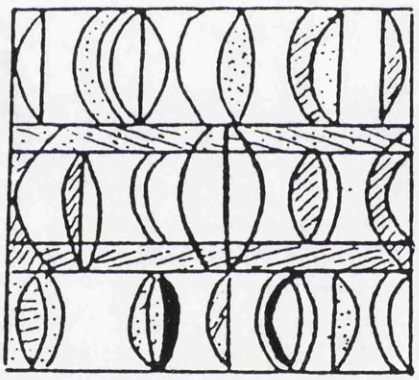
E

G

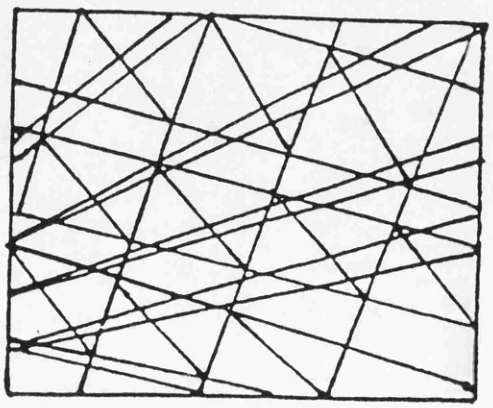
FIND AND TRACE FORM 'C'



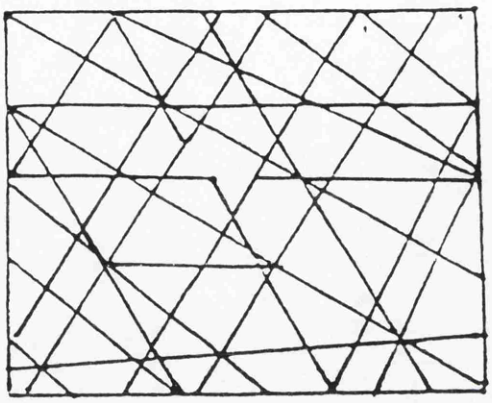
FIND AND TRACE FORM 'D'



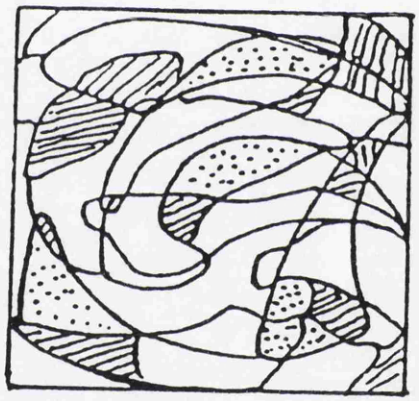
FIND AND TRACE FORM 'B'



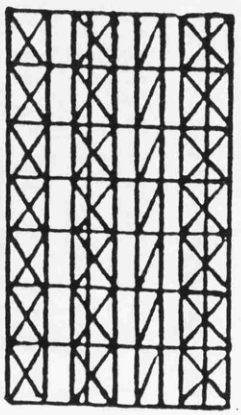
FIND AND TRACE FORM 'E'



FIND AND TRACE FORM 'G'



FIND AND TRACE FORM 'C'



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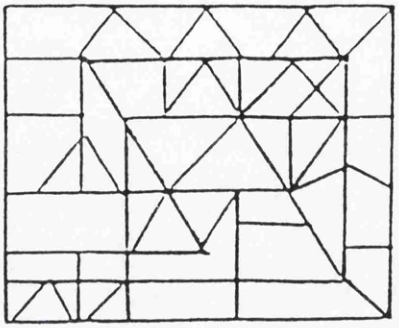

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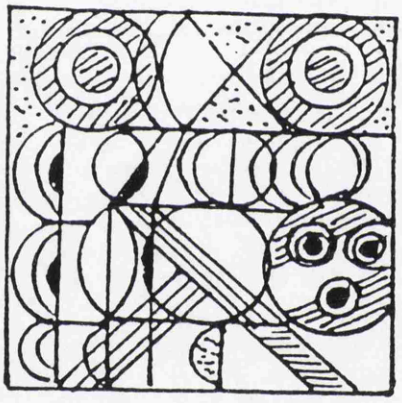

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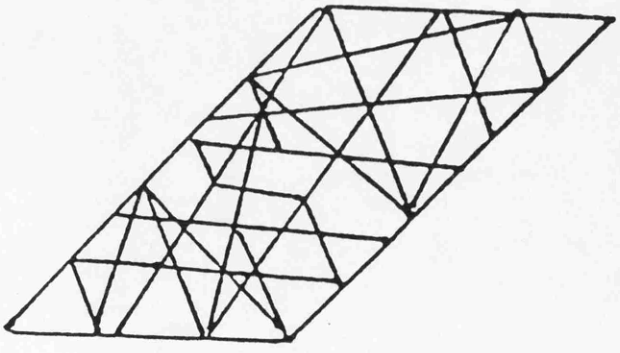
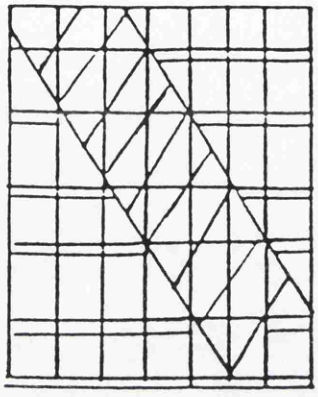


FIND AND TRACE FORM 'A'



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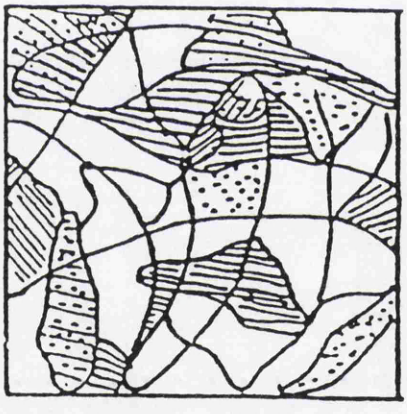
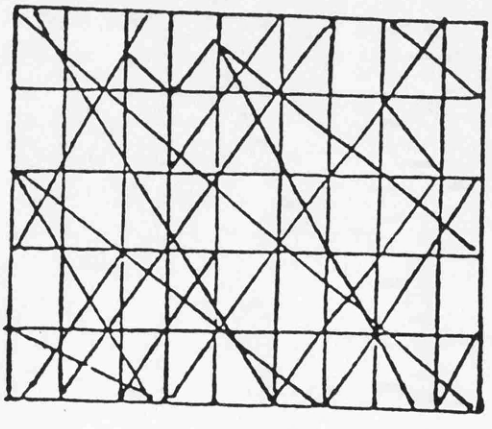
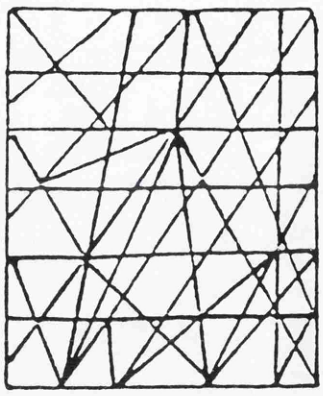


FIND AND TRACE FORM 'A



FIND AND TRACE FORM 'C'



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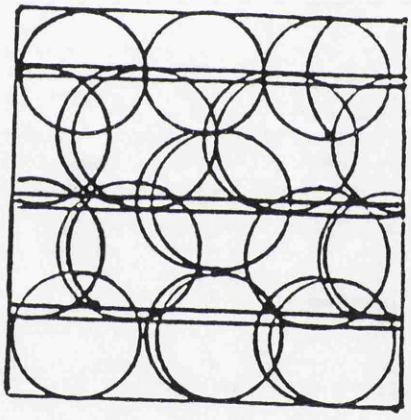

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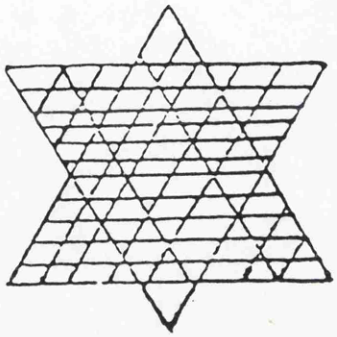
FIND AND TRACE FORM 'E'



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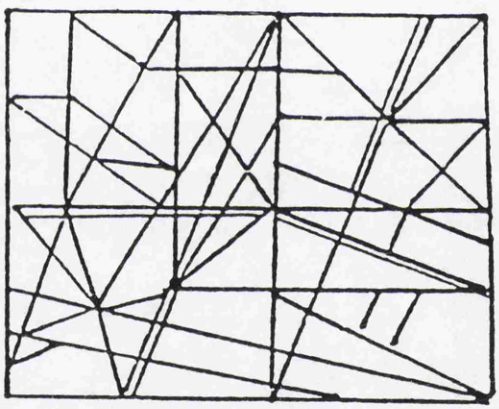

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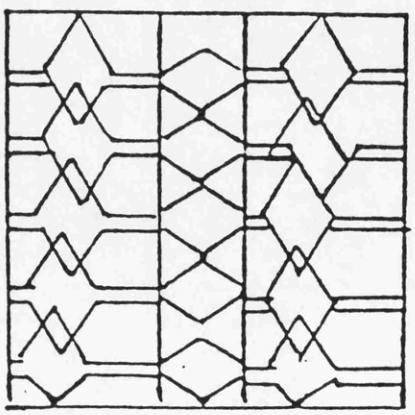
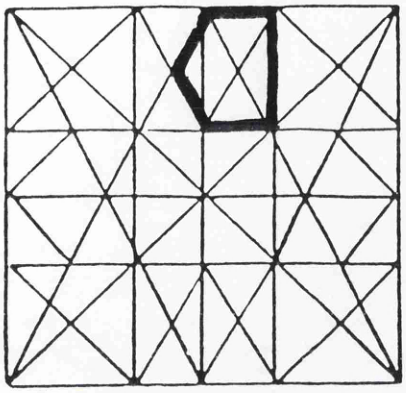


B. HFT - SCORING KEY



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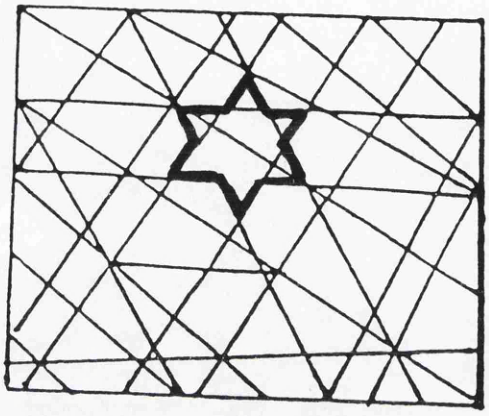

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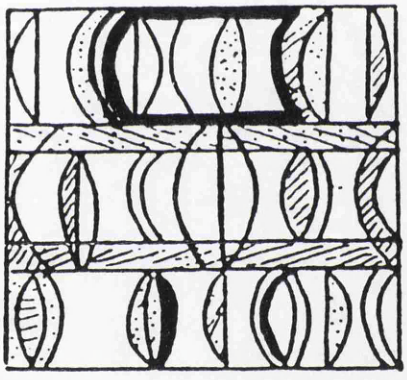

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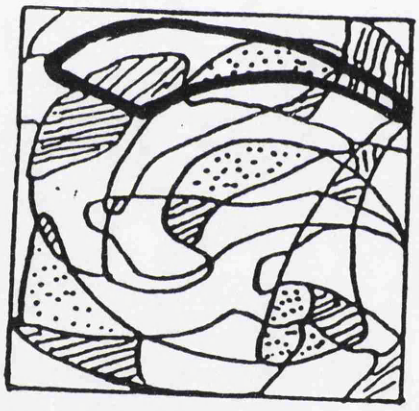

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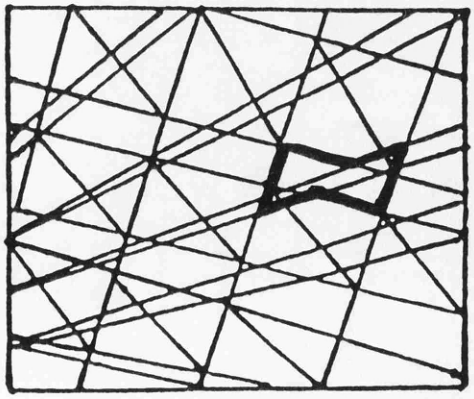

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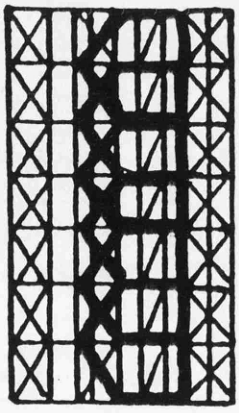

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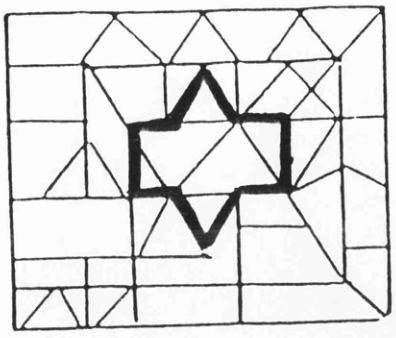

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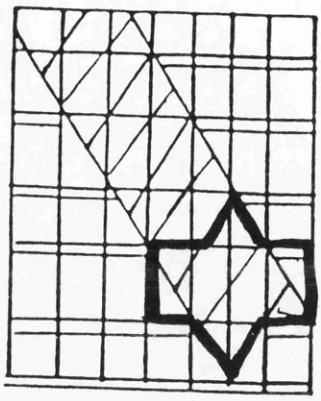

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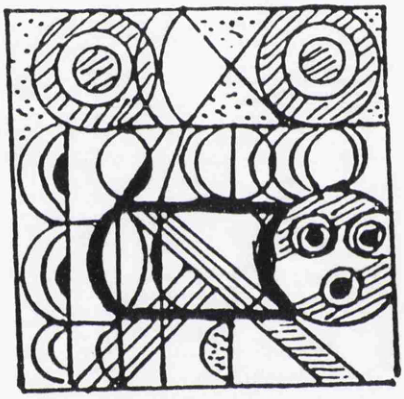

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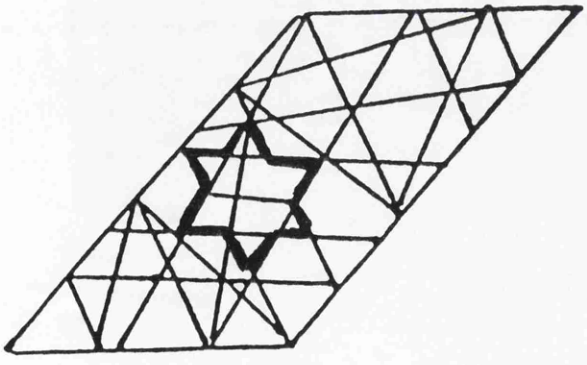

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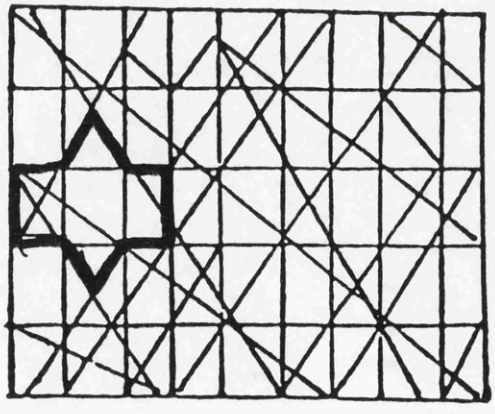

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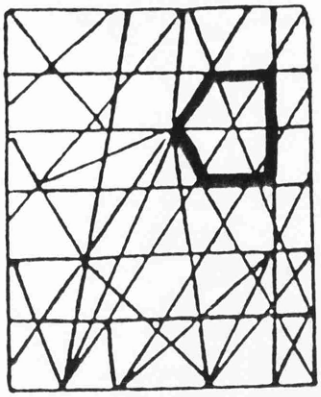

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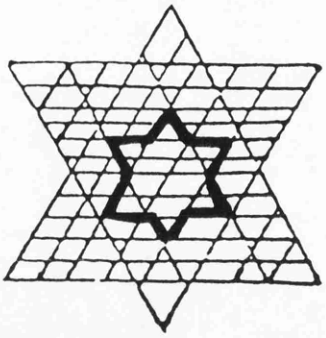

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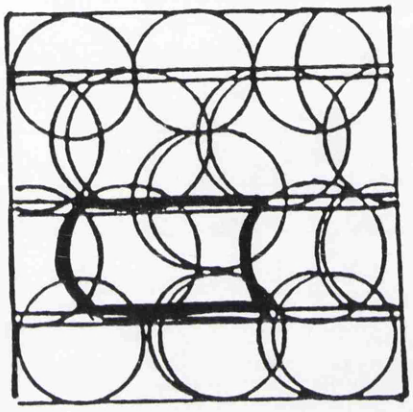

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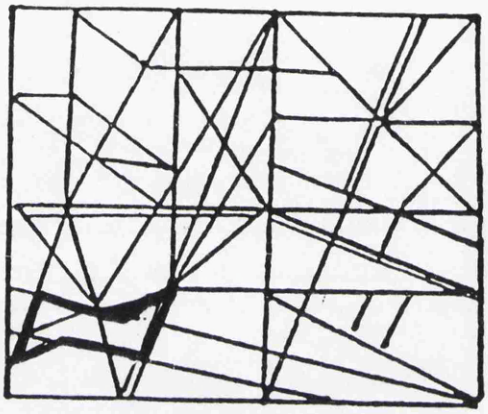

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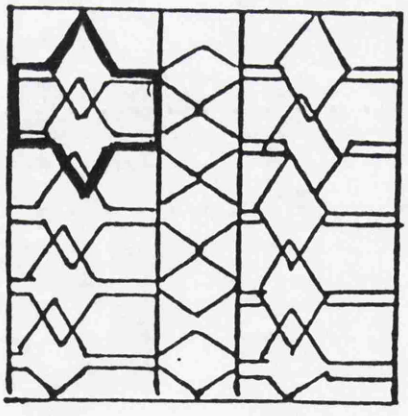


A

APPENDIX 3

CONVERGENCE/DIVERGENCE TEST

NAME : SEX :

SCHOOL : DATE OF BIRTH :

These are some tests to measure the way you think. The results will not affect your school mark in any way.

Test 1 5 minutes

When you are writing, it is often necessary to think of several different words having the same meaning or similar meanings, so that you do not have to repeat one word again and again. In this test you will be asked to think of words having meanings which are the same as or similar to a given word. The given words will be ones that are well known to you.

For example

If the word were short, you would write at least some of the words written below:

Short: brief abbreviated concise momentary little limited deficient abrupt petite crisp compact curtailed

Now try the following words. You probably will not be able to fill in all the spaces, but write as many words as you can think of.

1- Strong:

---------- ---------- ---------- ---------- ----------
---------- ---------- ---------- ---------- ----------
---------- ---------- ---------- ---------- ----------

2- Dark:

---------- ---------- ---------- ---------- ----------
---------- ---------- ---------- ---------- ----------
---------- ---------- ---------- ---------- ----------

3- Clear:

---------- ---------- ---------- ---------- ----------
---------- ---------- ---------- ---------- ----------
---------- ---------- ---------- ---------- ----------

Test 2

In this test you will be asked to write as many sentences as you can. Each sentence should contain the four special words mentioned and any other words you choose.

For example

TAKE FEW LAND LITTLE

1- Few crops take little land.

2- A few little boats take supplies to land.

3- Take a few little boys with you to see the green land.

All four words are used in each sentence. The words must be used in the form that is given; for example, you cannot use "taking" or "took" instead of take. Notice that the sentences may be of any length. All sentences must differ from one another by more than merely one or two changed words, such as different pronouns or adjectives.

Now try the following words. Remember to number each new sentence as was done in the example above.

1- WRITE WORDS LONG OFTEN

_____

_____

_____

_____

_____

2- SISTER MAN YEAR CATCH

_____

_____

_____

_____

_____

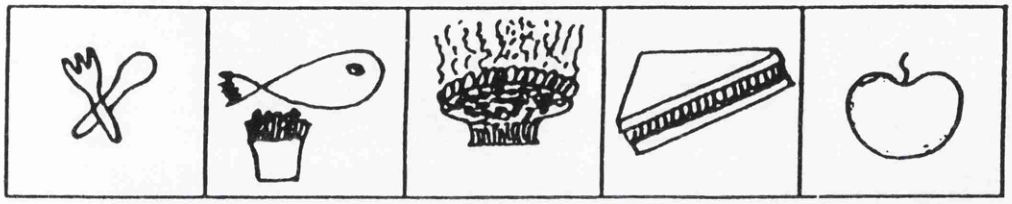
5 minutes

Test 3

This is a test of your ability to think up a number of different symbols that could be used to stand for certain words or ideas.

For example

The word is food. A sketch has been made to represent a fork and spoon. can you think of other symbols that could represent food? Draw them in the boxes. Each drawing can be as complicated as you choose.



Now draw as many symbols as you can think of (up to five) for each word or phrase below.

1- Quiet

2- Keep off the grass

3- Happy

4- Post Office

5 minutes

Test 4

This is a test to see how many things you can think of that are alike in some way.

For example

What things are always red or that are red more often than any other colour? You may use one word or several words to describe each thing.

tomatoes bricks watermelon

Go ahead and write all the things that are round or that are round more often than any other shape.

----------	----------	----------	----------
----------	----------	----------	----------
----------	----------	----------	----------
----------	----------	----------	----------
----------	----------	----------	----------

3 minutes

Test 5

This is a test of your ability to think rapidly of as many words as you can that begin with one letter and end with another.

For example

The words in the following list all begin with S and end with N.

sun spin stain solution

Now try thinking of words beginning with G and ending with T. Write them on the lines below. Names of people or places are not allowed.

----------	----------	----------	----------
----------	----------	----------	----------
----------	----------	----------	----------
----------	----------	----------	----------
----------	----------	----------	----------

3 minutes

Test 6

This is a test to see how many ideas you can think of about a topic. **Be sure to list all the ideas you** can about a topic whether or not they seem important to you. You are not limited to one word. Instead you may use a word or a phrase to express each idea.

For example

"A train journey". Examples are given below of ideas about a topic like this.

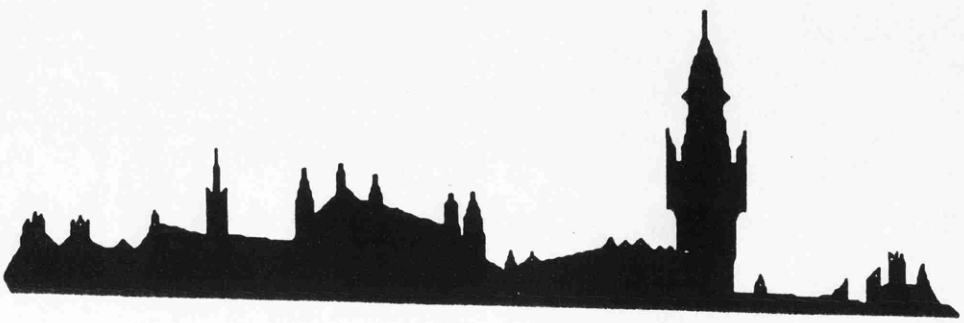
number of miles catching the train the train stations people in the train

Now list all the ideas you can about "crossing the stream".

_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

4 minutes

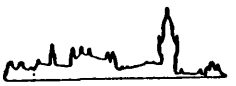
END OF TESTS



APPENDIX 4

SEMANTIC DIFFERENTIAL TEST

UNIVERSITY OF GLASGOW
CENTRE FOR SCIENCE EDUCATION



NAME _____ **CLASS** _____

This sheet is to ask for your opinion about **"Using Work-booklets or Activity Sheets in Science lessons".**

Example

If you were asked to give your opinion about "A Racing Car". You could do it like this:

"A Racing Car"

Fast	✓			Slow
Dangerous	✓			Safe
Fun		✓		Boring
Inexpensive			✓	Expensive

This shows that you think "a racing car" is fast, dangerous, neither fun nor boring, and expensive.

.....

NOW: Use the same method to give your opinion about:

"Using Work-booklets or Activity Sheets in Science lessons".

Interesting				Boring
Enjoyable				Unenjoyable
Difficult to read				Easy to read
Easy to understand				Difficult to understand
Bad				Good
Like them				Don't like them
Prevent me from following my own ideas				Allow me to follow my own ideas

Please, turn over the page

APPENDIX 5

DISTRIBUTION IN THE HIDDEN FIGURES TEST USING +/-0.5SD AND +/-0.25SD

Table I. Distribution of Pupils in the Hidden Figures Test Using +/-0.5SD.

Groups	FD	FInt	FI	Total
Pupils(n)	73	61	85	219
%	*33*	*28*	*39*	*100*

Table II. Distribution of Pupils in the Hidden Figures Test Using +/-0.25SD.

Groups	FD	FInt	FI	Total
Pupils(n)	101	16	102	219
%	*46*	*7*	*47*	*100*

APPENDIX 6

DISTRIBUTION IN THE CONVERGENCE/DIVERGENCE TEST USING +/-0.5SD AND +/-0.25SD

Table I. Distribution of the pupils in the Convergence/Divergence Test Using +/-0.5.

Groups	Conv.	AR	Div.	Total
Pupils(n)	68	78	73	219
%	*31*	*36*	*33*	*100*

Table II. Distribution of the Pupils in the Convergence/Divergence Test Using +/-0.25.

Groups	Conv.	AR	Div.	Total
Pupils(n)	94	32	93	219
%	*43*	*15*	*42*	*100*

APPENDIX 7

MEAN GRADES OF THE VARIOUS GROUPS IN THE INTERNAL EXAMINATION(using K&U and PS).

Table I. Mean grades of the motivational groups in science exam.

Motivational Patterns		Mean Grade
Achievers	(n=9)	2.9
Conscientious	(n=87)	3.5
Curious	(n=42)	2.6
Social	(n=65)	4.0
None	(n=16)	3.4

Table II. Mean grades of the conscientious pupils in science exam.

Overlapping Patterns		Mean Grade
Pure*	(n=13)	3.6
Achievers	(n=2)	3.5
Curious	(n=26)	3.1
Social	(n=32)	3.7

* Showed no overlap overall.

Table III. Mean grades of the curious pupils in science exam.

Overlapping Patterns		Mean Grade
Pure*	(n=2)	3.5
Achievers	(n=1)	1.0
Conscientious	(n=17)	2.8
Social	(n=11)	2.4

Table IV. Mean grades on the sociable pupils in science exam.

Overlapping Patterns		Mean Grade
Pure*	(n=17)	4.6
Achievers	(n=0)	-
Conscientious	(n=18)	3.7
Curious	(n=12)	3.6

Table V. Mean grades of the achiever pupils in science exam.

OverlappingPatterns		Mean Grade
Pure*	(n=1)	4.0
Conscientious	(n=3)	2.0
Curious	(n=2)	1.5
Sociable	(n=0)	-

Table VI. Mean grades of pupils of different degrees of field-dependence/ independence in science exam.

Groups		Mean Grade
FD	(n=101)	4.1
FInt	(n=33)	3.8
FI	(n=85)	2.6

Table VII. Mean grades of the convergers and divergers in science exam.

Groups		Mean Grade
Convergers	(n=77)	3.8
All-rounders	(n=65)	3.5
Divergers	(n=77)	3.0

Table VIII. Mean grades of pupils of different cognitive styles.

Groups		Mean Grade
FD/Conv.	(n=35)	4.7
FD/Div.	(n=31)	3.8
FI/Conv.	(n=30)	2.8
FI/Div.	(n=35)	2.4

Table IX. Mean grades of differently motivated pupils of different degrees of field-dependence/independence.

Groups	FD		FI		*Difference
	n	mg	n	mg	
Conscien.	45	4.3	32	2.3	2.0
Curious	12	3.3	21	2.0	1.3
Social	32	4.2	21	3.6	0.6

* Difference between the mean grades of the FD and FI in each motivational group.

Table X. Mean grades of differently motivated pupils of different degrees of convergence/divergence.

Groups	Convergers		Divergers		Difference
	n	mg	n	mg	
Conscien.	26	4.0	36	3.1	0.9
Curious	14	2.9	20	2.2	0.7
Social	25	4.2	17	3.8	0.4

Table XI. Mean grades of pupils of different motivational patterns and cognitive styles.

Groups	Conscien.		Curious		Social	
	n	mg	n	mg	n	mg
FD/Conv.	15	**5.1**	4	**4.5**	9	**4.2**
FD/Div.	16	**4.1**	5	**2.6**	8	**4.0**
FI/Conv.	9	**1.9**	6	**1.7**	11	**4.0**
FI/Div.	16	**2.3**	12	**2.0**	5	**3.6**

APPENDIX 8

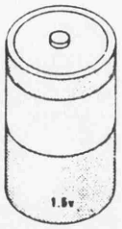
A. Chemistry Worksheets

(Pages 138-146 are part of **Topic 11 - MAKING ELECTRICITY.**)
(The original sheets were printed back to back.)

MAKING ELECTRICITY

You probably use, at least, one thing every day which uses batteries. Here are just a few examples:

— a radio
— a personal stereo
— a digital watch
— a calculator



There are several different kinds of battery, but they all do the same thing — they provide us with a convenient and portable source of electricity.
This topic looks at how electricity is made from the chemicals in a battery.

A cell is an apparatus which makes an electric current from a chemical reaction.

Apparatus which produces electricity from chemicals is usually called a **BATTERY.** Chemists use the word **CELL** instead. A battery is really when two or more cells are joined together.

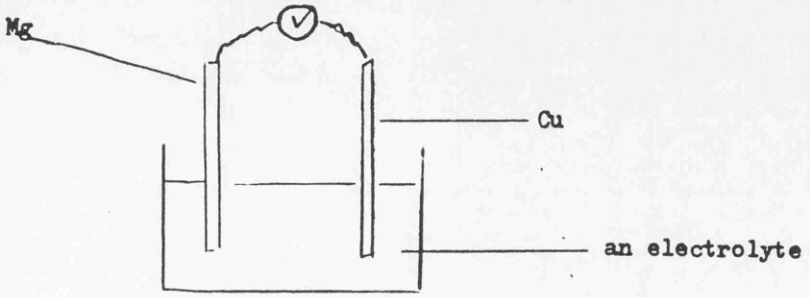
A SIMPLE CELL

In Topic 10, we discovered that when a metal reacts, the metal atoms lose electrons and form POSITIVE IONS.

$$Mg \longrightarrow Mg^{2+} + 2e^- \qquad (or \quad Mg - 2e^- \longrightarrow Mg^{2+})$$

A very reactive metal will give away electrons easily; an unreactive metal will give away electrons less easily.

This loss of electrons will occur when a metal is placed in water - or even better, in a solution of ions - I.E. an ELECTROLYTE.



The electrons "build up" on the surfaces of the 2 metals. The build up of electrons on the magnesium metal compared to the copper metal can be shown using a voltmeter.

metals

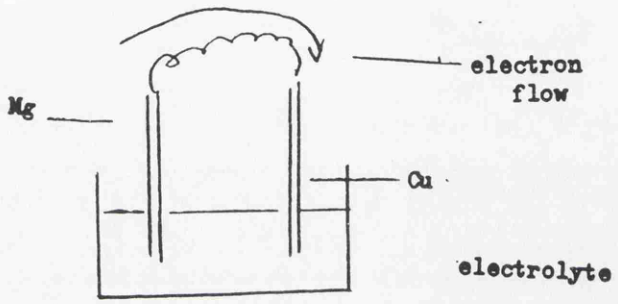
A voltage (or potential difference) is made when 2 substances with different numbers of electrons are connected.

Voltage is measured in volts (v).

Which of these 2 metals is the more reactive? _____

Which of the metals will give away electrons more easily?

_____



If the two metals are connected by a wire, the electrons will flow through the wire.

Although both metals want to "push" away electrons through the wire, the Mg can push away electrons more strongly than the Cu (I.E. the Mg "wins"), and the electrons will flow through the wire from the Mg towards the Cu.

This flow of electrons is an Electric Current and when we make electricity from chemicals in this way, we have made a CELL.

The electrolyte in the beaker completes the circuit.

In a cell made from 2 metals, the electrons always flow from the more reactive metal (loses electrons more easily) to the less reactive metal (loses electrons less easily) through the wire.

The flow of electrons - electric current - can be measured using an ammeter.

Current is measured in amps (A).

Very small currents are measured in milli amps (mA).

Experiment 11.1 USING TWO METALS TO MAKE A CELL.

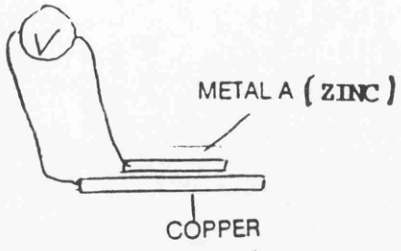
COLLECT Kit 11.1

WHAT TO DO

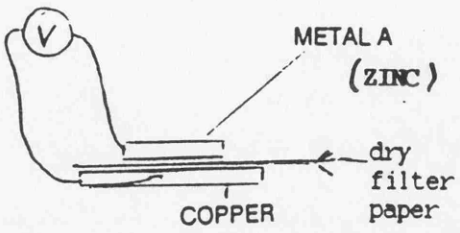
1. Place a piece of copper on the bench and lay another metal (METAL A) on top of it.

2. Using crocodile clips and wires connect both metals to a voltmeter as shown in diagram A.

A.



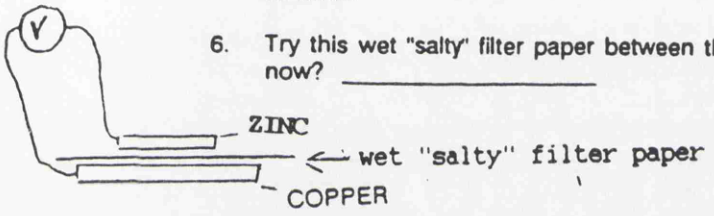
B.



3. Now place a piece of DRY filter paper between the metals as shown in B above. Do you get a reading?

4. Dip the paper in tap water and try again.
Is there a reading this time?

5. Take another piece of filter paper and dip it in ammonium chloride solution.



6. Try this wet "salty" filter paper between the metals. What is the reading now? _____

7. **Record the result in the table**

Metal A	Reading on Voltmeter (v)
Zinc	

8. **Ammonium chloride ($NH_4^+Cl^-$) is an ionic compound.**
Explain why the filter paper soaked in the ammonium chloride solution is used.

_____

_____

9. Replace the zinc with another metal (clean it before you use it). Make sure you keep the copper attached to the same terminal of the voltmeter and the filter paper wet. Record the result on the table

Don't forget copper on copper

10. Once you have tested all the metals, make a list of the metals in order of their voltage (largest first).

_____

_____

_____

_____

_____

11. Why is there no reading when copper isconnected to copper?

_____

Why must you not replace both metals at the same time?

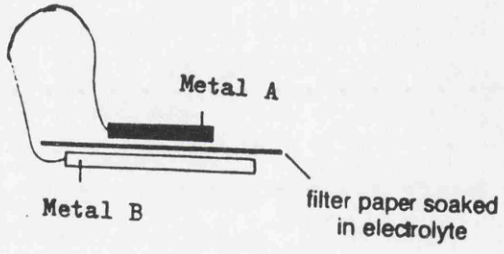
_____

TEACHER CHECKPOINT

HOW TO SET UP A CELL

There are several ways of setting up a cell to produce electricity.

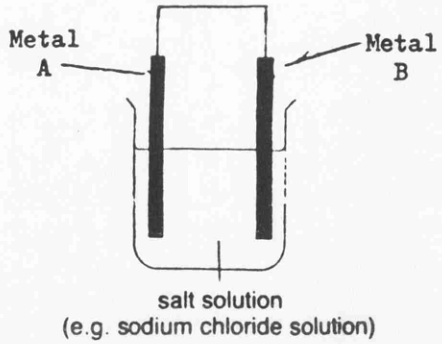
(a)



Metal A and Metal B are connected by a wire, and the filter paper soaked in an electrolyte completes the circuit.

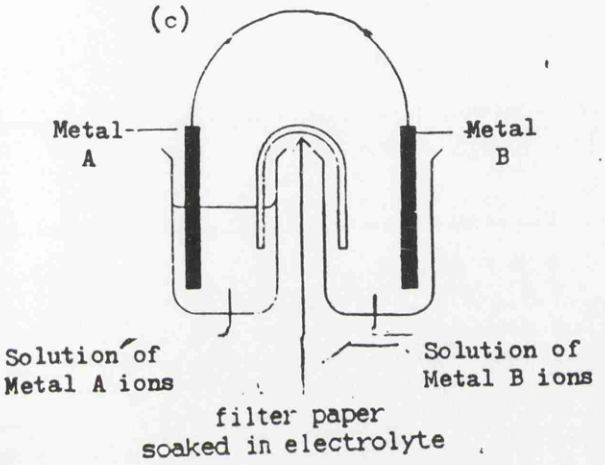
This is the method you used in experiment 11.1

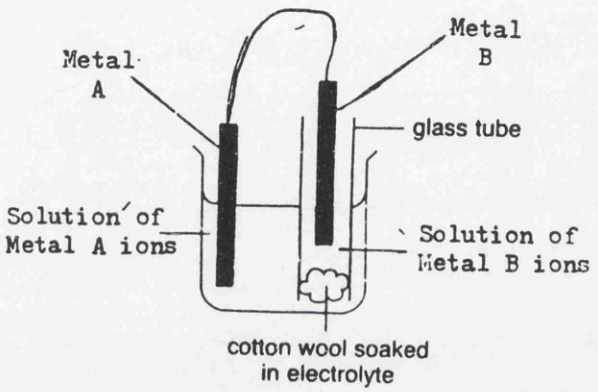
(b)



Metal A and Metal B are connected by a wire, and dipped into a beaker containing an electrolyte.

(c)

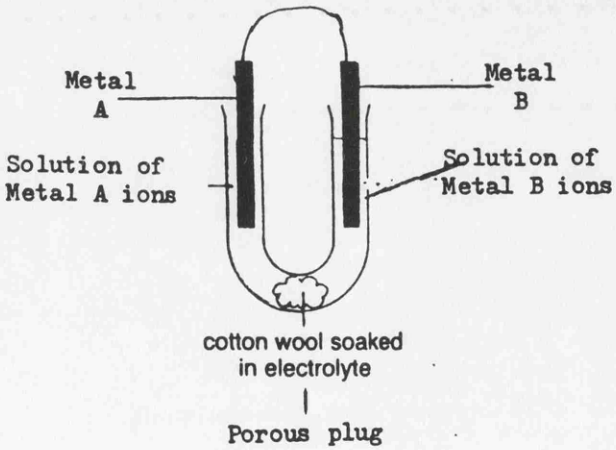




This time, Metal A and Metal B are connected by a wire and placed in separate beakers containing solutions of the metal ions. The circuit is completed by joining the beakers with an "ion bridge" (or sometimes called a "salt bridge"), which contains an electrolyte.

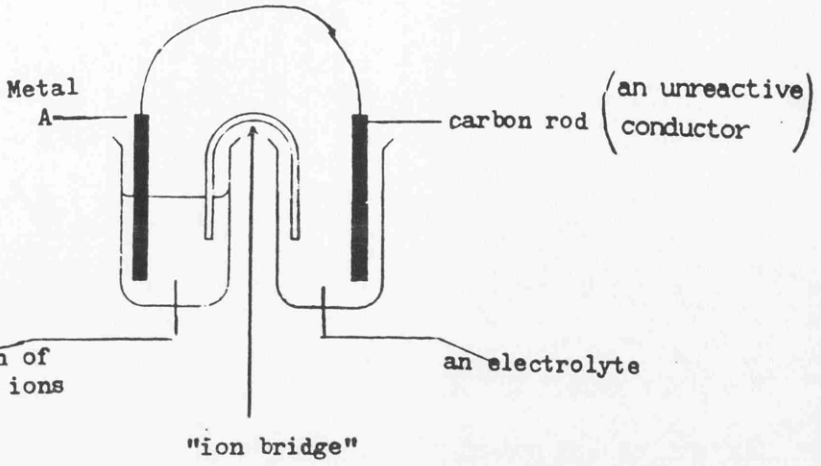
This can be a filter paper or cotton wool soaked in electrolyte.

(d)



In this type of cell, the metals are placed in a "U Tube" and the solutions of metal ions are kept separate using a "porous plug".

(e) A cell like any of the above can be set up using only 1 metal joined by a wire to a carbon rod.



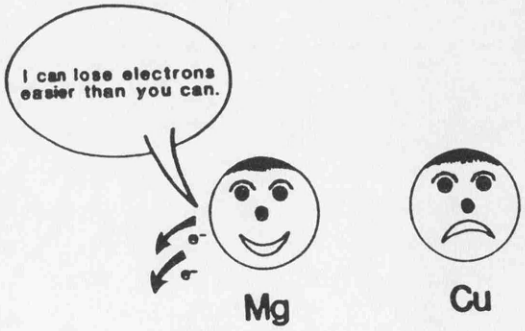
THINGS YOU NEED TO KNOW ABOUT CELLS.

(i) Each side of the cell is called a "half-cell".

(ii) The metal, or carbon rod, is called an ELECTRODE.

(iii) To find out if an electric current is flowing in a cell, we can place a lamp, or a bell, or an ammeter into the wire.

(iv) Metals can be put in order of how easily they lose electrons to form positive ions when part of a cell.
This order is called the ELECTROCHEMICAL SERIES. (Page 7 of the data book.)
(It is almost the same order of metals as the Reactivity series you formed in Topic 10).



(v) When 2 metals are joined together in a cell, a VOLTAGE is produced.
When the metals used are far apart in the Electrochemical Series - a large voltage is produced.
When the metals used are close together in the electrochemical series - a low voltage is produced.
The voltage of a cell is measured using a VOLTMETER.

Experiment 11.2

MORE ABOUT CELLS

Your teacher will show you how to set up a cell.

Collect Kit 11.2

What to Do

1. Pour about 25cm^3 of $Mg^{2+}(aq)$ ion solution into a beaker.
2. Set a strip of magnesium metal in the solution. REMEMBER CLEAN THE METAL
3. Repeat steps 1 and 2 with $Cu^{2+}(aq)$ ion solution and copper metal in another beaker.
4. Connect both metals in solutions of their ions to a voltmeter.
5. Complete the circuit by using a folded filter paper soaked in salt water as an "ion bridge".

6. Draw a diagram of your cell in the space above.
7. The voltage is _____.
8. Remove the voltmeter and replace it with an ammeter.

   The reading on the ammeter is _____.

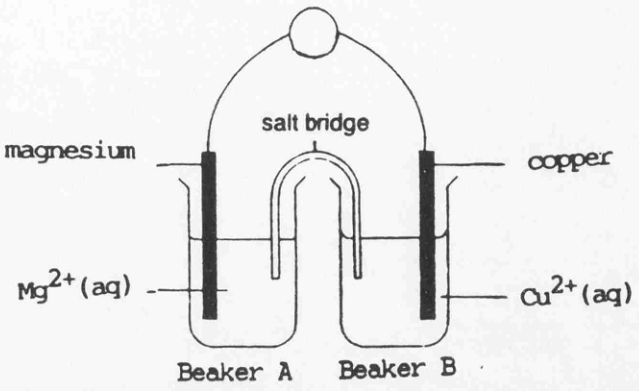
   The electrons flow from the _____ to _____.

   Which is the more reactive metal? _____

TEACHER CHECKPOINT

CLEAR AWAY YOUR APPARATUS.

In the cell you have set up, electrons flow from the more rective metal Magnesium to the less reactive metal Copper.



The reactions taking place in each side of the cell (each half-cell) can be shown by writing ion-electron equations.

In Beaker A
The magnesium metal atoms are losing electrons and forming Mg^{2+} ions.

$$Mg_{(s)} \longrightarrow Mg^{2+}_{(aq)} + 2e^-$$

{or $Mg_{(s)} - 2e^- \longrightarrow Mg^{2+}_{(aq)}$ }

The electrons flow through the wire to Beaker B, and the ions go into solution. This means that the magnesium gets lighter (smaller) and the number of Mg^{2+} ions in the beaker increases (i.e. the solution becomes more concentrated).

In Beaker B
The copper II ions (Cu^{2+}) pick up these electrons and change into copper atoms

$$Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)}$$

This means that the number of Cu^{2+} ions in the solution decreases (i.e. the solution becomes more dilute) and the copper metal becomes heavier (larger).

The ion bridge (salt bridge) allows ions to flow from one beaker to the other to complete the circuit.

The flow of electrons will stop when one of the chemicals is used up.

Experiment 11.2 (B)

MORE CELLS

Collect Kit 11.2 (B)

1. Use some of the other metals and their solutions to set up some other cells (look back at experiment 11.2(A)).
2. In your jotter, draw labelled diagrams of the cells.
   Under each diagram record the voltage and the direction of electron flow each time.
   Write ion electron equations for each cell.
3. Clear away all your apparatus.

TEACHER CHECKPOINT

THE ELECTROCHEMICAL SERIES

The table below lists the metals in order of voltage reading compared to copper - just as you did in experiment 11.1.

METAL	SYMBOL	VOLTAGE READING	EQUATION FOR FORMING THE ION IN SOLUTION
magnesium	Mg	2.7	$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$
aluminum	Al	2.1	$Al(s) \rightarrow Al^{3+}(aq) + 3e^-$
zinc	Zn	1.1	$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$
iron	Fe	0.8	$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$
tin	Sn	0.5	$Sn(s) \rightarrow Sn^{2+}(aq) + 2e^-$
lead	Pb	0.4	$Pb(s) \rightarrow Pb^{2+}(aq) + 2e^-$
copper	Cu	0.0	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
silver	Ag	-0.5	$Ag(s) \rightarrow Ag^{+}(aq) + e^-$

If we were to use a different standard for comparison the metals would be in the same order but the voltage readings would be different.

A fuller electrochemical series can be found on Page 7 of the data book.

NEXT Exercise 1

(Pages 147-152 are part of **Topic 7A - BIOTECHNOLOGY**, Subtopic A - Living Factories.)
(The original sheets were printed back to back.)

LIVING FACTORIES

G1

Yeast is a tiny living thing. It is called a microbe. It is used in baking and brewing. Yeast makes many useful products. For example yeast can break down glucose into carbon dioxide and ethanol (alcohol). This is called fermentation. Yeast obtains energy by doing this.

YEAST AT WORK IN BAKING

You are going to carry out an experiment to show the action of yeast in baking. It uses glucose as food and releases carbon dioxide gas. This gas makes the dough rise.

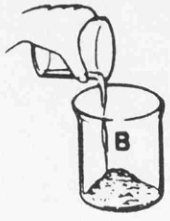
Collect

glucose solution with yeast
glucose solution without yeast
two gas jars
two 100 cm^3 beakers
two samples of flour (25g each)
two elastic bands

What to do

1. Pour the glucose solution containing yeast onto one sample of flour in a beaker. Label this 'A'.

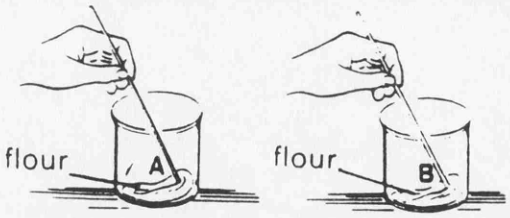
2. Pour the glucose solution without yeast onto the other sample of flour in a beaker. Label this 'B'.



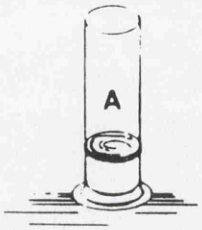
LIVING FACTORIES

G1

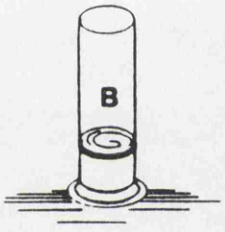
3. Stir both beakers well to form dough.



4. Put the contents of beaker 'A' into a gas jar
Label this 'A'.

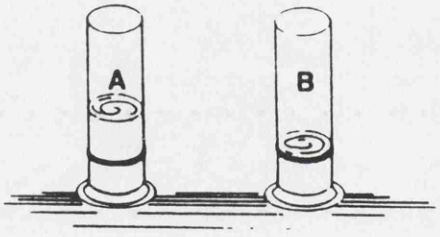


5. Put the contents of beaker 'B' into a gas jar
Label this 'B'.



6. Mark the levels of the dough with elastic bands.

7. Leave aside until next day.



8. Describe what has happened in each jar.

Notes

LEARN

Use the word bank that follows to fill in the blanks below:–

rise **carbon dioxide** **yeast**

Yeast ferments glucose and makes two important substances _____ _____ gas and alcohol. In baking, bubbles of this gas are formed which make the dough _____. Baking finally kills the _____ and cooks the dough.

checkpoint

LIVING FACTORIES

G1

LOOKING AT YEAST

You are going to look at yeast using a microscope.

Collect collect the yeast in glucose solution from the previous experiment.

a microscope slide and coverslip.

a dropper

a microscope

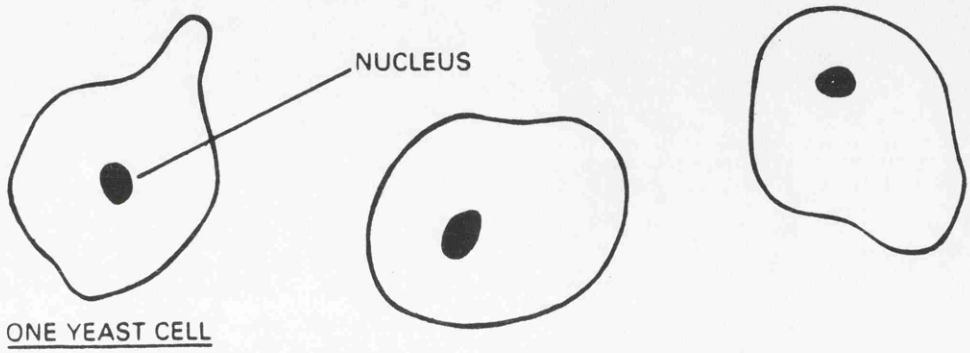
What to do

1. Using the dropper carefully take up a little of the yeast in glucose solution.

2. Add a drop onto the glass slide – place a coverslip on top.

3. Examine under the microscope (high power).

4. Draw what you see – this diagram may help you.



ONE YEAST CELL

LIVING FACTORIES

G1

Notes

LEARN ANSWERS

Using the class resources find out some facts about yeast:

1. – what kind of living organism is yeast?
2. – are the cells separate or joined together?
3. – what does yeast use as food?

ANSWERS

1.

2.

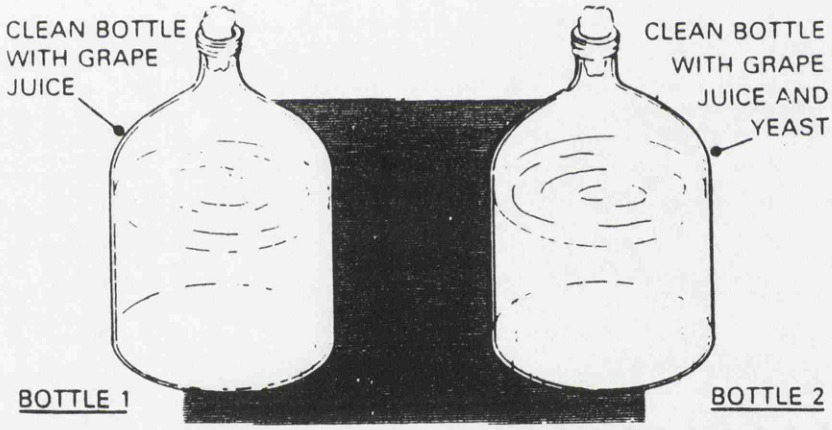
3.

YEAST AT WORK IN BREWING

You are going to look at an experiment which shows the action of yeast in brewing.

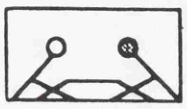
D

Look at the display 'YEAST AT WORK IN WINE MAKING'. Bottles '1' and '2' were set up as shown below.



What to do

- make labelled drawings of bottles 1 and 2
- what do the contents of the bottles look like and smell like?
- what two ingredients are needed to make wine?
- does one bottle feel warmer than the other to touch?



At the start of the fermentation process bottle 2 became warm to the touch – discuss with your partner how you could measure the heat energy given off

Write down your idea.

LIVING FACTORIES

G1

Notes

- This word equation summarises the process of fermentation of glucose by yeast. Write it into your notes:–

LEARN.

Glucose $\xrightarrow{\text{YEAST}}$ Ethanol + Carbon Dioxide – Energy

- Copy and complete this sentence:–

  The manufacture of beer and wine depend on the activities of the microbe _____

You should now know that:–

- Yeast is a microbe used in baking and brewing.
- The raising of dough depends on the production of carbon dioxide by yeast.
- The manufacture of beer and wine depends on the production of alcohol by yeast.

- Yeast is a microscopic fungus made up of single cells.
- Yeast can use sugar as food.

- Fermentation of glucose by yeast can be represented by the following word equation:

Glucose $\xrightarrow{\text{YEAST}}$ Ethanol – Carbon Dioxide – Energy

checkpoint

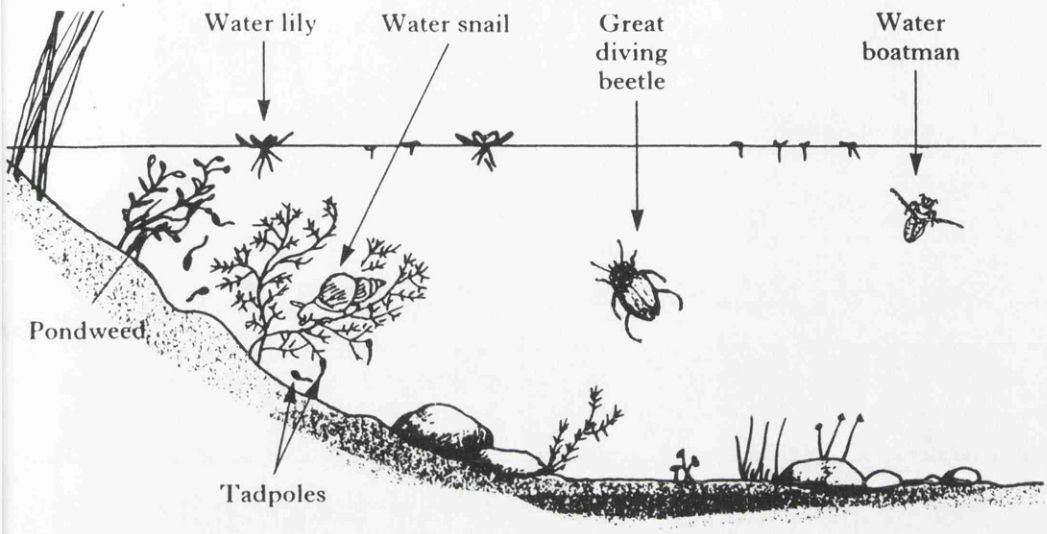
APPENDIX 9

A. SCOTTISH CERTIFICATE OF EDUCATION BIOLOGY EXAM (Standard Grade-General level, 1993)

Question 1 (pages 153-154).

Marks | KU | PS

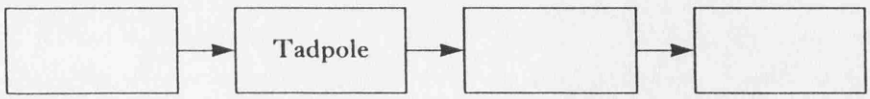
1. The diagram below shows part of a freshwater pond.



(*a*) The table below contains information about organisms in the pond.

Organism	*Information*
Pondweed	Carries out photosynthesis
Water boatman (an insect)	Attacks tadpoles and sucks their juices
Tadpole	Feeds on pondweed
Water snail	Feeds on pondweed
Great diving beetle	Fierce predator, kills and eats other insects

(i) Complete the food chain below, using information from any part of the table.



(1)

(ii) In terms of energy, what do the arrows in the food chain show?

_____

_____

(1)

Running Sub totals

Sub totals carried forward

Marks KU PS

(*b*) Choose **three** words from the box below and explain the meaning of each.

habitat	population	community	ecosystem

1. Word _____ Meaning: _____

_____

2. Word _____ Meaning: _____

_____

3. Word _____ Meaning: _____

_____ **(3)**

(*c*) The diagram below shows some examples of pollution.

Main source of pollution	*Examples of pollutants*	*Part of the environment affected*
Housing	smoke →	B
A	fertilisers →	Freshwater
Industry	oil spills →	C

(i) Name the source of pollution at box A.

_____ **(1)**

(ii) Name **two** parts of the environment affected in boxes B and C.

B. _____ C. _____ **(1)**

(*d*) Complete the following table using letters from the list.

List

A. Treat sewage
B. Use lead-free petrol
C. Set-up conservation areas
D. Use alternatives to fossil fuels

Environmental problem	*How to reduce damage*
Brain damage to children from lead poisoning	
Extinction of rare species	
Death of fish from lack of oxygen	
Global warming from increased atmospheric carbon dioxide	

(2)

Running Sub totals

B. SCOTTISH CERTIFICATE OF EDUCATION CHEMISTRY EXAM (Standard Grade-Credit Level, 1993 and General Level, 1992).

Question 6 - Credit Level, 1993 (page 155).
Question 8 - General Level, 1992 (page 156).

KU	PS

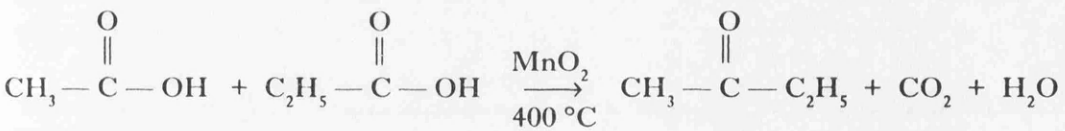
6. Alkanones and alkanoic acids are two families of carbon compounds. Each family has a particular arrangement of atoms.

alkanone

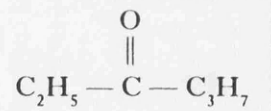
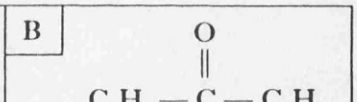
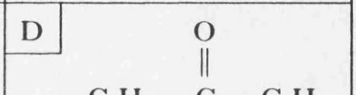
alkanoic acid

[ ] represents the rest of the molecule

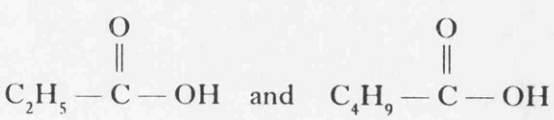
Alkanones can be prepared from alkanoic acids.



The grid shows the structural formulae for some alkanones.

A 	B 
C 	D 

(*a*) Identify the alkanone which can be produced by heating a mixture of:



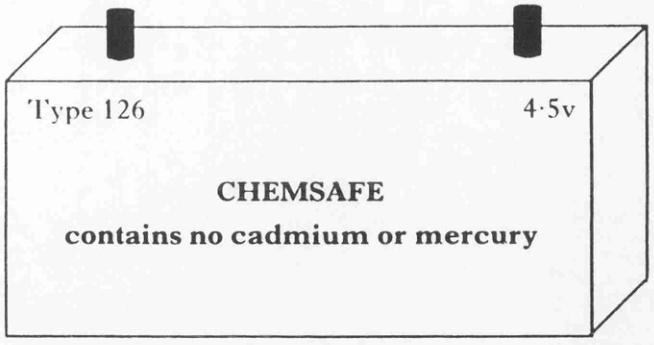
A	B
C	D

(*b*) Identify the alkanone which can be prepared by heating only one alkanoic acid.

A	B
C	D

KU	PS

8. Some batteries no longer use mercury or cadmium.



Identify the statement(s) which can be applied to **both** cadmium and mercury.
You may wish to use the data booklet.

A	They both conduct electricity.	A
B	They were discovered after 1820.	B
C	They both have a higher atomic number than silver.	C
D	They are both more reactive than potassium.	D